The Republic of Colombia
National Unit for Disaster Risk Management (UNGRD)
Institute of Hydrology, Meteorology and Environmental Studies (IDEAM)
Autonomous Regional Corporation of Cundinamarca (CAR)
Department of Cundinamarca
Ministry of Environment and Sustainable Development (MADS)

Project for Strengthening Flood Risk Management Capacity in the Republic of Colombia

Completion Report

July 2018

Japan International Cooperation Agency (JICA)

Oriental Consultants Global Co., Ltd.
Pacific Consultants Co., Ltd.

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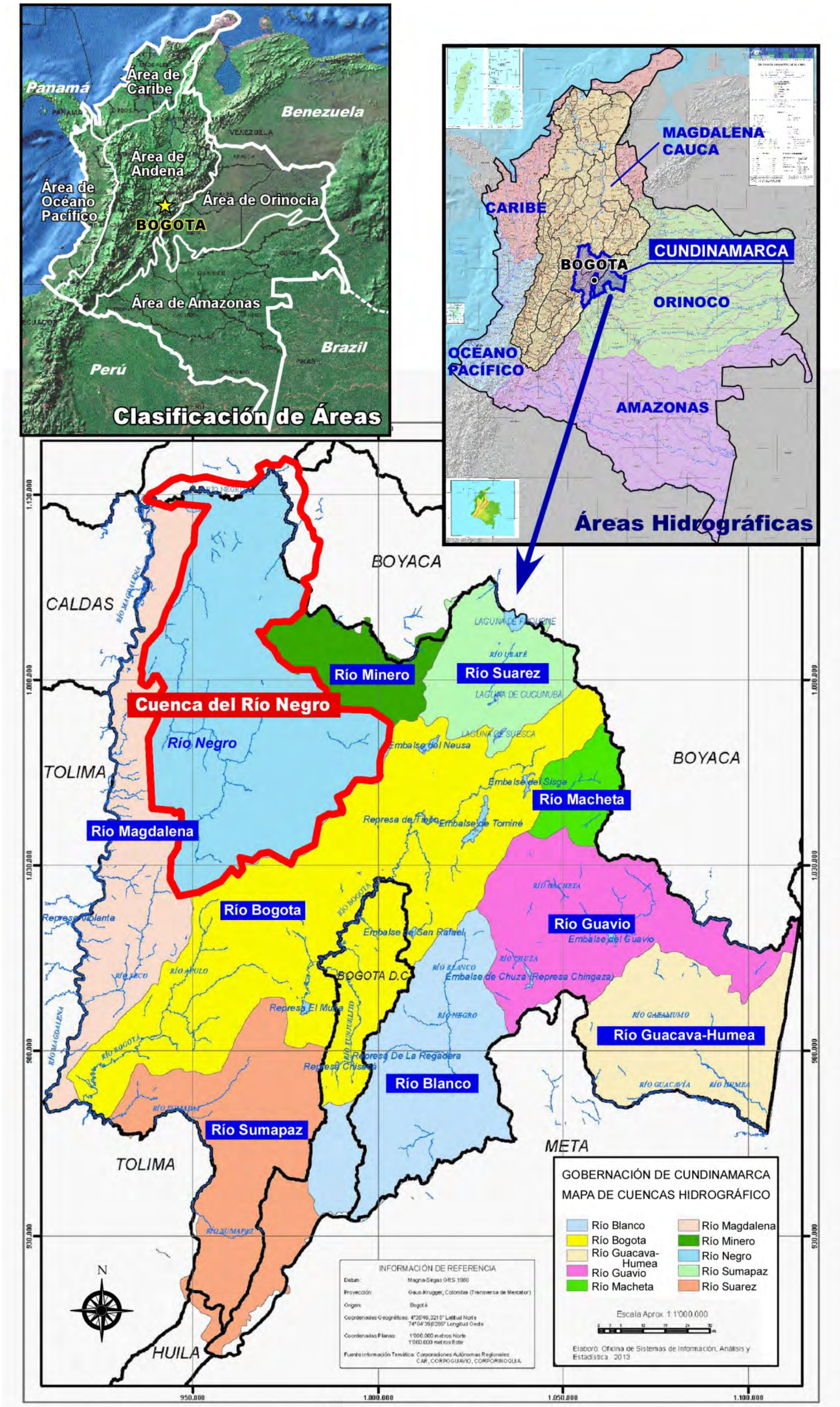
Abbreviations

C/P	Counterpart
CAR	Autonomous Regional Corporation of Cundinamarca (acronym in Spanish)
CARMAC	Regional Environmental Council of the Macro-basin (acronym in Spanish)
CIRMAG	Scientific Research Center of the Magdalena River Alfonso Palacio Rudas (acronym in Spanish)
COP	Colombia Peso
CORMAGDALENA	Regional Autonomous Corporation of the Rio Grande de la Magdalena (acronym in Spanish)
CORPOBOYACA	Autonomous Regional Corporation of Boyaca (acronym in Spanish)
DAC	Development Assistance Committee
DANE	National Administrative Department of Statistics (acronym in Spanish)
DEM	Digital Elevation Model
DGIRH	Direction of Integral Management of the Water Resource (acronym in Spanish)
DHI	Danish Hydraulic Institute
DNP	National Planning Department (acronym in Spanish)
DRR	Disaster Risk Reduction
DTM	Digital Terrain Model
EM-DAT CRED	Emergency Events Database, Centre for Research on the Epidemiology of Disasters
ESRI	Environmental Systems Research Institute
GIS	Geographic Information System
HEC HMS	Hydrologic Engineering Center Hydrologic Modeling System
HEC RAS	Hydrologic Engineering Center River Analysis System
IC/R	Inception Report
ICHARM	International Centre for Water Hazard and Risk Management
ICUU	nstitute of Infrastructure and Concessions of Cundinamarca (acronym in Spanish)
IDEAM	Institute of Hydrology, Meteorology and Environmental Studies (acronym in Spanish)
IFAS	Integrated Flood Analysis System
IFMP	Integrated Flood Risk Management Plan
IFMP-RP	Integrated Flood Risk Management Plan - Río Principal
IFMP-SZ	Integrated Flood Risk Management Plan - Sub-Zona
IGAC	Geographical Institute Agustin Codazzi (acronym in Spanish)
IPCC	Intergovernmental Panel on Climate Change
iRIC	international River Interface Cooperative
JCC	Joint Coordination Committee
JICA	Japan International Cooperation Agency

M/M	Minutes of Meeting
MADS	Ministry of Environment and Sustainable Development (acronym in Spanish)
MLIT	Ministry of Land, Infrastructure, Transport and Tourism, Japan
MVCT	Ministry of Housing, City and Territory (acronym in Spanish)
PDM	Project Design Matrix
PMA	Exploitation Master Plan for Magdalena River (acronym in Spanish)
PO	Plan of Operation
POD	Departmental Management Plan (acronym in Spanish)
POMCA	Management and Regulation Plan for a Basin (acronym in Spanish)
POT	Land Management Plan (acronym in Spanish)
R/D	Record of Discussion
SE	System Engineer
SGC	Colombian Geological Service (acronym in Spanish)
SNGRD	National System for Disaster Risk Management (acronym in Spanish)
TIC	Tokyo International Center
UNGRD	National Unit for Disaster Risk Management (acronym in Spanish)
UNISDR	United Nations International Strategy for Disaster Risk Reduction
USACE	United States Army Corps of Engineers
USGS	United States Geological Survey



Target Area for Pilot Project

1. Basic Project Information

1.1. Target Country

Colombia

The target area of the pilot project is the Río Negro basin in the Department of Cundinamarca (Detailed location can be found on page v).

1.2. Title of the Project

Project for Strengthening Flood Risk Management Capacity in the Republic of Colombia

1.3. Duration of the Project

Planned: July2015 – July 2018

Actual: Same as above

The target area of the pilot project is the Rio Negro basin in the Department of Cundinamarca (the detailed location can be found on page v)

1.4. Background

The Republic of Colombia (Land area: 1, 141,748 km^2, Population: about 47.1 million inhabitants according to the National Administrative Department of Statistics (DANE) 2013 estimate.) is located on the fringe of the volcanic Andes, with great rivers and presenting vulnerabilities to weather and natural disasters. During La Niña between 2010 and 2011; 28 of the 32 departments in Colombia were affected by floods and landslides caused by massive heavy rains. This historical disaster wreaked 2.3 million affected people (5% of the national population) and 26 billion pesos (1.26 billion Yen[1]) for recover and rehabilitation. Nine of the 10 major natural disasters in the last two decades in Colombia were flood and the affected population reached 8 million. (CRED EM-DAT. 2014). That is why floods are the most frequent disasters and large-scale damage to the Republic of Colombia.

In response, the Government of Colombia promulgated Decree 4147 of 2011 regarding responsibility of the National Unit for Disaster Risk Management (UNGRD), Law 1523 of 2012 regarding adaptation of the national policy on disaster risk management and establishment of the National System for Disaster Risk Management (SNGRD), Decree 1640 of 2012 regarding formulation of Management and Regulation Plan for a Basin (POMCA), Resolution 1907 of 2013 the Ministry of Environment, and Sustainable Development (MADS) regarding technical guideline for formulation of POMCA, Decree 1807 of 2014 regarding incorporation of risk management in Land Management Plan (POT); also other relevant regulations are promulgated to accelerate efforts to prevent and reduce disaster by introducing the Disaster Risk Management in regional planning.

However, due to the protracted situation where risk management is defined as part of the environmental management, role sharing for managing flood risk among the institutions at national, departmental and municipal level are currently not sufficiently organized and the activities related to flood risk management are not being implemented effectively. Those causes problems such as

[1] 1 COP= 0.04836JPY(rate reported by the Bank of Japan in August 2015)

insufficient exchange of observational data, lack of maintenance and proper administration of the observation infrastructure.

Likewise, the responsibilities related to the hydrological and meteorological monitoring in addition to the publication of forecasts and warnings are the National Institute for Environmental Studies (IDEAM) of the Ministry of Environment, Housing and Territorial Development, but the results of the observation are not being sufficiently proficient in the flood forecasting and warning, and the formulation of structural plan against flood. To meet these current challenges, it is required the clarifying responsibilities of relevant organizations related to flood risk management, the developing methodology for risk assessment, and flood forecasting and warning system, and the developing river management plan. Added to the above, there is the challenge of developing mechanism of formulating river management plan at basin level.

Due to this, in 2013, the Government of Colombia requested a project with the objective of strengthening the SNGRD through measures against meteorological disasters, disasters on slopes and floods, and this request was approved by Japan. However, due to the wide scope of the project, the idea of giving importance to the implementation of the project was studied by the parties, and it was decided to limit the type of disaster on the floods as they cause the greatest damage in Colombia. JICA carried out 2 studies for the formulation of the plan in detail in July and October 2014 to refine the contents of the cooperation. As a result, both parties agreed to implement this project, signing the Record of Discussions (R/D) for implementation on April 20, 2015.

1.5. Overall Goal and Project Purpose

Overall Goal: The reduction of flood risk in Colombia

Project Purpose: Capacity of Colombian institutions in flood management is enhanced.

Expected Outputs:

Output 1: Capacity on flood risk assessment is improved and concept of integrated flood management planning and river basin management is introduced

Output 2: Capacity on flood forecasting, warning and information dissemination to relevant organizations is improved (mainly IDEAM and UNGRD)

Output 3: Roles and responsibility of the central and local government for flood risk reduction are elucidated and enhanced (mainly UNGRD and IDEAM)

Output 4: Capacity of flood management planning is enhanced through formulation of integrated flood management plan (IFMP) in the pilot river basin

Project Framework:

Figure 1.1 summarizes the project framework.

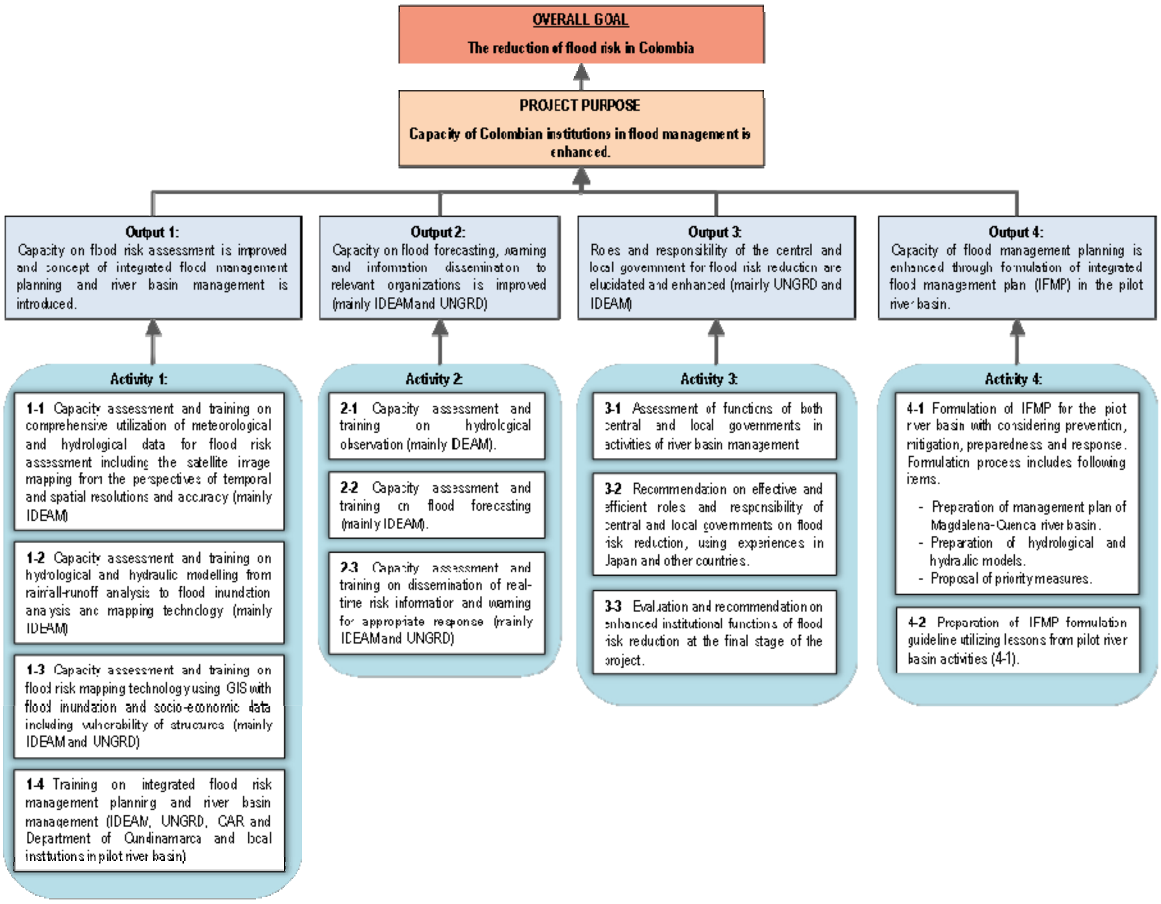


Figure 1.1 Project Framework

1.6. Relevant agencies

<u>Implementing Agencies</u>

- National Unit for Disaster Risk Management (UNGRD)
- Institute of Hydrology, Meteorology and Environmental Studies (IDEAM)

<u>Cooperative Agencies</u>

- Autonomous Regional Corporation of Cundinamarca (CAR)
- Department of Cundinamarca
- Ministry of Environment and Sustainable Development (MADS)

These 5 agencies will be called Counterpart (C/P).

2. Results of the Project

2.1. Results of the Project

2.1.1. Inputs by the Japanese side (planned and actual)

<u>Japanese expert team</u>

The comparison between the planned visit and the actual visit by the Japanese experts is shown in Appendix-16. Below is the table of visits by Japanese experts.

Table 2.1 Visits by Japanese Experts

Names	Responsibility	Man/Month
Work in Colombia		
Kenji Morita	Chief Advisor/ Flood Risk Management (1)	10.37
Kazunori Inoue	Deputy Chief Advisor / Flood Risk Management (2) / Hydrology, Hydraulics and Flood Forecast	5.30
Masaki Todo	River Plan	6.83
Masahito Fujimoto	Dissemination of Alert and Evacuation Information	3.67
Akihiro Furuta	Flood Risk Mapping, Flood Risk Assessment and GIS	4.00
Hirotada Hasegawa	Disaster Risk Management Policies	2.17
Takeshi Katayama	Disaster Risk Management Policies	1.67
	Subtotal	34.00
Work in Japan		
Kenji Morita	Chief Advisor/ Flood Risk Management (1)	1.10
Kazunori Inoue	Deputy Chief Advisor / Flood Risk Management (2) / Hydrology, Hydraulics and Flood Forecast	0.15
Masaki Todo	River Plan	0.50
	Subtotal	1.75
	Total	35.75

Purchase of Equipment and Materials

Below is the table of equipment and materials already purchased/ transferred as agreed in R/D and equipment authorized in the Work Implementation Contract.

Table 2.2 Equipment and Materials

Name of Equipment (Item from R/D)	#	Purchase/Transfer Status	Price
Equipment Agreed in R/D			
Desktop/Laptop Computer	2	2 units purchased in August 2015 and transferred to IDEAM in June 2018	2,469,000 COP/unit (119,401JPY/unit)
Multifunctional Photocopier (Printer/Copier)	2	1 unit purchased in August 2015 and transferred to IDEAM in June 2018 (Additional units will not be purchased)	10,400,000 COP (502,944JPY)
Color Inkjet Printer	2	1 unit purchased in August 2015 and transferred to IDEAM in June 2018 (Additional units will not be purchased)	630,000 COP (30,467JPY)
Hydrological Analysis Software	2	2 units purchased in February 2016 and transferred to IDEAM in June 2018	0 JPY (Free Software)

GIS Software	2	2 units purchased in February 2016 and transferred to IDEAM in June 2018	636,398 US$[2]/unit (789,134JPY/unit)
Equipment not agreed in R/D but authorized in the Work Implementation Contract			
Desktop/Laptop Computer	1	1 unit purchased in August 2015 and transferred to IDEAM in June 2018(Additional units will not be acquired)	2,469,000 COP/unit (119,401JPY/unit)

2.1.2. Inputs by the Colombian side

<u>Participation in the Project</u>

To carry out the project activities, each C/P assigned main participants. Figure 2.1 shows the input of the main people of each C/P according to the activity period of the project in Colombia. The activity period of the project in Colombia coincides with the period of periodic monitoring in the project (Section 2.1.3.6 (19) includes the details of the monitoring).

Entity/Name	2015.10 ～ 2015.11	2016.2 ～ 2016.3	2016.5 ～ 2016.8	2016.10 ～ 2016.11	2017.2	2017.4 ～ 2017.8	2017.9 ～ 2018.3
<UNGRD>							
Julio González	■	■	■	■	■		
Lina Dorado						■	
Joana M. Pérez						■	■
<IDEAM>							
Fabio Bernal	■	■	■	■	■	■	■
María Constanza Rosero						■	■
<CAR>							
Milena Castillo	■	■	■	■	■	■	
Rafael Robles				■	■		
Maryeny Caraballo				■	■	■	■
Juan Carlos Loaiza						■	■
Fernando Ospina						■	■
Oscar Santos							■
<Department of Cundinamarca>							
Jaime Matiz	■	■	■	■	■	■	■
William Barreto			■	■	■	■	■
María Cristina Rúiz			■	■		■	
Wilson García				■	■		
Magda Yamile Rúiz					■	■	
<MADS>							
Yolanda Calderón		■	■	■		■	■
Luz Francy Navarro			■	■	■	■	■
Sergio Salazar				■			
Linda Irene Gómez						■	

Figure 2.1 Inputs by Main Participants from C/P

The participation by other C/P members is found in the list of workshops in Appendix-2.

[2] 1US$=124JPY (exchange rate reported by the Bank of Japan in August, 2015)

Training in Japan

This section presents the participant lists and details of their participation in the 3 series of trainings in Japan during the project.

The purpose of the 3 training series was "to deepen the knowledge on the current situation of flood and river management in Japan to use it not only in the project activities but also in the future formulation of strategies for flood and river management in Colombia." Number 2.1.3.6 (16) "Trainings in Japan" shows the details of the trainings

Table 2.3 Summary of the First Training in Japan (November-December 2015)

Entity	Title	Names	Period of Stay	Places of Visit
UNGRD	Official of knowledge of disaster risk section(specialist)	Mr. Julio Cesar González Velandia	2015/11/15 -12/3	• Ministry of Land, Infrastructure, Transport and Tourism (MLIT), Office of Water Management and Territorial Protection, River Plan Section • MLIT, Kanto Region Management Office • MLIT, Chubu Region Management Office • MLIT, Kinki Region Management Office • MLIT, Center of Integral Research of Technological Policy for National Territory • Japan Meteorology Agency • Nagano Prefecture • Kiotanabe City • Civil Engineering Research Institute ICHARM • Civil Engineering Research Centre, Research Centre for Coexistence with Nature • Centre for Future of the Humanity and Disaster Prevention
IDEAM	Director of the hydrology section	Mr. Nelson Omar Vargas Martínez	2015/11/15 -11/22	
CAR	Technical director	Mr. Cesar Clavijo Rios	2015/11/15 -11/28	
	Technician (specialist)	Ms. Heidy Milena Castillo Montano	2015/11/15 -12/3	
Cundinamarca Department	Officer of the administrative unit for disaster risk management (specialist)	Mr. Jaime Matiz Ovalle	2015/11/15 -12/3	

Table 2.4 Summary of the Second Training in Japan (November 2016)

Entity	Title	Names	Period of Stay	Places of Visit
UNGRD	Official of the knowledge of disaster risk section (specialist)	Mr. Martín Mauricio Mazo Villalobos	2016/11/6-11/23	• MLIT, Office of Water Management and Territorial Protection, River Plan Section, International Room • MLIT, Disaster Forecast Center • MLIT, Kanto Region Management Office, Downstream River Office of Arakawa • MLIT, Kanto Region Management Office, Upstream River Office of Arakawa • MLIT, Kanto Region Management Office Shimodate Office • MLIT, Kanto Region Management Office Keihin River Office • MLIT, Chubu Region Management Office Tenryu Dam Integral Management Office, Miwa Dam Management Section • MLIT, Chubu Region Management Office Office of Integral Development and Works of the Mibu River • MLIT, Chubu Region Management Office Upstream River Office of Tenryu River • MLIT, Chubu Region Management Office Downstream River Office of Kiso River • MLIT, Center of Integral Research of Technological Policy for National
IDEAM	Technician (specialist)	Mr. Jorge Andrés González Rojas	2016/11/6-11/23	
	Technician (specialist)	Mr. Fabio Andrés Bernal	2016/11/6-11/23	
CAR	Director of section of disaster risk management, consultant	Mr. Rafael Iván Robles López	2016/11/6-11/23	
	POMCA Technician (specialist)	Ms. Maryeny Caraballo Hueso	2016/11/6-11/23	

Cundinamarca Department	Director of the hazard management section	Mr. William Barreto Rodríguez	2016/11/6-11/23	Territory River Research Room • Japan Meteorology Agency, General Affairs Department, Planning Section, International Room • Nagano Prefecture. Construction Office of Suwa • Kanagawa Prefecture, Prefecture Ordination Office, River and Sewage Section • Kanagawa Prefecture, Civil Engineering Office of Atsugi • Yamato City, Hazard Management Section • Civil Engineering Research Institute ICHARM • Civil Engineering Research Centre, Research Centre for Coexistence with Nature
	Director of infrastructure	Mr. Wilson Leonard García Fajardo	2016/11/6-11/23	
MADS	Coordinating officer of the risk management section	Mr. Henry Leonardo Gómez Castiblanco	2016/11/6-11/23	
	Technician (specialist)	Ms. Luz Francy Navarro	2016/11/6-11/23	
CORMAGDALENA	Technician (specialist)	Ms. Claudia Sofía Martínez	2016/11/6-11/23	
CIRMAG	Director	Mr. César Garay	2016/11&6-11/19	
DNP	Specialist	Mr. Diego Rubio	2016/11/6-11/23	

Table 2.5 Summary of the Third Training in Japan (November 2017)

Entity	Title	Names	Period of Stay	Places of Visit
UNGRD	Director	Mr. Carlos Ivan Marquez	2017/11/7-11/11	• MLIT, Office of Water Management and Territorial Protection, River Plan Section, International Room • MLIT, Kanto Region Management Office Keihin River Office • MLIT, Chubu Region Management Office, Tenryu Dam Integral Management Office Miwa Dam Support Office • MLIT, Chubu Region Management Office, Office of Integral Development and Works of the Mibu River • MLIT, Chubu Region Management Office, Upstream River Office of Tenryu River • MLIT, Chubu Region Management Office, Downstream River Office of Kiso River • Ministry of Environment, Natural Environment Office • Ministry of Agriculture, Forestry and Fisheries, Forestry and Fisheries Office • Office of the Cabinet, Person responsible for disaster prevention • Nagano Prefecture, Construction Office of Suwa • Kanagawa Prefecture, Prefecture Territorial Development Office, Sewage Section • Kanagawa Prefecture, Civil Engineering Office of Fujisawa • Yamato City, Crisis Management Section • Global Environment Office
	Coordinating officer of risks of the municipalities	Mr. Juan Carlos Guzman	2017/11/5-11/18	
IDEAM	Technician (specialist)	Ms. Maria Costanza Rosero	2017/11/5-11/18	
	Technician (specialist)	Ms. Eliana Claritza Castro	2017/11/7-11/18	
CAR	Director of environmental management evaluation	Mr. Carlos Antonio Bello Quintero	2017/11/5-11/18	
Cundinamarca Department	Deputy director of the disaster risk awareness section	Ms. Magda Yamile Ruiz	2017/11/5-11/18	
MADS	Technical consultant	Ms. Yolanda Calderon Larragaña	2017/11/5-11/18	

2.1.3. Activities (Planned and Actual)

In this project, all the work items were carried out as specified in the specification document and PDM. Work items according to PDM are presented below.

Table 2.6 Work Items according to PDM

Items in Specification Document		Activity Number in PDM
Works Related to the Entire Project		
(1)	Analysis of existing materials	–
(2)	Preparation of Inception Report (IC/R)	–
(3)	Explanation and description of IC/R	–
(4)	Collection, classification and analysis of basic information for the formulation of IFMP-SZ in the Rio Negro basin	–
Works Related to Output 1		
(5)	Training to improve the ability to assess flood risk	1-1 Capacity assessment and training on comprehensive utilization of meteorological and hydrological data for flood risk assessment including the satellite image mapping from the perspectives of temporal and spatial resolutions and accuracy. 1-2 Capacity assessment and training on hydrological and hydraulic modelling from rainfall-runoff analysis to flood inundation analysis and mapping technology. 1-3 Capacity assessment and training on flood risk mapping technology using GIS with flood inundation and socio-economic data including vulnerability of structures.
(6)	Training related to the processes necessary to formulate the Basin Management Plan and IFMP	1-4 Training on integrated flood risk management planning and river basin management
Works Related to Output 2		
(7)	Understanding current problems related to hydrological observation and the administration, processing and utilization of and hydrological data	2-1 Capacity assessment and training on hydrological observation. 2-2 Capacity assessment and training on flood forecasting. 2-3 Capacity assessment and training on dissemination of real-time risk information and warning for appropriate response.
(8)	Training on hydrological observation and the administration, processing and utilization of and hydrological data	2-1 Capacity assessment and training on hydrological observation. 2-2 Capacity assessment and training on flood forecasting. 2-3 Capacity assessment and training on dissemination of real-time risk information and warning for appropriate response.
Works Related to Output 3		
(9)	Collection, processing and analysis of basic information of each entity related to the basin management	3-1 Assessment of functions of both central and local governments in activities of river basin management
(10)	Development of coordination and cooperation system	3-2 Recommendation on effective and efficient roles and responsibility of central and local governments on flood risk reduction, using experiences in Japan and other countries. 3-3 Evaluation and recommendation on enhanced institutional functions of flood risk reduction at the final stage of the project

Items in Specification Document		Activity Number in PDM
Works Related to Output 4		
(11)	Support in the formulation of IFMP-RP for the Magdalena River	4-1 Formulation of IFMP for the pilot river basin with considering prevention, mitigation, preparedness and response. Formulation process includes following items.
(12)	Organization of items required for the formulation of IFMP-RP for the Magdalena River and preparation of road map	4-1 Formulation of IFMP for the pilot river basin with considering prevention, mitigation, preparedness and response. Formulation process includes following items.
(13)	Advice for the formulation of IFMP-SZ del Rio Negro	4-1 Formulation of IFMP for the pilot river basin with considering prevention, mitigation, preparedness and response. Formulation process includes following items.
(14)	Organization of items required for the formulation of IFMP-SZ del Rio Negro and preparation of road map	4-1 Formulation of IFMP for the pilot river basin with considering prevention, mitigation, preparedness and response. Formulation process includes following items.
(15)	Preparation of guidelines for the formulation of IFMP-RP and IFMP-SZ	4-2 Preparation of IFMP formulation guideline utilizing lessons from pilot river basin activities.
Works for the Entire Project Period		
(16)	Training in Japan	1-4 Training on integrated flood risk management planning and river basin management
(17)	Preparation of Progress Report	—
(18)	Preparation of Project Brief Note	—
(19)	Monitoring	—
(20)	Preparation of Final Report	—

Notes: 1) SZ is an abbreviation for subzone, which refers to the hydrographic subzone.
2) RP is an abbreviation for principal rivers

Regarding the work schedule for the entire duration of the project, the version prepared at the beginning of the project (in the preparation of the work plan) is presented in Figure 2.2, and the version at the time of the conclusion of the project in Figure 2.3. The implementation period dates refer to the extension or change in the activity period. The monitoring period refers to the changes made as a result of the discussions with JICA on the contents of the activities and the period of activity in Colombia in August 2015 after the start of the project, with respect to the original plan for the carrying it out every 6 months. The JCCs (Joint Coordination Committee) refer to the unforeseen implementation in February 2016 for the approval of the new C/P entity and the subsequent changes in its schedule due to this (basically once a year).

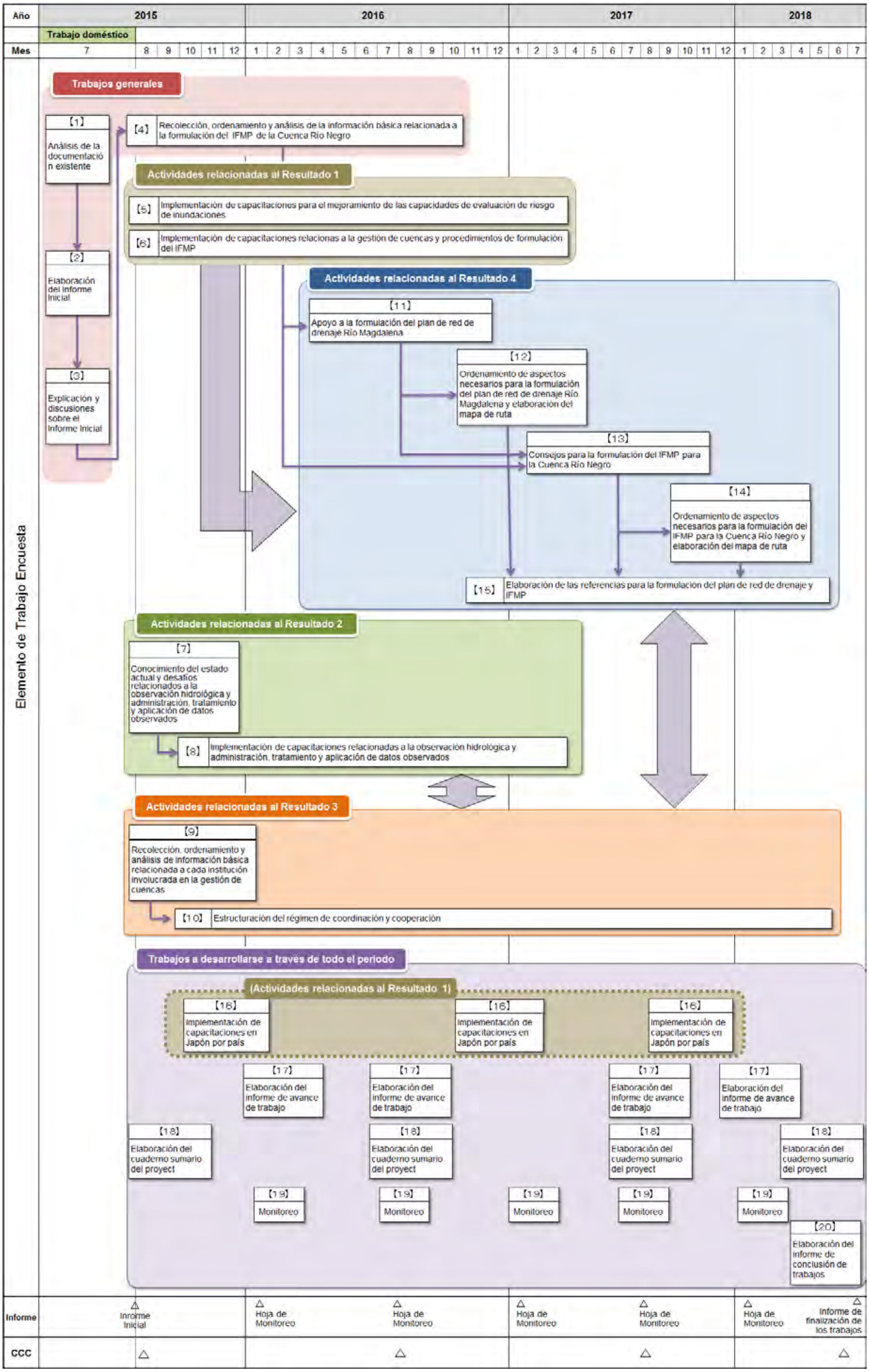


Figure 2.2 Work Schedule (at the Beginning of the Project)

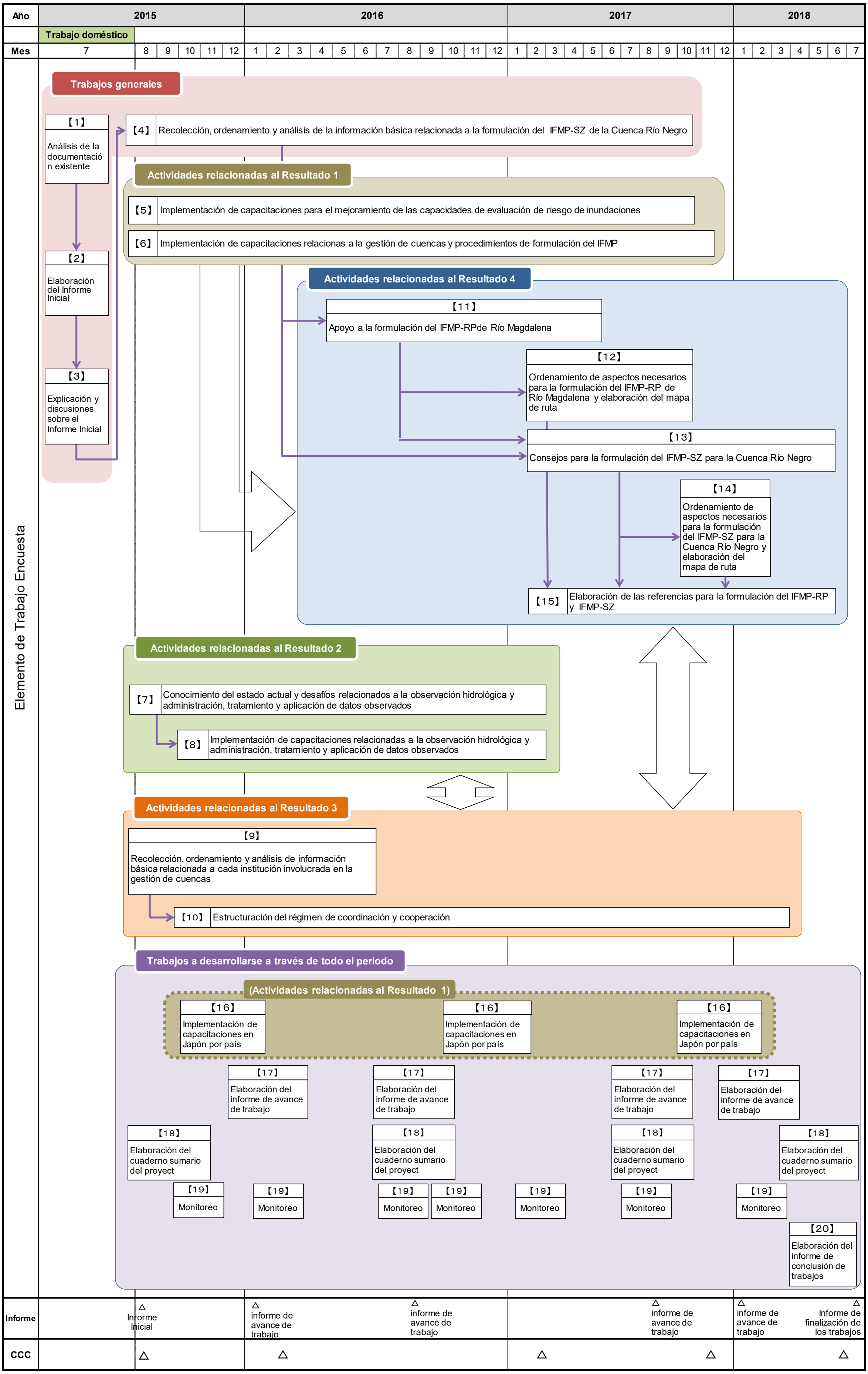


Figure 2.3 Work Schedule (at the end of the Project)

2.1.3.1. Work Related to the Entire Project

(1) Analysis of existing materials: Completed in June 2015.

In order to understand the content of activities in Colombia and important items, studies and analysis of the materials described below were conducted. Based on their results, the items that require confirmation or additional questions from the relevant entities were organized, and a questionnaire was developed to request the provision of materials.

Table 2.7 Analyzed Existing Materials

Category	Items
Project-related materials	• Record of Discussions (R/D) • Minutes of Meetings (M/M) • Detailed Feasibility Report • Data Collection and Confirmation Report of the Disaster Prevention Sector (JICA, 2013)
Materials developed by other donors	• Analysis of Disaster Risk Management in Colombia (World Bank, 2011)
Relevant Colombian laws and decrees	• Decree 4147 of 2011 regarding responsibility of the National Unit for Disaster Risk Management (UNGRD), Law 1523 of 2012 regarding adaptation of the national policy on disaster risk management and establishment of the National System for Disaster Risk Management (SNGRD) • Decree 1640 of 2012 regarding formulation of Watershed Management and Development Plan • Resolution 1907 of 2013 the Ministry of Environment, and Sustainable Development (MADS) regarding technical guideline for formulation Watershed Management and Development Plan (POMCA) • Decree 1807 of 2014 regarding incorporation of risk management in Land Management Plan (POT)

Additionally, satellite rainfall data were purchased in the areas surrounding the of Rio Negro pilot basin, in order to study the possibility of its use in the flood risk management in Colombia. (After starting the activities in Colombia, these data were compared with the observation data, and it was concluded that it does not have enough resolution to be used in the flood analysis in the pilot basin; therefore, they were not used in the concrete analysis.)

(2) Preparation of Inception Report (IC/R): Completed in August 2015.

Considering the studies of (1), information and materials available in Japan were organized, and basic work guidelines, implementation system, road map (methods, processes, accuracy, technique transfer methodology) were studied and elaborated. IC/R that clearly presents the work items for the entire process of the project and distribution of activities.

IC/R was written in the most concrete and detailed way possible as this report shows the structure of the project and because it will be distributed to the relevant Colombian entities. Efforts were made to create content that would allow Colombian entities to clearly imagine the activities and purpose of each result, the relationship between the results, and the roles of each entity.

Parallel to the elaboration of IC/R, presentation materials for the explanation of IC/R were prepared through meetings with relevant entities.

(3) Explanation and description of IC/R: Completed in August 2015.

On July 29, 2015, after the arrival of the expert team in Colombia, an informative meeting on IC/R was held at IDEAM. 15 people from 4 C/P entities, which are the UNGRD, the IDEAM, the CAR and the Department of Cundinamarca, participated. At the meeting, the draft IC/R was distributed and the presentation prepared in (2) was presented in order to present and discuss the basic guidelines of the project, the content of activities, personnel plan, implementation system, processes, target area, road map in Colombia, methodology, facilities that Colombia will provide, distribution of C/P technicians, and activity schedule. After subsequent meetings with each entity and discussions on PDM index, the content of IC/R incorporating the results of these discussions was presented to the members of the first JCC on August 13, with which they agreed. The final version of IC/R after JCC was presented to C /P on August 19.

(4) Collection, classification and analysis of basic information for the formulation of IFMP-SZ in the Rio Negro basin: Completed in October 2017

At the information meeting on IC/R, individual meetings with each entity and JCC, the necessary information was requested for the formulation of IFMP-SZ of the Rio Negro basin through the list of required information (Table 2.8). In Appendix-1, List of Collected Materials, the materials collected so far are presented, including the specific work periods for the study and formulation of the IFMP-SZ.

Table 2.8 Materials to Collect, Organize and Analyze

Category	Item	Target Area/Possible Information Source	
		Rio Negro Basin	Magdalena River Basin
Natural condition of the basin	• River and basin profile • Topography • Geology • Climate, meteorology(in general)	CAR IGAC SGC IDEAM	IDEAM IGAC SGC
Social condition of the basin	• Distribution of the population and settlements in the basin • Land use • Agricultural production（Crop system, production, income, etc.） • Industrial production, economic activities • Condition of transportation infrastructure	CAR Cundinamarca Department （hereinafter "Departament"） Municipalities	DNP IGAC
Hydrological, meteorological data, sediment production, runoff, river bed change	• Rainfall data in the pilot basin and the surrounding areas • Location of level and discharge stations and their data • Meteorological data such as evapotranspiration • Sediment production and runoff • Data on river bed change per section	IDEAM, CAR	IDEAM
River Structures	• Information on river structures (dams, retention and control reservoirs, dykes, bank protection, hydrological structures or water intake, irrigation channels in the target basin) (location, size, administrator, rules of use, etc.)	CAR Department Municipalities	UNGRD, IDEAM （Only great-scale structures）
Past floods	• Past floods (rainfall, discharge) and damages (rupture of dams, flood areas, flood depth, etc.) • Flood marks and past flood damage situations	CAR Department Municipalities	UNGRD, IDEAM
Plan of measures against floods and current situation	• Measures against floods carried out by Colombia or by other donors (structural and non-structural measures), their current plans and situations	UNGRD, IDEAM MADS CAR Department Municipalities	UNGRD, IDEAM MADS
Decrees and organizations related to basin management	• Laws, policies, development plans related to disaster measures and basin management in Colombia => Confirm the compatibility with the project and the goal, position, feasibility and priority thereof.	UNGRD, IDEAM MADS CAR Department Municipalities	UNGRD, IDEAM MADS
Confirmation of situation of support by other donors	• Support in the process of implementation or with implementation plans by other donors (including the existence of funds or other support system)	UNGRD, IDEAM MADS CAR Department	UNGRD, IDEAM MADS

2.1.3.2. Work Related to Output 1: "Capacity on flood risk assessment is improved and concept of integrated flood management planning and river basin management is introduced"

The activities related to Output 1 are shown in (5) and (6), which will be the basis for the activities to be implemented related to Output 4. Therefore, for Output 1, concrete and practical activities were carried out in order to use them effectively for Output 4

(5) Training to improve the ability to assess flood risk: Completed in October 2017

In this item, the necessary training was carried out to improve capacity for risk assessment of floods. The training items and records are presented in Tables 2.9 and 2.12.

Except for one initially planned training item, all the items were dealt with in the conferences or discussions in the workshops.

Table 2.9 Items, Target Participants and Implementation Method for the Improvement of Flood Risk Assessment Capacities

Item	Workshop Contents and Methodology	Remarks
① Integral use of meteorological and hydrological information for flood risk assessment	1) Understand the flood phenomenon based on existing materials • Where in the basin do the floods occur? • Level data at the moment? (to suppose what happened upstream) • Rainfall data at the moment? (difference in time at which floods occurred, volume) 2) River topography • Characteristics of the channel where floods occur (eg. By geology or is it an alluvial river?) 3) Selection of meteorological and hydrological information according to characteristics of the type of flood for the evaluation of risk in the future, discussion on the appropriate hydrological model	
② Use of hydrological and hydraulic modeling technology and mapping from rainfall run-off to floods	• Development of a hydrological analysis model • Development of a hydraulic model • Mapping calculation results (flood area) • Transfer and use of radar data (in case the radars are installed in 2016 as planned) →	It was not carried out due to the delay in the acquisition and introduction of radars by IDEAM. Currently (June 2018), two of the 3 radars that are planned to be installed have already been installed, and are being configured. It is planned to start the operation in August
③ Use of technology for risk mapping and risk assessment using GIS including flood conditions and information on socioeconomic conditions such as vulnerability of infrastructure to be protected	• Preparation of flood risk map with GIS • Flood risk assessment with GIS	

Activities carried out for this item are shown below.

1) Baseline survey (Output 1, 2, 3, 4)

After the visit in July 2015 before the trainings, a C/P baseline survey was carried out, which will be direct targets of the trainings, and a summary of the current situation in Colombia related to Output 1 was prepared. The results of the baseline survey are found in Appendix-3. These results were used to review the PDM evaluation indicators and were reflected in the PDM approved in the first JCC carried out in August 2015.

The main challenges related to Output 1, which were identified through the baseline survey and activities during the first year of the project, can be organized in Table 2.10. For Output 1, activities of items (5) and (6) were carried out, using the following methods to solve the problems.

Table 2.10 Main Challenges related to Output 1 and Approach to Challenges

Main Challenges	Analysis on Challenges	Approach to Challenges
How to organize the system of past disaster data and hydrological data with sufficient level for the appropriate risk assessment	The existing data of past disasters do not contain clear dates of occurrence, degree of damage and flood area. Most hydrological data is only recorded daily. The basic data is not organized enough, and this aspect should be improved.	<Explanation and practice in the workshops> The expert team would explain the methods to organize and use the data. Practice the analysis processes using real data, and study the points that need improvement and the methods to achieve this.
How to evaluate the flood hazard with better precision and with a hydrological-hydraulic methodology	Many of the existing materials related to the flood hazard have been developed based on a qualitative assessment of past floods and from geological and geomorphological points of view. The existing model of the middle course of the Magdalena River is relatively inaccurate due to the lack of hydrological data. The topographic data are not of good quality either, so the accuracy of the hazard assessment is not sufficient. It is necessary to increase the accuracy.	<Explanation and practice in the workshops> The expert team would explain the methods to organize the data. Carry out the analysis with existing data, understand the limitations in the analysis due to the limitations of the data, and study the points that require improvement and the methods to achieve this. Perform new analysis with satellite data, compare the result with the result of the analysis with existing data, and study methods to improve accuracy. Understand the method for the field survey and the use of the data obtained from this survey to improve the accuracy of the analysis.
How to introduce the concept and methodology of the formulation of measures based on the quantification of flood risk and risk assessment results	As of the moment, there is no defined methodology for handling items that are difficult to quantify such as social, cultural and environmental conditions in the evaluation of the vulnerability necessary for risk assessment. The methodology for projection and quantification (the projected number of people affected, the cost) of the damage caused directly or indirectly by the flood has not been defined. Currently, the formulation of structural and non-structural measures using the results of the risk assessment is not very frequent. Ideas and methodologies related to the appropriate assessment of flood risk and the formulation of measures based on it will hopefully be studied.	<Explanation and practice in the workshops> The expert team presents the Japanese methodology for risk assessment. Use the Japanese methodology and evaluate the risks to understand the methodology. Discuss the applicability of the methodology in Colombia.

How to introduce the formulation and evaluation of the plan from the point of view of the integrated flood risk management and river engineering	Although the flood measures implemented in the past are expected to have some effectiveness, the justification of the plan from the point of view of river engineering or the quantitative evaluation of the impact of the measure is not clear. There is no practice of studying local flood problems through the analysis of the entire basin or the longitudinal analysis of the river based on river engineering. Concepts of integrated flood risk management, formulation and evaluation of the plan from the point of view of river engineering are expected to be presented in order to adopt these practices appropriately later.	<Explanation and practice in the workshops> The expert team explains the principles of integral flood risk management and the methods to formulate and evaluate the plan from the point of view of river engineering. Conduct joint field studies to deepen the river's engineering point of view. Study Colombian rivers to contemplate the method of application. <Understanding through training in Japan> Understand the Japanese examples of the formulation of plans, including the contexts and the real measures, to study the method of application in Colombia.

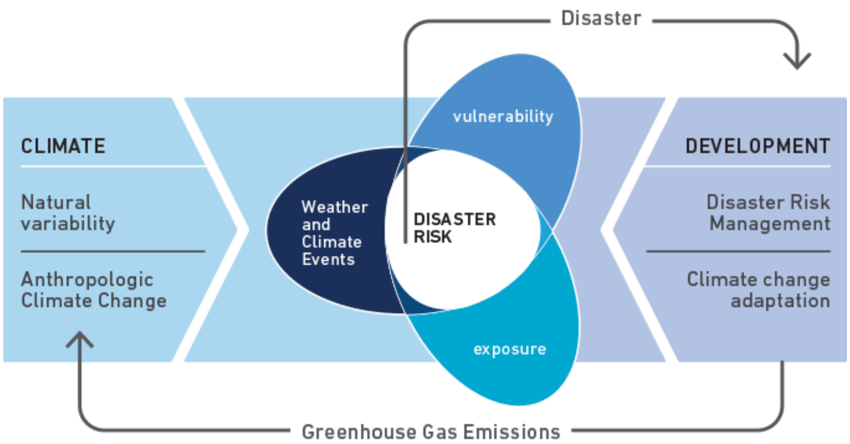
The following table summarizes the hazards, exposure, vulnerability, risk definition and their relationships from the previous table.

Table 2.11 Definitions Related to Risk

Term	Definition
Hazard	A dangerous phenomenon, substance, human activity or condition that may cause loss of life, injury or other health impacts, property damage, loss of livelihoods and services, social and economic disruption, or environmental damage.
Exposure	People, property, systems, or other elements present in hazard zones that are thereby subject to potential losses.
Vulnerability	The characteristics and circumstances of a community, system or asset that make it susceptible to the damaging effects of a hazard.
Risk	The combination of the probability of an event and its negative consequences.

Reference: Terminology of Disaster Risk Reduction, United Nations, UNISDR, 2009

According to the 5th IPCC report, the risk of the impact of climate change is generated by the interaction between the "external force of disasters" of climate change and "vulnerability (lack of response capacity" and "exposure" (existence of residents and goods in the affected places "that the society possesses to the impact of climate change, as shown in the following figure. It is considered necessary to reduce vulnerability and exposure to adapt.



Reference: 5th Report of the IPCC

Figure 2.4 Climate Change Risk Concept

2) Definition of the items to be determined and the basic guidelines related to this at the beginning of the project

After a baseline survey and discussions with C/P, before November 2015, the following basic guidelines and the items to be defined at the beginning of the project were determined..

A. Software to use (purchase) for development of flood analysis and development of model for warnings and alerts

Initially MIKE series (MIKE11, MIKE SHE) of DHI and the HEC series (HMS, RAS) of USACE (Corps of Engineers of the US Army) or IFAS of ICHARM were to be used for the construction of models. However, after the discussions with C/P, it was decided the HEC series would be used, since it is frequently used by C/P entities, it is free, and therefore it would easy to use in the process of replicating the exercise in other basins in the future.

iRIC the software developed by the University of Hokkaido and USGS, will also be used as needed, since the use of this software can expand the methods of analysis and comparison and it is also a free software, like the HEC series.

B. Topographic data to be used in model development

As a result of the baseline survey, it was confirmed that the current existing topographic data do not have sufficient resolution or present a large difference in resolution from region to region (there is a 1:10,000 scale map; however it is not for all the national territory). It was decided satellite data would be used also to study the possibility of its future use in Colombia. Specifically, the WorldDEM was selected, which has an accuracy with a margin of error of less than 4m in a 12m pixel (purchased in December 2015 for the Rio Negro pilot basin). The existing cross sections of the river and data obtained in the topographic surveys by C/P will also be used.

Additionally, 3D standard topographic data of AW3D, which are DTM data with a 5m pixel, was purchased for the area around the main channel of Rio Negro and the main tributaries. This is to improve the accuracy of the model and to study the possibility of its use in Colombia, since surface altitude data with 5m pixel based on satellite data had been developed for greater areas in Colombia by July 2017, at a price similar to that of WorldDEM (purchased in August 2017).

C. GIS software to use (purchase) for risk assessment and mapping

ArcGIS from ESRI (American) (Purchased in February 2016) or Q-GIS from a volunteer development group was to be used. However, after the discussions with C/P, it was decided ArcGIS would be used, since it is frequently used by the C/P entities and the workers are highly proficient with this software.

3) Conferences, discussions and exercises in the workshops

Within the trainings for (6), the trainings for this item are specifically to the technological elements necessary for each step in the formulation of IFMP, such as a method for the effective use of information to understand the characteristics of floods and the channel, and the use of GIS software for hydrological and hydraulic modeling and risk assessment.

Between October and November 2015, the content of the training for this item and its explanation were mainly studied. In the activities from February 2016 to the present, the technical significance and content of each item, such as the organization of the characteristics of the river, the development of the model and the preparation of the risk map, were explained in detail in the workshops held. C/P deepened their knowledge on the methodology through productive discussions on the current situation of relevant information in Colombia and specific exercises in the workshops. In Table 2.12, the list of workshops carried out for this item is presented. (Note: there are cases in which the contents of the workshops are related to several items and the items are repeated in the lists of other items. In these cases, the items in common in the table are shown) (The list of all the workshops, including the workshops for this item, and meetings held during the project period and list of participants, is attached in Appendix-2.)

As presented in Table 2.9, workshops on the introduction and use of radar data had initially been planned. However, this was not possible due to the fact that the radars had not been installed yet as of July 2017. According to IDEAM officials, the possibility of completing the installation during the project period is low; therefore, the workshops on this topic were cancelled. However, the expert team presented the characteristics of meteorological radars used in Japan, the history of use and the use of data in the workshop held on July 26, 2017, in order to contribute to the Colombian effort to introduce and use the radar data.

Additionally, as one of the activities to improve the flood risk assessment capacity, a seminar was held in order for the participants to learn the method of hydraulic analysis, flood analysis, sediment transport analysis as well as the use of software (iRIC) to perform these analyzes. The seminar was held in the computer room in the National University of Colombia for 4 days, from October 17 to October 20, 2017. Professor Shimizu, professor at the University of Hokkaido, associate professor Takebayashi of the University of Kyoto, and the specialist Baba served as instructors. A total of 30 people participated, twenty from C/P entities and relevant organizations, along with 10 academics (professors, assistant professors and students). JICA was the main organizer of the seminar (who provided the instructors and materials) with the support of the Water Resources Engineering Research Group (GiReH), (who provided the venue and the equipment). Out of the 30 participants, 22 people participated for all four days (14 of which come from C/P and relevant organizations), and 5 people participated for three days (4 of which come from C/P and relevant organizations); the participation was active in general, and in the Q&A session, productive discussions were held. Throughout the seminar, the participants' comprehension of the method of analysis and the proficiency in the software are considered to have deepened, this is expected to be of great help for the same type of analysis in Colombia in the future.

Table 2.12 Workshops Related to Work Item (5) of Output 1

Date	Contents
October 19-20, 2015	Joint field survey (also found in Work Item (6)) (Main Magdalena River, areas affected by floods in the Rio Negro Basin, hydrological stations)
November 12, 2015	Measures against sediment disasters in Japan and concept of sediment balance, which is important for the plan (also found in Work Item (6))
February 10, 2016	Joint field survey (also found in Work Item (6) & (8)) (Interviews about flood damage and responses, as well as measures after the flood in Pacho, located within the Rio Negro basin)
February 19, 2016	Introduction of the Japanese flood risk assessment methodology and discussion on the application in Colombia
February 29, 2016	Introduction of the details of the Japanese flood risk assessment methodology and economic studies related to water governance, discussion on the application in Colombia
March 9, 2016	Introduction of Japanese methodology for flood risk assessment and example of application of economic studies of water governance in Colombia, discussion on the application
May 4, 2016	"Proposal for a manual for the formulation of the river plan", characteristics of flood damage in the Magdalena River (also found in Work Item (6) & (11))
May 11, 2016	Characteristics of flood damage in the Magdalena River and the Rio Negro basin (also found in Work Item (6) & (11))
May 19-20, 2016	Joint field survey (Quebrada Negra) (also found in Work Item (6))
July 15, 2016	Reflections on the accumulation of sediments observed in a field study in Quebrada Negra carried out in May (also found in Work Item (6))
July 22, 2016	Discussion on the flood process in 2010 in the Magdalena River and discussion on the retention capacity of floodplains (also found in Work Item (6) & (11))
July 28, 2016	Introduction of the flood hazard map process in Japan
October 31, 2016	Introduction and discussion on the data needed for risk assessment
November 9, 2016	Introduction of the flood risk assessment methodology and the processes in this project and discussion on the necessary data collection (also found in Work Item (6))
July 26, 2017	Introduction of meteorological radar characteristics used in Japan, history of use and use of data
October 17-20, 2017	Seminar on the simulation of flood analysis and analysis of sediment transport with the use of analysis software (iRIC)

Joint Field Survey

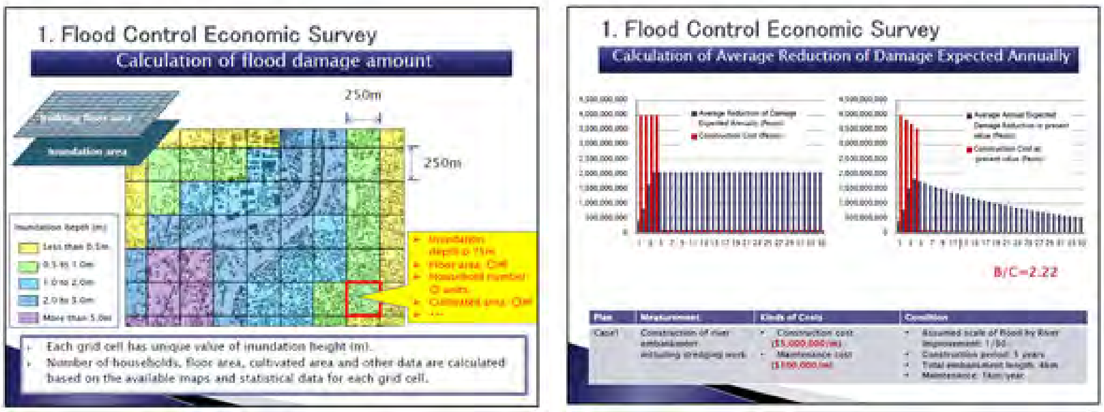


Figure 2.5 Introduction of the Example and Analysis of the Flood Control Economics Survey

<Analysis of the Activity Result>

Knowledge of C/P was deepened through lectures and numerous discussions in workshops on the items initially proposed, especially the concept and methodology on understanding of channel characteristics and floods, hydrological and hydraulic modeling, and flood risk assessment (economic evaluation). As a result, regarding the characteristics of the river channels and the characteristics of the floods, topographic survey by C/P was promoted to collect basic data, field surveys after the floods and the implementation of interviews. In hydrology and hydraulic modeling, the use of the results of the field survey for the construction and calibration of the hydraulic model was highly recognized. With respect to the method of economic evaluation of flood control, it was recognized that it is very useful, although it is a method that has not been used in Colombia, and the incorporation of this in various guides, etc. is beginning to be considered.

After the completion of the activities related to this item, within the framework of Output 4, activities were continued in order to improve the flood risk assessment capacity, including the use of hydrological information, hydrological and hydrological modeling, mapping and the risk assessment among others. C/P continued putting into practice the contents of the training already carried out related to specific activities for the formulation of the plan for the pilot basin area from Output 4 and deepening knowledge.

(6) Training related to the formulation processes of the Basin Management Plan and IFMP: Completed in November 2017

Training on to the formulation of the river plan necessary to understand the steps of formulation of the IFMP and river plan was carried out mainly for C/P and other personnel of relevant entities. In the workshops held between October 2015 and March 2016, the methods of study of the concepts, steps, and important items for the formulation of the river or basin management plan were explained, in the form of lectures using the presentation materials with examples in Japan and information about the Magdalena River and Rio Negro. Additionally, the Japanese methodologies for formulating the plan were presented, and discussions were held on how and what parts of the Japanese methodology can be incorporated in Colombia where the size of the rivers is different.

In the workshops held between April and August in 2016, the type of conference held by the experts was changed; the methodologies were first explained within the "Proposal for a Manual for the Formulation of the River Plan" prepared by the expert team, and then C/P conducted specific exercises. Joint field surveys were also carried out, in which C/P and the expert team visited the river in order for the participants to observe the process of understanding its characteristics as well as the point of view and knowledge of the flood mechanism. In the workshop on May 11, 2016, the team of experts explained the River Law, in the context of Japanese laws related to the river administration and flood management, since C/P expressed interest on the subject during training in Japan. The explanation was given by specialist Baba, along with the explanation on the law of measures against flood damage of the river in special cities. The specialist Baba participated in the workshops held on May 4, 11 and 17, 2016, and gave advice from the administrative point of view. Table 2.13 is a list of workshops held for this item (. In addition to the workshops shown in the Table 2.13, the lessons on flood management and river management in Japan presented in training courses held in Japan related to the item (16) are important elements for this item.


Workshops for Output 1

Table 2.13 Workshops Related to Work Item (6) of Output 1

Date	Contents
October 19-20, 2015	Joint field survey (also found in Work Item (5)) (Main Magdalena River, areas affected by floods in the Rio Negro Basin, hydrological stations)
October 23, 2015	River management plan in Japan, relevant entities in the Magdalena River (also found in Work Item (10))
November 3, 2015	Steps for the formulation of the river plan for the Magdalena River and the Rio Negro basin, role sharing among relevant entities
November 5, 2015	Joint field survey (Interviews about measures after the flood in Villeta, located within the Rio Negro basin)
November 10, 2015	Role sharing among relevant entities (also found in Work Item (10))
November 12, 2015	Measures against sediment disasters in Japan and concept of sediment balance, which is important for the plan (also found in Work Item (5))
February 10, 2016	Joint field survey (also found in Work Item (5) & (8)) (Interviews about flood damage and responses, as well as measures after the flood in Pacho, located within the Rio Negro basin)
February 16, 2016	Introduction on training in Japan, discussion on the role sharing for the relevant entities (the Magdalena River) (also found in Work Item (10))
March 2, 2016	Discussion on the role sharing among relevant entities (Magdalena River and the Rio Negro basins) (also found in Work Item (10))
May 4, 2016	"Proposal for a manual for the formulation of the river plan", characteristics of flood damage in the Magdalena River (also found in Work Item (5) & (11))
May 11, 2016	Characteristics of flood damage in the Magdalena River and the Rio Negro basin (also found in Work Item (5) & (11))

May 17, 2016	Formulation of the river plan for the Magdalena River and the Rio Negro basin, the response to disasters in Útica in April 2011 (also found in Work Item (11))
May 19-20, 2016	Joint field survey (Quebrada Negra) (also found in Work Item (5))
July 15, 2016	Reflections on the accumulation of sediments observed in a field study in Quebrada Negra carried out in May (also found in Work Item (11))
July 19, 2016	Joint field survey (also found in Work Item (8) & (11)) Interviews with disaster prevention entities in Barrancabermeja and Puerto Wilches and observation of the Magdalena River between these two points
July 22, 2016	Reflection on the river environment observed in the field survey on the Magdalena River on July 19 (also found in Work Item (11)) Discussion on the flood process in 2010 in the Magdalena River and discussion on the retention capacity of floodplains (also found in Work Item (5) & (11))
July 28, 2016	Introduction of past disasters data base in the Rio Negro basin, study of the flood volume in the Magdalena River (also found in Work Item (11))
November 9, 2016	Introduction of the flood risk assessment methodology and the processes in this project and discussion on the necessary data collection (also found in Work Item (5))
February 10, 2017	Introduction of the knowledge acquired in training in Japan

<Analysis of the Activity Result>

C/P has deepened the knowledge on the steps to formulate the basin plan, IFMP and the river plan through the activities carried out such as conferences and specific exercises in the workshops. Especially the understanding of the fact that currently in Colombia the role sharing or the system to formulate a flood plan and implement it is not clear. Active discussion on the solution of this problem began.

After the completion of the activities related to this item, C/P continued to deepen the understanding, putting into practice what was learned in the trainings during the formulation of the IFMP.

Apart from the activities described above, training was held in Japan in order for the members to deepen their knowledge about the integrated flood risk management plan and the specific theories and practices related to basin management. The details of these trainings will be presented in Numeral (16). 24 people in total from the entities of C/P and relevant entities at national level travelled in 3 series of trainings to learn the real situation of the flood management and the river administration in Japan.

2.1.3.3. Works Related to Output 2: "Capacity is strengthened in flood forecasting, warning and dissemination of information to relevant organizations"

(7) Understanding current problems related to hydrological observation and the administration, processing and utilization of and hydrological data: completed in February 2017

In order to improve the capacities for flood forecasting and warning as well as communication of information in Colombia, current information on hydrological observation and the administration, processing and use of this data was collected and organized. Since the visit in July 2015, current situation was confirmed through interviews and the request of current data with C/P entities, especially IDEAM. The results confirmed before August 2015 were organized as a result of the baseline survey, and were also used for the review of PDM evaluation indicators in August 2015. Since it had still not been possible to confirm all the entirety of the current situation due to lack of time as of August 2015, it was decided the confirmation and discussion of individual detailed situation would be continued in parallel to the activities of (8).

Important issues related to this result can be organized in the current context of Colombia as follows.

The main challenges related to Output 2, which were identified through the baseline survey and activities during the first year of the project, can be organized in Table 2.14. For Output 2, item (8) activities were carried out, using the following methods to solve the problems.

Table 2.14 Main Challenges related to Output 2 and Approach to Challenges

Main Challenges	Analysis on Challenges	Approach to Challenges
How to use the data and information held by the IDEAM and the CAR for specific evacuation activities	In the Rio Negro basin, the number of level stations and the frequency of observation are not sufficient, and it is feared that they will not be able to provide the warning information with sufficient precision that would contribute to the evacuation. IDEAM plans to install meteorological radars, and in the future it is expected to improve the accuracy of the warning using rainfall data. It is hoped that the method to use the information in an effective manner for the evacuation will be studied in the context in which the usable information is limited.	<Study in the workshops> Confirm the type and content of the usable information, and discuss and study the method and the possibility to use this information for evacuation. Discuss and study the steps to follow to improve the observation system that contributes to the improvement of the forecast and warning as well as the evacuation.
How to develop early flood warning activities based on good examples at the municipal level	Colombia is under a decentralization process, and sometimes a notable difference in the effort and progress in the measures against flooding is observed among the municipalities. Some municipalities seem to have good examples related to the early flood warning, either through their own efforts or with the support of the entities at the national level. Therefore, good examples of the early warning flood at the municipal level should be selected to be replicated in other municipalities, in order to improve the overall quality of the flood warning system at the municipal level.	<Confirmation, information sharing and study in the workshops> Observe the municipalities that implement early warning activities that are good examples, disclose the content of these activities, and discuss and study the possibility of replicating the system in other municipalities.
How to build and implement flood early warning with coordination among municipalities within the basin	The early flood warning system in Rio Negro basin mainly consists of the person in charge of the municipality observing the increase in level personally and initiating the activities for the evacuation. However, considering the assurance of the lead time for the evacuation, it is necessary to study how to build the forecast system and early flood warning not only in each municipality but also by basin.	<Replication study in the workshops> Discuss and study what type of flood early warning system can be built at the basin level, including the study of the flood wave propagation velocity. Study the method of construction of this system and replication in other basins.

(8) Training on hydrological observation and the administration, processing and utilization of and hydrological data

Workshops described below on the hydrological observation as well as administration, processing and use of this data were carried out with a focus on the use of hydrological data and effective communication of information for flood forecasting and warning.

Table 2.15 Workshops Related to Work Item (8) of Output 2

Date	Contents
February 10, 2016	Joint field survey (also found in Work Item (5) & (6)) (Interviews about flood damage and responses, as well as measures after the flood in Pacho, located within the Rio Negro basin)
February 16, 2016	Introduction of the Japanese Flood Forecast and Warning System and discussion on the application in Colombia.
February 25, 2016	Joint field survey (Observation of a good example of flood forecasting and warning system in Colombia (Soacha, Cundinamarca))
March 9, 2016	Introduction of a good example of flood forecasting and warning and discussion on application and development
July 15, 2016	Discussion on early warning system with focus on upstream-downstream coordination in the Rio Negro basin
July 19, 2016	Joint field survey (also found in Work Item (6) & (11)) (Interviews with disaster prevention entities in Barrancabermeja and Puerto Wilches and observation of the Magdalena River between these two points)
July 22, 2016	Discussion on forecasting and flood warning and evacuation in the Magdalena River, based on the interviews from the field survey on July 19 (also found in Work Item (11))
July 28, 2016	Presentation on the current situation related to the early warning between Utica and Quebrada Negra, and evacuation
August 3, 2016	Discussion on future guidelines related to collaboration between upstream and downstream municipalities for early warning in the Rio Negro basin
February 17, 2017	Workshop carried out jointly by the Government and the project team on the early warning system for collaboration between the municipalities in the Rio Negro basin, with the participation of the representatives of the municipalities in the basin.

Within the activities carried out for this item, a conference was held on the use of hydrological data in the process of formulating the river plan within the activities for Output 1. In order to consider an appropriate forecast and warning system for floods for situations in Colombia, along with the study of the current situation of forecasting and warning activities during the floods in several municipalities in the Rio Negro basin, discussions were held in the workshops between February and March 2016 on the ideal system in Colombia taking into account the introduction and explanation by the experts on the methodology to define the flood forecasting and warning system and the parameters for forecasting and warning in Japan. A field survey was carried out in Soacha, Cundinamarca, where there is a good example of hydrological observation and flood forecast and warning, in order to use it for flood forecasting and warning at the municipal level in Colombia. In the workshops held in July and August 2016, a discussion on early warning with focus on upstream-downstream coordination within the basin was conducted, while confirming the current system of municipalities within the Rio Negro basin. In this period, the topic of the Magdalena River flood forecasting and warning system and evacuation was also discussed, taking into account the results of the field survey.

Especially, for the early warning of the main river of Rio Negro, an analysis was also carried out as shown in the Figure 2.6 below, and discussions were carried out based on them. In the main river of Rio Negro, the high water level propagates in half a day or a day from upstream to downstream, resulting in an increase in water level from a normal level to the flood level in a matter of hours. However, the warning by IDEAM is only issued 2 or 3 times a day. Given this context, in the workshops the expert team and C/P recognized the importance of communication between municipalities upstream and downstream to ensure the lead time for response to disaster and evacuation.

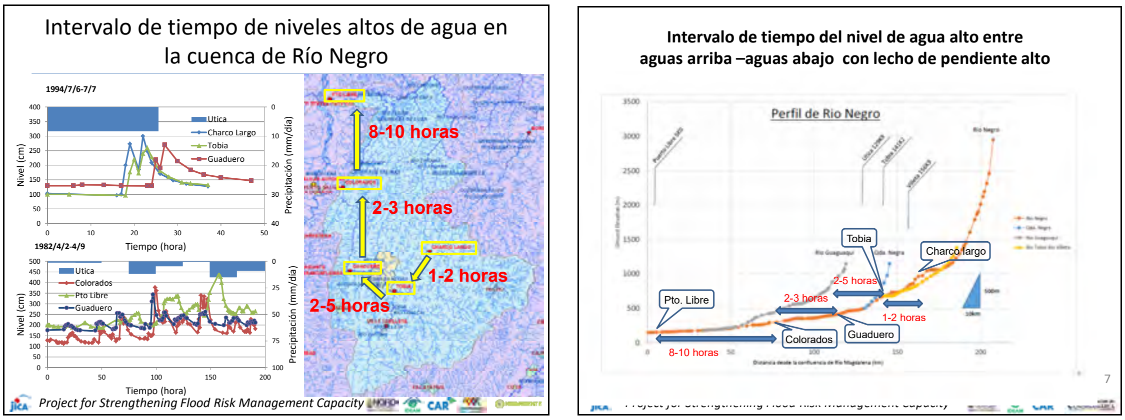


Figure 2.6 Analysis of the Velocity of Flood Wave Propagation

Although IDEAM and CAR are organizing rainfall and level stations for flood forecast and warning in the Rio Negro basin, the temporal and spatial resolution is still not enough. Also, through the discussions in the workshops and interviews in the places that experienced flood damage, it was confirmed that there is a worrying possibility of not being able to guarantee sufficient lead time for the evacuation since the main methodology of the forecast and warning operation currently is the local response in each municipality (risk recognition by level observation per official in charge).

Given the above, an "Early Warning Workshop for the Municipalities of the Rio Negro basin" was held in the municipality of Guaduas in the Rio Negro basin, under the leadership of the Department of Cundinamarca, with support from CAR and UNGRD, on February 17, 2017. This workshop involved 11 of the 24 municipalities within the part of the Rio Negro basin located in Cundinamarca, including mayors, planning officials or risk managers and firefighters. The expert team presented the result of the analysis of the propagation of the flood wave and the lead time, the Cundinamarca Department presented the summary of the early warning system for the community, and CAR explained the collaboration within the basin for the update of POMCA. Participants reacted positively, expressing they are willing to take immediate actions based on the results of the analysis of the expert team and the ideas for collaboration. Not only C/P but also the relevant municipalities recognized the importance of collaboration between municipalities upstream and downstream before the occurrence of flood.

“Early Warning Workshop for the Municipalities of the Rio Negro basin” in the municipality of Guaduas

<Analysis of the Activity Result>

Through lectures, discussions and concrete works in the workshops, C/P has clearly deepened the understanding of the study of the effective early warning system that uses the hydrological data and the characteristics of the river, in a concrete and practical manner. Especially, the workshop for the study of the forecasting and early warning that was carried out under the leadership of C/ P inviting the municipalities within the basin is considered a great progress.

After the completion of the activities related to Output 2, knowledge was further deepened through the study of the forecast and the flood warning and the concrete operation for the communication of information.

Additionally, C/P recognizes the need to carry out a workshop similar to the one carried out in the municipality of Guaduas to construct and implement the system studied in this plan. It is expected to be carried out under the leadership of the Cundinamarca Department and CAR and with the support of other C/P entities.

In Appendix-4, the Recommendations for early flood warning for Colombia are attached, taking into account the knowledge acquired through the activities for Output 2.

2.1.3.4. Works Related to Output 3: "Roles and responsibilities of the central and local government are clarified and strengthened for the reduction of flood risk"

(9) Collection, processing and analysis of basic information of each entity related to the basin management

Regarding the Colombian situation related to basin management, the basic information related to basic management that each entity has was organized. The jurisdiction related to the flood risk management of the C/P entities (the 4 initial entities) was organized based on the results of the study of the existing texts.

Table 2.16 Jurisdiction Related to Flood Risk Management of C/P Entities

Entity	Jurisdiction related to flood risk management
UNGRD	In 2012, Law 1523 came into effect, and UNGRD became responsible for implementing a new disaster prevention policy, the implementation of the National Disaster Risk Management System (SNGRD), the coordination of the interested parties, and the development of technical capacity, etc. It is a member of the councils and committees of the SNGRD and serves as the permanent secretariat with the responsibility of implementing the disaster prevention policy of the country. Regarding flood risk management, it plays a role in the issuance and dissemination of flood warnings, but does not have a legal obligation. It has departments that have relevant technical capacities related to the responsibilities of MADS, IDEAM, CAR that have legal responsibilities.
IDEAM	It is the only public institution covering all of Colombia in terms of hydrological meteorological observation, forecasts and alerts, and is related research, etc. It plays a very important role in the sustainable environmental development of the national development plan and the implementation of the disaster prevention strategy. Specifically, it conducts high-precision hydrometeorological surveys and observations, provides effective hydrological meteorological information/data for risk management and early warning systems, and is an organization that works hard to manage disaster risk, including disaster prevention, disaster reduction, adaptation to climate change, etc.

CAR	It is an organization responsible for the management of water resources and the management of basins based on environmental policies. Of the four regional autonomous corporations operating in the provinces of Cundinamarca, which is the target department of this technical cooperation, CAR is responsible for the management of the Rio Negro pilot basin and the formulation of POMCA. Besides being obliged to formulate POMCA, it is obliged to support the formulation of the municipal plan for which municipalities are responsible such as POT, and in particular, technical support in the risk assessment part of the municipal plan. In addition, in restoration and reconstruction after the disaster, it is responsible for the design and management of the construction.
Cundinamarca Department	Develops and implements a disaster risk management plan at the departmental level, and also collects disaster information. With regard to floods, it is responsible for communicating hydrological information to the municipalities, and it communicates disseminates the meteorological hydrological reports received from the IDEAM and the CAR and the flood warnings from the IDEAM to relevant municipalities. In addition, along with regional autonomous corporations, it also supports municipalities to develop municipal plans.

As for the entities that are not part of C/P and that collect a considerable amount of information, interviews were conducted with a questionnaire prepared in (1) between July and August 2015, shortly after the start of the project. Table 2.17 presents the entities interviewed.

Table 2.17 Entities Interviewed and Information of Interest to Collect

Entity	Information of Interest to Collect
• Geographic Institute Agustin Codazzi : IGAC • Ministry of Environment and Sustainable Development : MADS • Colombian Geological Service: SGC • Ministry of Housing, City and Territory：MVCT	• Organization chart • Budget • Role sharing related to basin management and flood risk • Relevant laws and decrees

The information obtained through the interviews with each entity is presented in Table 2.18. As a result of this study, involvement of the Ministry of Environment and Sustainable Development in the activities was determined to be necessary as it is an important entity from the point of view of basin management and flood control. It was decided other entities would be called up on for support in the provision of data as necessary.

Table 2.18 Information Collected in the Interviews

Entity	Information
Geographic Institute Agustin Codazzi : IGAC	• Organization: IGAC is part of DANE, and is responsible for collecting, accumulating and publishing geographical knowledge. There are 23 regional offices, and it has more than 4000 officials, including geologists and civil engineers. • Budget: 2015 budget was 2900,000,000 pesos. • Responsibility in basin management and flood risk management: collecting geographic information used in the management of rivers and basins as well as flood risk management (public topographic survey, georeferencing system management, work related to GIS update), and formulate sediment disaster hazard maps, according to law 1523. Emergency response in case of disaster upon request by UNGRD. • Related decree: 1440 of 1935, etc.
Ministry of Environment and Sustainable Development : MADS	• MADS prepared the guidelines for the incorporation of risk management in POMCA in 2013. • An important role of MADS is environmental management, and it also delimits areas for environmental conservation. Although the main purpose is environmental conservation, the area can also be considered from the point of view of disaster prevention. The result of the conservation area study is part of POMCA and POT. • The role of MADS in flood risk management is the formulation of policy. It is important to incorporate the concept of risk management into environmental management, and it wishes to create standards for risk management. • The strategic plan for 5 watersheds including Magdalena-Cauca is currently being drafted, and coordination and agreement between the sectors in the study of the policy are the important responsibility of MADS.
Colombian Geological Service: SGC	• SGC develops methodologies for zoning influenced by fenomenos related to sediment movements (ZAMM) • Hazard assessment of "flood that includes sediments produced by landslide or collapse of a slope" is considered to be the responsibility of the entity • The risk assessment is also the responsibility of the entity, although currently the entity is not large enough for it. • Probably will work jointly with the Department or the municipalities in the study related to the sediments if they request the collaboration to SGC.
Ministry of Housing, City and Territory：MVCT	• MVCT conducts the revision of 354 POT, a document that is prepared in all the municipalities of the country. • Residents suffer from flood damage in the rainy season since in the last 25 years people have begun to live in areas where they previously did not live due to the increase in population. • SGC is responsible for the evaluation of the hazard of sediment movements and earthquakes, while IDEAM and UNGRD carry it out together for the flood. In Colombia, in 2014 Law 1807 established guidelines for hazard assessment. However, currently the municipalities have little capacity to perform the risk assessment. • It is necessary to project the damages in the whole basin for the measures against the flood; however, the POT is designed in each municipality. Currently, studies are not conducted outside the jurisdiction of each municipality, and the hazard assessment is possibly not being carried out properly.

Individual meetings were held with each of the relevant entities identified through the discussions for (10) (CORMAGDALENA, CIRMAG, DNP) as needed to collect and organize information. Table 2.19 presents the responsibilities related to the flood risk management of each entity.

Table 2.19 Responsibilities Related to the Flood Risk Management of Each Relevant Entity

Entity	Responsibilities related to flood risk management
CORMAGDALENA	As an organization that reports directly to the presidency and has jurisdiction over the basic development of the Magdalena River, it has the following main responsibilities 1. Recovery and assurance of the navigability and activity of the river port 2. Conservation and use of the national territory (within the basin) 3. Electric power generation and transmission 4. Use and protection of fishing and renewable natural resources CORMAGDALENA made progress in the formulation of basin management policies and plans for the Magdalena River and created the Master Plan for Utilization (PMA) in the Magdalena River basin in 2013. This existing plan (PMA) is composed of four pillars of "navigation", "hydroelectric power generation", "environmental management", "other plans", and measures against flooding and sediment discharge are classified as part of " environmental management "and" other plans ".
CIRMAG	It is positioned as a technical research center of CORMAGDALENA (study and research). It was closed in March 2018 during the implementation of the project.
DNP	The Director of the DNP is a member of the National Risk Management Council, the highest decision-making body of SNGRD. In the prevention stage, he is responsible for the formulation and monitoring of the national development plan and the budgeting and operation of the National Fund for Disaster Risk Management. In the disaster response stage, in addition to preparing the necessary temporary budget for the activities of the national relief organizations (firefighters, military relief brigade), it will support the early warning response of UNGRD and IDEAM as members of the SNGRD. During the restoration/reconstruction phase, the National Disaster Risk Management Fund operates.

The issues confirmed with the existing information and the information gathered in the interviews related to Output 3 are organized below.

The main challenges related to Output 3, which were identified through the baseline survey and activities during the first year of the project, can be organized in Table 2.20. For Output 3, item activities were carried out (10), using the following methods to solve the problems.

Table 2.20 Main Challenges related to Output 3 and Approach to Challenges

Main Challenges	Analysis on Challenges	Approach to Challenges
How to distribute responsibilities among entities at the national and regional levels and carry out activities in an effective and efficient way to reduce the risk of flooding	The river administrator and the entity responsible for flood control are not clear, and several relevant entities carry out activities with little coordination without a clear division of responsibilities. As a result of the decentralization due to the 1991 Constitution, the responsibility of the municipalities increased; consequently, the municipalities are theoretically responsible for the evaluation of hazards and measures against flood. However, they do not coordinate between upstream and downstream to manage flood phenomena that affect several municipalities (for example, the relationship of locations of the points at which floods occurred and protection targets are not studied), and the responsible for this exercise is also not clear. It is necessary to clarify the role sharing among the relevant entities for the reduction of flood risk.	<Mutual understanding and discussion in the workshops> Deepen the understanding of the activities that each entity is already putting into practice and its legal justification and study the appropriate division of responsibilities.

How to share information related to flood risk management	Information related to flood control is not organized consistently. It is not clear which entity has what kind of information, nor is the information shared very frequently. To perform effective flood control, avoid duplication of activities, and share information among relevant entities in the future, it is necessary to confirm which entity has what type of information with what level of precision and categorize it, as well as clarify what type of information is missing and must be collected.	<Confirm the content of the quality that each entity owns through the data collection> Collect data required in the activities of the project and at the same time confirm and organize the type and quality of the information that each entity possesses. Discuss and study the method for sharing information.

(10) Development of coordination and cooperation system: Completed in March 2018

Discussions were held in the workshops in order to present the existing information and information collected and categorized through the interviews to the C/P and relevant entities, as well as to prepare a proposal related to the organization of the flood risk management implementation system, including the effective and efficient role sharing between the national government and the regional government for the reduction of flood risk. Table 2.21 shows the workshops related to Output 3 that were carried out.

Table 2.21 Workshops Related to Work Item (10) of Output 3

Date	Contents
October 23, 2015	River management plan in Japan, relevant entities in the Magdalena River basin (also found in Work Item (6))
November 3, 2015	Steps for the formulation of the river plan for the Magdalena River and the Rio Negro basin, role sharing among relevant entities (also found in Work Item (6))
November 10, 2015	Role sharing among relevant entities (also found in Work Item (6))
February 16, 2016	Discussion on the role sharing among relevant entities (Magdalena River basin) (also found in Work Item (6))
March 2, 2016	Discussion on the role sharing among relevant entities (Magdalena River Basin and the Rio Negro Basin) (also found in Work Item (6))
October 5, 2016	Discussion on the participation of CORMAGDALENA and CIRMAG in this project.
October 28, 2016	Discussion on the participation of CORMAGDALENA and CIRMAG in this project.
October 12, 2017	Discussion on the role sharing regarding risk reduction
October 25, 2017	Discussion on the role sharing regarding risk reduction
February 14, 2018	Discussion on the role sharing in flood risk reduction measures
February 23, 2018	Discussion on the role sharing in flood risk reduction measures
March 1, 2018	Explanation of concrete ideas on structural measures in the Rio Negro basin, and discussion on the role sharing in flood risk reduction measures in the Rio Negro basin

Discussion on Role Sharing

< Activities between October 2015 and August 2017>

In the workshops, based on the steps of formulating the river plan, prepared in the activities of Output 1, a discussion was held between C/P and relevant entities regarding the current role sharing and the ideal distribution in each stage of planning (evaluation, implementation, administration and maintenance).

With respect to the Magdalena River basin, in the discussions in the October and November 2015, it was discovered that the 1991 Constitution makes CORMAGDALENA responsible for the basic management of this river, for which MADS has been developing the strategic policy of the macro-basin in recent years, and that these two entities will be the main actors in the management of the Magdalena River in basic terms. Therefore, MADS, who had been attending the workshops as a related entity since October 2015, became an official C/P at CCC in February 2016. CORMAGDALENA actively participated in the workshops, the activities of the project (mainly Output 3) and in the discussions from February 2016 as a related entity. C/P recognized the responsibilities of each entity with respect to the management of the Magdalena River as follows.

- IDEAM: meteorological and hydrological observation of the basin, hydrological and hydraulic modeling of the main channel, forecast and flood warning
- UNGRD: disaster risk management activities
- Department of Cundinamarca and CAR: activities that are in accordance with the policies of CORMAGDALENA and MADS, support for municipalities
- MADS: formulation of strategies
- CORMAGDALENA: formulation of the basin management plan in the areas under its jurisdiction around the Magdalena River
- Municipalities: definition and implementation of measures, administration and maintenance

As the management guidelines taking into account the entire basin and the formulation of the medium and long-term management plan are high priority in Colombia, it was confirmed that a mechanism with participation of both relevant entities and entities that investigate the regions in question will be of paramount importance after several discussions. Below is a summary of the role sharing for flood risk management in the Rio Negro pilot basin:

- IDEAM: meteorological and hydrological observation of the basin, hydrological and hydraulic modeling of the main channel, forecast and flood warning
- UNGRD: disaster risk management activities

- CAR: meteorological and hydrological observation of the basin, hydrological and hydraulic modeling, study of structural measures, activities to incorporate flood risk in POMCA, support to municipalities
- Department of Cundinamarca: support for municipalities
- MADS: formulation of strategies
- Municipalities: definition and implementation of measures, administration and maintenance

In the formulation of IFMP-SZ for the Rio Negro basin in this project, IDEAM and CAR have the main roles.

In the discussions it was confirmed with CORMAGDALENA and MADS that it is necessary to coordinate with the municipalities located near the point of confluence in the formulation of IFMP-SZ for the Rio Negro. Since this type of policy definition is related to POMCA, the importance of the results of this project was recognized. It was also clarified that decision making to implement concrete measures against flood is the responsibility (or is based on the criteria) of municipalities (or mayors). It was recognized that this is the main problem when formulating and implementing measures against flood at the basin level.

In the initial plan, the first draft of recommendations was to be published in 2015; however, the discussions in 2 workshops during the year were not sufficient, and it was decided there would be homework on the role sharing in 2015 and the discussion would be resumed in 2016. The first draft of recommendations was elaborated with the results of discussions in the workshops between February and March 2016 and discussions for other Outputs in the workshops between April and May. It was decided that this draft would be reviewed in the concrete activities for the formulation of the flood risk management plan, specifically in Output 4.

It was decided continuous categorization of the information held by the relevant entities would be carried out as part of the activities (Item (4)) to collect basic information related to the formulation of IFMP-SZ of the Rio Negro basin.

< Activities since October 2017>

In the workshops held on October 12 and October 25, 2017, discussions were held on the role sharing for the formulation of the flood management plan and the role sharing for the implementation of projects related to water management. Flood risk, based on past activities. In the workshop on October 25, with the participation of short-term stay experts (specialist Baba from JICA's Department of the Environment), the historical or administrative background of the management of Japanese rivers was explained, and the discussion progressed with appropriate advice from the experts, taking into account the current situation in Colombia.

In the 3 workshops held between February and March 2018, details and explanations were added to the material prepared on the role sharing in the study and the implementation of flood risk reduction measures in the two workshops held in October 2017. It was summarized in a table in order to facilitate the concrete discussion of responsibilities, and a discussion was held along with the explanation of concrete structural measures. In this discussion, the launch and role of CARMAC[3] in

[3] CARMAC is a regional environmental council of the macro-basin, composed of MADS, related ministries, CAR and departments based on the Decree 1076 of 2015 and partially modified Decree 050 of 2018. CARMAC is established by each macro-basin. Operational regulations for CARMAC Magdalene-Cauca was approved by means of minutes of CARMAC Magdalena-Cauca, dated November 30, 2017. As of March, 2018, only CARMAC Magdalena-Cauca was confirmed to be operating in five macro-basins. Some of the scope of CARMAC are participating in formulation and monitoring of the strategic plan of the macro-basin, and promoting inter-institutional and inter-sectoral agreements and strategic actions in the macro-basins.

the Magdalena - Cauca Macro-basin were introduced from C/P and the CARMAC was added to discussion of role sharing as an organization responsible for flood risk management.

The following table of role sharing was elaborated in the workshop, and it was confirmed among the participants that it is correct.

Table 2.22 Detailed Role sharing for the Study and Implementation of Measures to Reduce the Risk of Flooding in the Rio Magdalena Basin

Items to implement				Central Governmanet				Regional Government			
				UNGRD	CARMAC	MADS	IDEAM	COR MAGDALENA	Departamento	CAR	Municipio
Recognition of problems	Understand flood damage situations	Where did the flood occur? The magnitude of the damage (response just after disaster)	current situation	Support during large scale flood			information providing		Support during mid scale flood		○
			ideal	Support during large scale flood			information providing		Support during mid scale flood		○
		The cause of the flood?	current situation				Implement against large scale flood			Implement agaisnt middle scale flood	△
			ideal				○	Support	Support	Support	Support
	Comprehensive assessment and organization of problems		current situation							△	
			ideal	○	○	○	Support (only for hazard)	Support	Support	Support	Support
Study measures	Determine the goal of flood risk management - Determine target area and design scale		current situation				information providing		○		○
			ideal	○	Support	Support	○	Support			
	Where will these measures be implemented? - Determine design flood discharge and inundation area - Study of cost benefit ratio		current situation				information providing		○		○
			ideal	○	Support	Support	○	Support			
Impliment structural measure (Levee development)		Study and design	ideal	○			information providing	Support	Support	Support	Support
		Works	ideal	Support			information providing	Support	Support	○	Support
		Maintenancee and administration / Monitoring	ideal	Support			information providing	Support	○	○	○
Implement non-structural measure (Land use regulation in floodplains)		Policy and guideline	ideal			○					
		Study and planning / Regulation / Monitoring	ideal							○ Land use management	

○ : Principal entity

Table 2.23 Detailed Role sharing for the Study and Implementation of Measures to Reduce the Risk of Flooding in the Rio Negro Basin

Items to implement				Central Governmanet			Regional Government		
				UNGRD	MADS	IDEAM	CUNDINAMARCA (Departamento)	CAR	Municipio
Recognition of problems	Understand flood damage situations	Where did the flood occur? The magnitude of the damage (response just after disaster)		Support during large scale flood		Information providing	Support during mid scale flood		○
		The magnitude of the damage?							
		The cause of the flood?				○		○	○
	Comprehensive assessment and organization of problem (current situation)							△	
	Comprehensive assessment and organization of problem (ideal)			Support			Support	○	Support
Study measures	Determine the goal of flood risk management (current situation)							Support	○
	Determine the goal of flood risk management (ideal)				○	Information providing		○	○
	Where will these measures be implemented? (current situation)							Support	○
	Where will these measures be implemented? (ideal)				○	Information providing		○	○
Implement structural measures	Planning of flood prevention structure	Flood wall / Bank protection etc	Study and design			Information providing		○	
			Works			Information providing	○	○	Support
			Maintenance and administration / Monitoring			Information providing	○	○	○
	Sediment control	Sediment retention dams (SABO dams)	Study and design			Information providing		○	
			Works			Information providing	○	○	Support
			Maintenance and administration / Monitoring			Information providing	○	○	○
		Dredging in the confluence with the tributary	Study			Information providing		○	
			Works (dredging etc)	Support			○	○	Support
			Maintenance and administration / Monitoring				○	○	○
Implement non-structural measure	Land use regulation	Disaster Risk Reduction Map (DRR Map)	Collect information and identify flood areas			○		○	○
			Runoff and flood analysis			Support		○	
			Creation and distribution of DRR Map			○		○	○
		Land use regulation in floodplains (Conservation of wetland)	Policy and guideline		○				
			Study and planning			Information providing		○	○
			Regulation / Monitoring					○	○
	Flood forecast and warning	Improvement of the flood forecast and warning system	Observation oof precipitation and water level			○	○	○	
			Water level forecast			○	○	○	
			Organization of the system (communication of information)	○		○	○	○	○
		Raise awareness among residents	Preparation of brochures and carrying out orientations				○		○
	Response to flood	Improvement of the flood response system		○			○		○
		Improvement of the issuance of evacuation order					○		○
		Improvement of flood response activities and establishment of shelter		○			○		○

○ : Principle entity

<Analysis of the Activity Result>

Clearly, the participants better understood the importance of flood risk management and related concrete activities was achieved, as well as the need to generate understanding and coordination between the relevant entities, through discussions with C/P and other related entities. C/P has expressed that this type of discussion and coordination among government entities had been necessary before and was satisfied that this was achieved through this project. The discussions with C/P and the relevant entities were actively carried out not only in the workshops for Output 3 but also in all the other workshops, and it was possible to deepen the knowledge about the current situation and role sharing through them. It can be affirmed that the realization of these workshops itself contributed to the construction of a system of coordination and cooperation between entities related to the management of flood risk in Colombia.

The results were incorporated in the part on the role sharing in IFMP-SZ for the Rio Negro basin (Part D), developed as part of the activities for Output 4. In Appendix-5, a document named Recommendations on the Role sharing Related to Flood Risk Management among Local Governments and Central Government in Colombia is attached, taking into account the knowledge attacked through the activities for Output 3.

2.1.3.5. Work Related to Output 4: The flood management planning capacity is strengthened through the formulation of the integral flood risk management plan (IFMP) in the pilot basin

The activities related to Output 4 consisted of supporting the formulation of IFMP-SZ in the Rio Negro basin and creating guidelines for such formulation. Support was provided for IFMP-RP for the Magdalena River in order to clarify the position of the Rio Negro basin within the Magdalena River basin, and then support was provided in the formulation of IFMP-SZ taking into account the balance with the main river.

The main challenges related to Output 4, which were identified through the baseline survey conducted at the beginning of the project (July-August, 2015) can be organized in Table 2.24. For Output 4, activities of items (11) to (15) were carried out, using the following methods to solve the problems.

Table 2.24 Main Challenges related to Output 4 and Approach to Challenges

Main Challenges	Analysis on Challenges	Approach to Challenges
How to introduce the formulation of the plan and evaluation at the basin level and from the point of view of river engineering	Regarding flood control and river administration, the formulation of a plan and the study of measures based on river engineering are not currently carried out, nor is the economic evaluation carried out. The role sharing is also unclear. It is expected to study and introduce the methodology of the formulation of the flood risk management plan from the integral point of view.	<Study and practice in the workshops> Study the methodology for the formulation of appropriate plans for Colombia, through the activities of formulating the plan in the pilot project. In studying this, the sharing of responsibilities should also be studied. Prepare the guideline to share this methodology.

(11) Support in the formulation of IFMP-RP for the Magdalena River: Completed in May 2017

Regarding this item, discussions were held among C/P and other entities on theories and methodologies to formulate the river plan in the context of this project as part of the activities of Output 1. As a result, it was decided that the formulation activities for the river plan for Rio Magdalena would be carried out as follows.

< Basic guidelines related to the formulation of IFMP-RP for the Magdalena River >

In the Magdalena River there is an entity that administers the basic management called CORMAGDALENA. This entity was created under the Constitution of 1991, and with Law 161 of 1994, it began the concrete operation in 1996 reporting directly to the Presidency. Its main functions are: 1. recover and guarantee the navigability and port activities; 2. protection and use of the territory (within the basin); 3. Hydro-electric generation and distribution of energy; 4. utilization and protection of fishing and renewable natural resources.

CORMAGDALENA has advanced the formulation of the management policy of the Magdalena River and plans by phase, and in 2013 the Master Plan for the Magdalena River Basin (PMA, abbreviation in Spanish) was formulated. This existing PMA consists of 4 main points, which are "navigation", "hydroelectric generation", "environmental management", and "other plans". Measures against flood and sediment runoff belong to "environmental management" and "other plans".

After reviewing this plan, it was determined to be sufficiently solid to be considered as a master plan for the Magdalena River basin and that the flood measures indicated in it are appropriate at the master plan level considering the position of the flood within the plan. The objective of the study of the Magdalena River basin (study of the basin plan) in this project is "to establish the position of the Rio Negro basin, for which IFMP-SZ will be developed within the Magdalena River basin (main river) and to establish the conditions at the point of confluence of the Rio Negro with the Magdalena River "(Guidelines for Implementation and Notes on Work Instructions), and although it is possible to complement past studies related to floods if they are insufficient, the objective is not to formulate a plan that contemplates issues related to the Magdalena River basin in an integral manner.

Therefore, the results of this project will be the additional texts that will be studied and developed as part of the project activities in areas that may be considered insufficient in the existing CORMAGDALENA plan, such as the understanding and analysis of the flood phenomenon, example, in order to elaborate "IFMP-RP (provisional plan[4]) for the Magdalena River". Methodologies for understanding and analyzing the flood phenomenon will also be organized in a guide, since this type of study will be necessary for the formulation of similar plans in other river basins (principal rivers).

Based on these guidelines, methodologies for understanding the river characteristics, flood process and characteristics (volume received by the floodplains) of the Magdalena River have been explained, and an analysis of flood characteristics of the middle course of the Magdalena River was carried out as a C/P task. Below is the list of workshops held related to this item.

Table 2.25 List of Workshops Related to Work Item (11) of Output 4

Date	Contents
May 4, 2016	"Proposal for a manual for the formulation of the river plan", characteristics of flood damage in the Magdalena River (also found in Work Item (5) & (6))
May 11, 2016	Characteristics of flood damage in the Magdalena River and the Rio Negro basin (also found in Work Item (5) & (6))
May 17, 2016	Formulation of the river plan for the Magdalena River (also found in Work Item (6))
July 15, 2016	Discussion on the Magdalena River Plan from the point of view of flood protection, river environment and navigation (also found in Work Item (6))
July 19, 2016	Joint field survey (also found in Work Item (6) & (8)) Interviews with disaster prevention entities in Barrancabermeja and Puerto Wilches and observation of the Magdalena River between these two points

[4] As the topographic surveys were not carried out in this project, the plans formulated both in the Magdalena river basin and in the Rio Negro basin will be provisional plans.

July 22, 2016	Reflection on the field study on July 19 (also found in Work Item (6)), discussion on the flooding process in 2010 in the Magdalena River and discussion on the retention capacity of floodplains (also found in Work Item (5) & (6)), and discussion on flood forecasting and warning and evacuation in the Magdalena River from the study field of July 19 through the interviews (also found in Work Item (8)).
July 28, 2016	Study of flood volume in the Magdalena River (also found in Work Item (6))
October 13, 2016	Introduction and explanation of the basic guidelines related to the formulation of the IFMP-RP, detailed explanation and discussion on the activities for C/P in August-September (flood analysis of the middle course of the Magdalena River).
October 19, 2016	Introduction of the contents of the specific activities for the definition of the river area by CAR, technical discussion on the analysis of the flood volume in the Magdalena River.
October 31, 2016	Introduction of the methodology for the definition of the river area by MADS, its explanation and discussion, the explanation of the (real) example of application of the MADS methodology of the definition of the river area and discussion, the explanation of the general content of the river plan for the Magdalena River and the result of the flood analysis in the middle course of the Magdalena River, the discussion.
February 10, 2017	Discussion on the necessary items and the road map for the formulation of the draft IFMP-RP for the Magdalena River (provisional plan) and the IFMP-RP for the Magdalena River (principal plan) (also found in Work Item (12)).
February 20, 2017	Confirmation of the final IFMP-RP process for the Magdalena River (provisional plan).
May 30, 2017	Final confirmation of IFMP-RP for the Magdalena River (provisional plan), introduction and explanation of the part of analysis by C/P within the provisional plan.

The flood analysis carried out by IDEAM was included in the draft IFMP-RP for the Magdalena River (provisional plan) prepared by the expert team, which was distributed and explained at the workshop. Afterwards, the comments by the C/P entities and relevant entities were incorporated in the final version, which was delivered in PDF to C/P after the explanation in the workshop on May 30, 2017. IFMP-RP for the Magdalena River (provisional plan) is attached in Appendix-6.

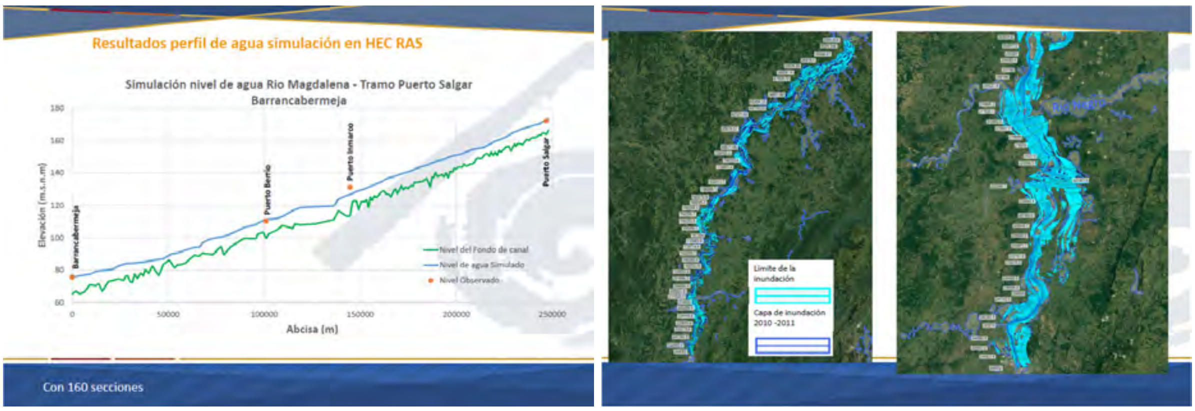


Figure 2.7 Comparison and Study of the Actual Flood of 2010-2011 and the Calculated Value

Figure 2.8 Study Related to the Proportion of the Discharge in the Floodplains of the Left Bank and the Right Bank

<Analysis of the Activity Result>

Through the activities, the shared knowledge of the C/P entities about the flood in the Magdalena River and the challenges was acquired and deepened. The strengthening of the analysis capacity of IDEAM was particularly highlighted, as IDEAM carried out most of the analysis. It was discovered during the process of finalizing IFMP-RP for the Magdalena River (provisional plan) that in the floods of 2010-2011 the Magdalena River exceeded the normal channel and the flood expanded approximately 15 km into the floodplains in the middle course where large floods occurred (from Sitio Nuevo to near Barrancabermeja). Therefore, it is necessary to study the flood in the Magdalena River by including the floodplains. Within the measures for flood reduction, the retention of flood using the swamps is a realistic and effective measure, and it was stressed that the measure of conservation of the floodplains including the swamps is indispensable. The revision of the Ronda Hidrica was recommended, which regulates "the normal channel + 30m" of the river through land use regulation for the administration of floodplains as items to study in the future.

After the completion of the activities related to this item, the necessary items for the formulation of IFMP-RP Magdalena River (principal plan) were organized and a road map was developed as part of the activities. In addition, the guidelines for the formulation of IFMP-RP were prepared as part of the activities of the item (15), taking into account the lessons learned in the activities for the formulation of the river plan for the Magdalena River (provisional plan).

(12) Organization of items required for the formulation of IFMP-RP for the Magdalena River and preparation of road map: Completed in October 2017.

The workshops that are presented in the table below were carried out in order to study the activities that should be carried out in Colombia after completing this Project (road map) related to the Magdalena River (for the formulation of IFMP-RP for the Magdalena River (principal plan)).

Table 2.26 Workshops Related to Work Item (12) of Output 4

Date	Contents
February 10, 2017	Discussion on the necessary items and road map for the formulation of IFMP-RP for the Magdalena River (principal plan) (also found in Work Item (11))
February 20, 2017	Discussion on the IFMP-RP road map for the Magdalena River
May 30, 2017	Discussion on the finalization of the road map for the formulation of IFMP-RP for the Magdalena River and its revision

June 5, 2017	Final confirmation of the road map for the formulation of IFMP-RP for the Magdalena River (principal plan)
July 25, 2017	Introduction and dissemination of MADS strategies related to the Magdalena River Discussion on the implementation of the road map for the formulation of IFMP-RP for the Magdalena River and its revision
August 27, 2017	Explanation and communication of the results of the study for the formulation of the basic policy in the Magdalena-Cauca Basin, carried out by DNP Ongoing discussion on the implementation of the road map for the formulation of IFMP-RP for the Magdalena River (main plan)
August 9, 2017	Continuous discussion on the implementation of the road map and the signing of an agreement between relevant entities for the formulation of IFMP-RP for the Magdalena River (principal plan)
September 27, 2017	Discussion and confirmation to specify and deepen the road map for the formulation of IFMP-RP for the Magdalena River (principal plan)
October 12, 2017	Discussion and confirmation to specify and deepen the road map for the formulation of IFMP-RP for the Magdalena River (principal plan)

In the activities, the draft road map prepared by the expert team was first presented to start the discussion, then the corrections and comments delivered mainly by CORMAGDALENA and the Scientific Research Center of the Magdalena River (CIRMAG) were incorporated, and then, taking into account information from MADS and the National Planning Department (DNP) about the past activities obtained through the workshops, and the discussion with the relevant entities was carried out in the workshops. Through the discussions, the participants reached agreement on the following points on the formulation of the plan for the Magdalena River: 1) The plan will not include several sectors but will focus on the flood component, taking into account other sectors; 2) Work will be done with the tentative date of the completion in 2023; 3) the main entities responsible will be CORMAGDALENA, MADS and IDEAM.

Picture: Discussion on the Concrete Road Map

This road map had been completed in May-June 2017; however, as a result of the discussion with the JICA headquarters, it was decided even more concrete plan would be elaborated from July and August, 2017. Spaces were created for the explanation of detailed items of each activity of the road map and for the entity that will lead each activity in order to formulate a more concrete plan. More time was needed for the entities that participated in the workshops to reach the same understanding of each activity, and the last items were not confirmed in the workshops in July and August. Therefore, the discussion continued in the September-October workshops of 2017. During those months, the road map was finalized, which is attached in Appendix-7.

<Analysis of the Activity Result>

Through the activities, the knowledge of the participants was deepened, and they have become more aware since the discussions about the concrete activities and the system necessary for the planning of the measures against the flood and its implementation n the Magdalena River, as well as the discussions about the limitations and regulatory challenges in Colombia, have been carried out in an active manner. In 2017, the entities that were assigned as leading agencies of future activities in the road map, which are MADS, CORMAGDALENA and IDEAM, carried out discussions for the preparation and signing of the official collaboration agreement document for future activities on their own initiative, which clearly demonstrates they have become aware of the need for ongoing activities. The progress on this agreement was presented in the 4th JCC held on November 24, 2017, and in the 5th and final JCC held on June 28, 2018, the official signing of this document by MADS, CORMAGDALENA and IDEAM was announced by MADS. It is expected that the C/P entities and relevant entities would continue with the activities within and outside the project.

(13) Advice for the formulation of IFMP-SZ for Rio Negro Basin: Completed in June, 2018

The explanation and discussion on the concept of IFMP, and methodologies and steps for the formulation of the river plan for C/P and other relevant entities were given, and as part of the activities for Output 1, and some specific activities were carried out related to this item as of February 2017, as presented in the table below.

Table 2.27 Workshops Related to Work Item (13) of Output 4

Date	Contents
February 10, 2017	Discussion on the necessary items and schedule for the formulation of IFMP-SZ for Rio Negro, detailed explanation and discussion on the C/P activities of November-January (collection of information on the Rio Negro basin)
February 16, 2017	Meeting for the confirmation of the situation of availability and collection of information for the formulation of IFMP-SZ for the Rio Negro Basin with the Planning Secretariat of the Department of Cundinamarca
February 17, 2017	Discussion on the early warning system based on collaboration between municipalities within the Rio Negro basin with attendance of the municipalities in basin, carried out by the Department and the project.
February 20, 2017	Explanation and disclosure of progress in the hydrological-hydraulic analysis by C/P in the Rio Negro Basin
February 24, 2017	Meeting to confirm the status of availability and collection of information for the formulation of IFMP-SZ for the Rio Negro Basin with the Planning Secretariat of the National Administrative Department of Statistics (DANE)
April 25, 2017	Explanation and dissemination of the understanding of the characteristics of the Rio Negro basin (topography, river morphology, hydrology) and the progress made in the hydrological-hydraulic analysis (construction of the hydraulic model) for the Ro Negro basin by C/P
May 2, 2017	Introduction and discussion on how to consider the design scale in the IFMP-SZ for the Rio Negro basin.
May 9, 2017	Reconfirmation of the process of the formulation of IFMP-SZ for the Rio Negro basin, discussion on the historical record of disasters and the target area of the plan, introduction and dissemination of C/P on the progress in the hydraulic analysis in the Rio Negro basin (conditions of the confluence), rainfall analysis and flood analysis.

May 10, 2017	Joint field survey (Study of the upper basin of Rio Negro (near the municipality of Pacho)
May 15, 2017	Participation in the Rio Negro Basin Committee, carried out by CAR, introduction of the project and activities in Rio Negro
May 26, 2017	Reconfirmation of the schedule for the formulation of the IFMP-SZ for the Rio Negro basin, the detailed analysis of the disaster record, selection of the target areas of the plan, discussion on the definition of the design scale (practice of the evaluation of the area of projected flood and economic evaluation of flood control), introduction and dissemination of progress in the analysis of hydrological conditions during the disaster in the Rio Negro basin by C/P.
June 1, 2017	Joint field survey (Flood survey at the points of damage in the lower basin of Rio Negro (Puerto Libre, El Dindal))
June 5, 2017	Introduction of flood study results in points of damage in the Rio Negro basin, discussion of the design scale and measures against flooding, introduction and dissemination of progress in the analysis of hydrological conditions during the disaster in the Rio Negro basin by C/P, introduction and distribution of the basic guidelines for the formulation of the plan, the law of prevention of sediment disasters.
July 19, 2017	Study of the early warning system by calculating the speed of the flood wave propagation and the time required for evacuation in the Rio Negro basin. Explanation and presentation of the result of the rainfall and flood discharge analysis in the Rio Negro basin by C/P and the expert team
July 24, 2017	Joint field survey (Flood survey in points of damage in the lower basin of Rio Negro (Cambrás, Colorados)).
July 26, 2017	Introduction of the characteristics, evolution and use of meteorological radars in Japan Discussion on the design scale of the IFMP-SZ for the Rio Negro basin
July 28, 2017	Joint field survey (flood survey at the points of damage in the lower basin of Rio Negro (Guaduero, Córdoba)).
August 2, 2017	Discussion on the plan of the early warning system in IFMP-SZ for the Rio Negro basin
September 13, 2017	Detailed explanation on the economic evaluation of flood management and the B/C analysis on the premise of the evaluation of structural measures in IFMP-SZ
September 22, 2017	Discussion on the configuration of the design scale, confirmation of the social conditions of the target area and the result of the flood study
October 4, 2017	Explanation of the hydrological analysis carried out by C/P, explanation of the latest hydraulic model and result of the analysis and contribution to the IFMP-SZ Discussion on the structural measures and non-structural measures studied in the IFMP-SZ, confirmation/discussion of draft disaster prevention maps
October 12, 2017	Discussion on the definition of the design scale, confirmation of the development plan of the target area and scope of the plan Discussion of the magnitude of target flood for structural measures
November 1, 2017	Discussion on structural measures in the target area, explanation and discussion of the draft IFMP
February 23, 2018	Explanation and discussion on the revised version of IFMP-SZ for the Rio Negro basin
March 1, 2018	Explanation of the concrete ideas for the structural measures in the Rio Negro basin and the discussion on the role sharing in the flood risk reduction measures taken in the Rio Negro basin as an example
May 31, 2018	Confirmation and discussion on the final version of IFMP-SZ for the Rio Negro basin (provisional plan)

June 14, 2018	Confirmation of the final version of Part D of IFMP-SZ for the Rio Negro basin (provisional plan)

For the formulation of IFMP-SZ for the Rio Negro basin, first the expert team explained the draft table of contents of IFMP-SZ, items related to the role sharing discussed in Output 3, the result of the categorization of the relationships between the activity items in the technical guides for the formulation of the river plan elaborated by the expert team. Later, progress was made in the collection and analysis of additional necessary information for the formulation of IFMP-SZ as well as the construction and analysis of the hydrological-hydraulic model by C/P.

In the workshops, the expert team explained the concept and methodology of understanding the characteristics of the Rio Negro basin, disaster analysis, hydrological analysis, hydraulic analysis, the planning process, the design scale, the target area of the plan and evaluation of the plan. In addition, the practices were carried out with the materials previously prepared, C/P implementation work and the explanation and discussion among the participants in order to deepen the knowledge about the formulation of the river plan of the C/P and the participants of the relevant entities through the specific activities. Field studies were also conducted in the areas that experienced flood damage to collect the information to understand the real situation of the disaster and the calibration of the flood analysis.

The discussion on the design scale was carried out taking into account the design scale and the results of the flood study, projected flood area as a result of the simulation, the social conditions of the target area, the land use plan of the target area, and the development plan of the target area. Discussions were held on the area to be protected within the target area of the plan or the target area of the structural measures, what the area to be protected is in terms of the design scale or the flood area by depth, and why the decision is taken, etc., and the target design scale was defined. As a conclusion of the workshop, it was agreed two scales of designs would be defined in this plan, one for non-structural measures (in order to avoid fatalities), and another for structural measures, although the appropriate design scale would be the magnitude of the flood April 2011, which is the maximum flood in recent years (equivalent to the return period of approximately 100 years in the Rio Negro basin). This is because the benefits for the implementation cost of the structural measures with this design scale are quite low, taking into account the population and the distribution of assets in the target areas of the measures, and it is because no future development is projected for this area. As concrete examples of discussion content from the workshops, it was agreed the design scale would be defined as the magnitude of the flood in April 2011, (equivalent to the 100-year return period) for disaster risk reduction maps (hazard map in Japan) and the return period of 50 years would be used for structural measures in Córdoba, one of the target areas of IFMP-SZ, since it is an area where the senior population is concentrated, a vulnerable population in disasters. Therefore, the largest possible area should be protected, even though the benefits of implementing these measures are not high and it is not an area where development is projected.

The results of this item include the analysis and categorization of the disaster record, organization of basic hydrological data, analysis of the hydrological conditions of the flood, the construction of the hydraulic and flood model, elaboration of the flood map of the basin, among others. Some of these results are presented below. In the plan, new versions of the models were used, since C/P updated the hydraulic and flood model with new topographic data with better resolution, purchased in August 2017.

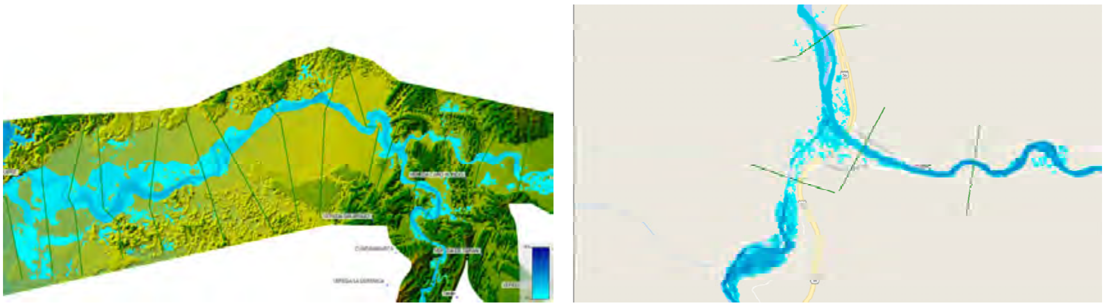


Figure 2.9 Results of the Flood Analysis with Hydraulic Model Updated by C/P

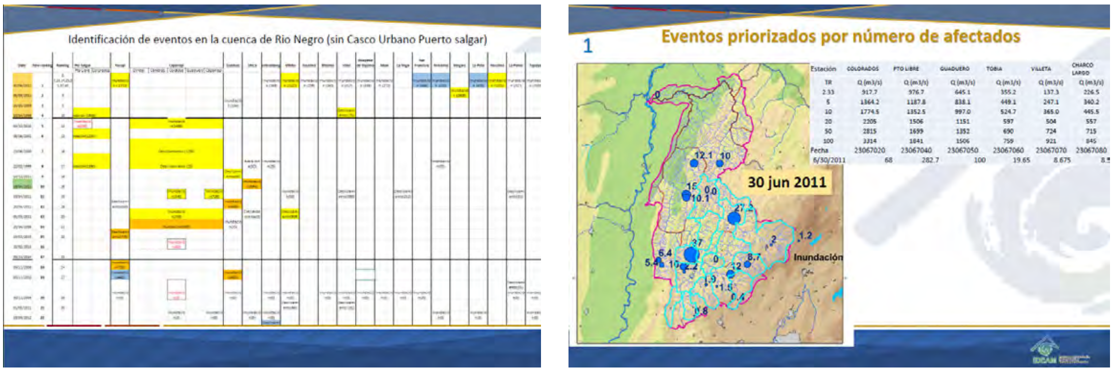


Figure 2.10 Categorization and Analysis of Large Past Floods

It had been noted in the activities related to Output 2 that collaboration between upstream and downstream municipalities is important for the study of the early warning system, which is one of the non-structural measures included in the anti-flooding measures of IFMP-SZ. In the workshops, of July-August 2017, this feasibility was verified through the discussions on the results of the theoretical calculation of the flood wave propagation speed and the time required for the evacuation as shown in the following figures, and the interviews in the field surveys in order to specify the methods for the system operation. In the workshops, the challenges clarified in the interviews were organized; then, these were categorized according to the elements of the early warning system plan in IFMP-SZ (hazard recognition, monitoring and warning service, dissemination and communication, and response capacity). Then, the content, responsible entity and the implementation period were discussed.

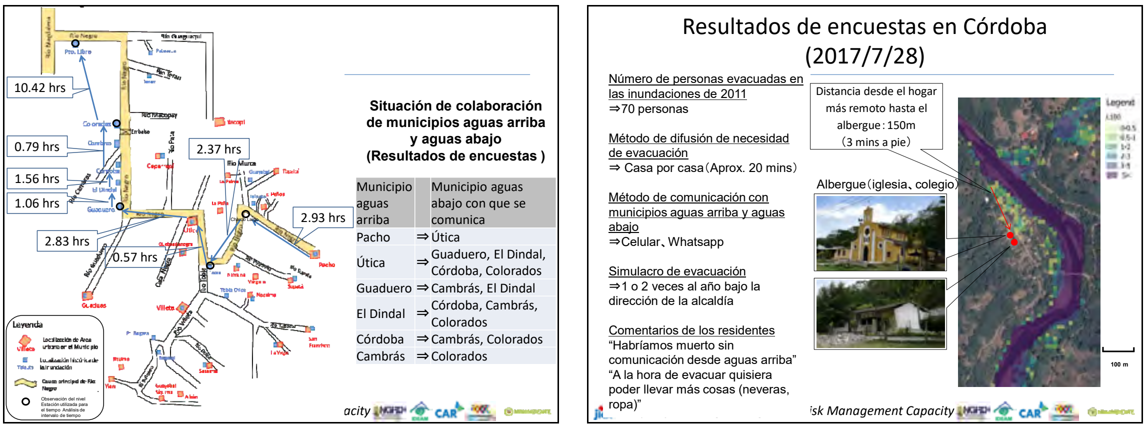


Figure 2.11 Study of the Propagation Speed of the Flood Wave and the Time Required for Evacuation

In the workshop, in addition to the above, the method of economic evaluation of flood management, which is one of the methods to study the validity of the measures, was reconfirmed. The options of measures concrete details of structural measures in the target area and the map of disaster prevention were also discussed. In the workshop on November 1, 2017, the IFMP-SZ (provisional plan) (first draft) for the Rio Negro basin was confirmed, which summarized the results obtained up to that point. Then, IFMP-SZ was finalized with support from C/P, based on the comments, corrections and revised materials of C/P on IFMP-SZ (provisional plan) (first draft), modifying the points suggested by JICA and adding the contents on the activities carried out between February and March 2018. The IFMP-SZ for the Rio Negro basin (provisional plan) is attached in Appendix-8.

<Analysis of the Activity Result>

The knowledge of C/P and relevant entities was significantly deepened through the concrete analysis and sharing of the result of the IFMP-SZ formulation process, types and methods of use of the necessary data in the plan, limitations of the content of the analysis due to the resolution of the information, challenges of the hydrological information currently categorized, the complexity of the relationship between the hydrological conditions in the pilot basin and flood events, the limit in the study of structural measures with limited information, and the importance of the information. It was observed that they understood the important items for the plan such as the definition of scale well, through repeated explanations, discussions and practices using concrete examples from the pilot basin. Additionally, it was observed that the understanding of the importance and effect of structural measures as methods to mitigate floods was gradually deepened. Above all, it can be concluded that the understanding was greatly improved not only on the process of formulating IFMP-SZ, but also on the content, significance and remaining items of each item in the plan, through the experience of going through the whole process of formulating IFMP-SZ for the pilot basin.

(14) Organization of items required for the formulation of IFMP-SZ del Rio Negro and preparation of road map

Regarding the IFMP for the Rio Negro basin, the workshops shown in the following table were carried out to consider the activities that must be carried out in Colombia once the project is completed (road map), so that the provisional IFMP formulated in this project can become the principal plan in the future.

Table 2.28 List of Workshops Related to Work Item (14) of Output 4

Date	Contents
November 22, 2017	Organization of necessary items for the formulation of IFMP-SZ (principal plan) for the Rio Negro basin, discussion on the road map, discussion on the incorporation of IFMP-SZ in POMCA.
February 23, 2018	Presentation of the draft road map for the formulation of IFMP-SZ (principal plan) for the Rio Negro basin
March 1, 2018	Discussion on the draft road map for the formulation of IFMP-SZ (principal plan) for the Rio Negro basin

In the workshop, the organization of the items needed to formulate the IFMP-SZ (principal plan) for the Rio Negro basin and the nature of the road map was discussed. How to incorporate IFMP into POMCA is one of the important conditions; therefore, this was also discussed.

In the workshop on November 2017, the difference between the provisional plan and the principal plan that had been foreseen in this project was explained and confirmed. Referring to the risk management part of POMCA of the Bogotá River created by CAR, the items necessary for the formulation of IFMP-SZ (principal plan) were classified, the road map and the relation of this with the incorporation of IFMP-SZ in POMCA were discussed. In the discussion, MADS expressed its intention to incorporate the IFMP-SZ into POMCA through the incorporation of the results of this project into the current Protocol of the risk component (which shows the content that should be included in the risk management part and its method of study). It was confirmed that MADS considers that this can sufficiently be achieved since the current Protocol has not been finalized (or legalized), although the POMCA elaboration guideline has been legalized. The process of this legislation depends on the legal section of MADS, and it is estimated that it would take at least a year, although it is not clearly known.

Regarding the IFMP-SZ (principal plan), although the current provisional plan has some sufficient aspects as information and method to incorporate POMCA, it is important to discuss the items necessary to convert the provisional plan into a principal plan, since it is necessary to understand what is missing, what should be done in the future, and what processes are necessary to achieve it. The participants agreed that the IFMP-SZ (principal plan) is necessary.

Since that the nature and direction of the road map were defined, the items necessary to formulate the IFMP-SZ (principal plan) were organized and a concrete debate was held on the road map in the workshop between February and March 2018. It was confirmed that CAR will lead future activities in the Rio Negro basin, the necessary items and the ideal timetable were reviewed. The road map was finally confirmed and approved by C/P in the workshop in March 2018. The road map for the formulation of IFMP-SZ (provisional plan) for the Rio Negro basin is attached in Appendix-9.

(15) Preparation of guidelines for the formulation of IFMP-RP and IFMP-SZ

The activities for this item were studied by the expert team in parallel with the activity items (11) and (13). In the workshop in February 2018, the expert team presented and explained the draft of the guideline to C/P, and the discussion began. The following table shows the workshops held related to this item. As shown in the table, the draft of the guideline was discussed intensively at the technical meeting and workshop between February and March 2018.

Table 2.29 List of Workshops Related to Work Item (15) of Output 4

Date	Contents
February 9, 2018 (technical meeting)	Explanation and discussion on the draft guideline for the formulation of IFMP-RP
February 14, 2018	Explanation and discussion on the draft guideline for the formulation of IFMP-RP
February 20, 2020 (technical meeting)	Discussion on the draft guideline for the formulation of IFMP-RP
February 23, 2018	Discussion on the draft guideline for the formulation of IFMP-RP Explanation and discussion on the draft guideline for the formulation of IFMP-SZ
March 1, 2018	Discussion on the draft guideline for the formulation of IFMP-SZ
May 31, 2018	Confirmation and discussion on the final draft of the guideline for the formulation of IFMP-SZ
June 7, 2018	Confirmation and discussion on the final draft of the guideline for the formulation of IFMP-RP

June 14, 2018	Final confirmation of the guideline for the formulation of IFMP-RP and the guideline for the formulation of IFMP-SZ

Discussions on the draft guideline for the formulation of the IFMP-RP focused particularly on the definitions of the guide, the position of the guide, target entities of the guideline (entities responsible for formulating IFMP-RP), basins (rivers) and the goal of the guide. These discussions were carried out actively. Regarding the target river basin (river) of the guide, the initial plan was to prepare IFMP-RP for each macro-basin of Colombia. However, due to the following, a new definition called "Principal River" was created, and C/P agreed that the basin of the "principal rivers" will be the objectives of the guide.

- There are five basins in Colombia classified as "macro-basins", one of which is the Magdalena River. However, the basin of the Magdalena (-Cauca) River is the only macro-basin that consists of a single river (a single drainage system) and the basin area of which as a whole is located in Colombia.
- For example, the Amazonas macro-basin only refers to a Colombian part of the Amazon River basin, which is an international river. The Colombian part of this basin can be divided into several basins. The Caribbean macro-basin refers to a group of hydrographic subzones located along the Caribbean coast (several rivers).
- The Magdalena River and the Rio Negro have the relationship of the "tributary-principal river", or "macro-basin-hydrographic subzone". The Magdalena (-Cauca) River macro-basin is the only one that can have this simple relationship with the hydrographic subzones.
- The project is centered on the Magdalena River and the Rio Negro, so the expert team had defined the macro-basin as an equivalent to a single large drainage system. However, C/P expressed dissatisfaction with this definition due to the conditions of other macro-basins.
- Considering the "principal river-tributary" relationship again, and searching the definition of the "principal river" for hydrographic subzones that have a solid legal definition, it was decided the concept of "principal rivers" would be proposed; they would have the hydrographic subzones as their tributaries.

Therefore, the "principal river" is defined as "a river that has an outlet in the lower part, or a river that crosses the border of the national territory, and is made up of several hydrographic subzones." The figure on the right it shows the basins of the principal rivers.

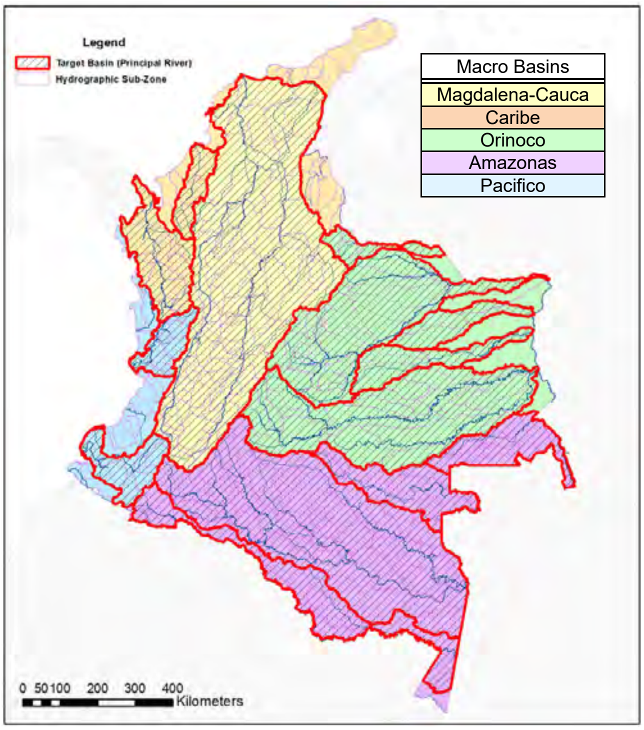


Figure 2.12 Delimitation of the Principal Rivers

Figure 2.13 shows the relationship between IFMP-RP for the Magdalena River, IFMP-SZ for the Rio Negro basin and two corresponding guidelines, all formulated in the project, and the existing plans in Colombia.

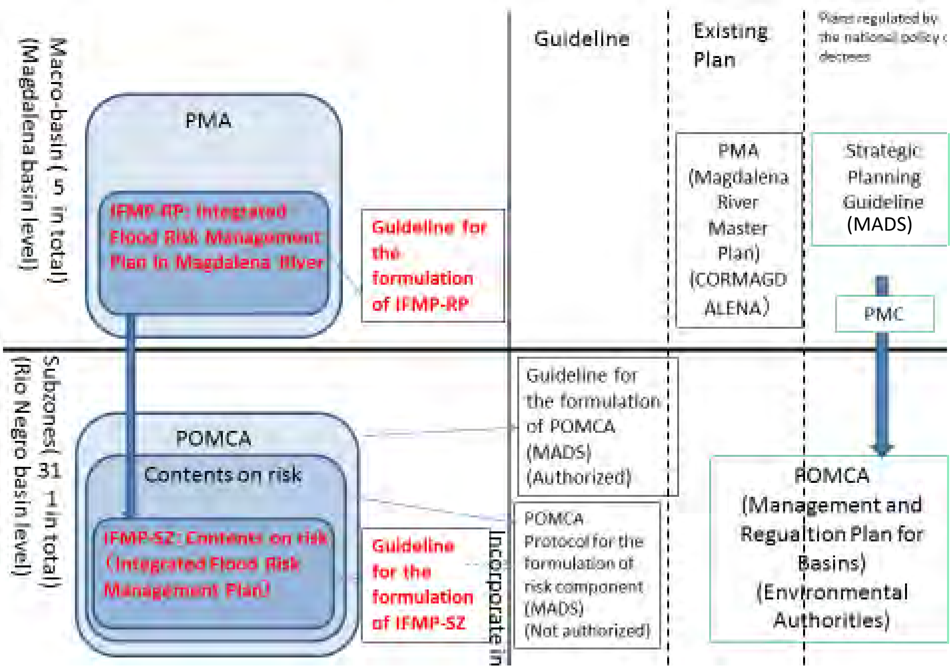


Figure 2.13 Relationship between the Products of this Project and the Existing Plans in Colombia

Regarding the guideline for the formulation of IFMP-SZ, C/P requested that concrete examples of materials developed by the expert team used in the formulation activities of IFMP-SZ be included, such as the flood damage questionnaire used in the field survey, the table used for the discussion of the role sharing, etc. In the workshop on March 2018, the expert team and the participants agreed to add these concrete examples would and the concrete processes of the hydrological and hydraulic analysis as well as the economic and hydrological evaluation processes for the planning and the concrete procedure of economic evaluation.

After the workshop in March 2018, the C/P comments, revisions and revised materials were reflected in the guide, and corrections and additions were made based on JICA's comments. In June 2018, both guides were finalized. The guides for the preparation of IFMP-RP and IFMP-SZ are attached in Appendices-10 and 11.

<Analysis of the Activity Result>

In the activities, active discussions were held, particularly on the definitions of the guide, the position of the guide, target entities of the guideline (entities responsible for the formulation of IFMP-RP), target river basins (rivers) of the guide. It was noted that the understanding of C/P on the position and necessity of IFMPs (both RP and SZ), the responsibilities of the relevant entities in the formulation of IFMPs (both RP and SZ), and the balance between the main river and the tributaries in IFMP (both RP and SZ) was deepened. It is also hoped that the activities for the formulation of IFMP-RP for the Magdalena River (principal plan) will be carried out with the guideline, that the principal river plan will be studied in the CARMAC, and that studies of other subzones will be carried out with the methodology of the guideline, since a better understanding of the content of the guide was achieved through the discussions. Additionally, it is considered that these activities can be advanced with legal force when the contents of the guide are incorporated into the Protocol for the preparation of the risk management component in POMCA and the Protocol is legalized. It is expected that the incorporation into the Protocol and its legalization will be carried out within a few years after the end of the project.

2.1.3.6. Works for the Entire Project Period

(16) Training in Japan: Completed in November 2017

Three series of trainings were held in Japan after discussions on the program and the guests. Below is a summary of the training.

<Summary of the First Series of Training in Japan >

1) Training Period

November 15, 2015 – December 3, 2015 (19 days)

2) Number of Participants

5 persons (2 executive level and 3 technicians)

Table 2.30 List of Participants

	Names	Position	Participation Period
I	UNGRD		
1	Mr. Julio Cesar González Velandia	Specialized Professional Subdirectorate of Knowledge of the Risk of Disasters to Position of Floods	November 15-December 3

II	IDEAM		
2	Mr. Nelson Omar Vargas Martínez (Ejecutivo)	Subdirector of Hydrology	November 15-November 22
III	CAR		
3	Mr. Cesar Clavijo Rios (Ejecutivo)	Technical Director/Zootechnician, Public Management Specialist	November 15-November 28
4	Ms. Heidy Milena Castillo Montano	Specialized Professional- Civil engineer specialized in environmental planning and integral management of natural resources	November 15-December 3
IV	Cundinamarca Department		
5	Mr. Jaime Matiz Ovalle	Specialized Professional- Administrative Unit of Risk Disasters Management of Cundinamarca	November 15-December 3

3) Contents of Training

The goal is to deepen the knowledge about the current situation of the management of floods and rivers in Japan (policies, strategies, administrative regime, process of formulation and content of the river and flood plan, role sharing among entities, measures implemented for the reduction of flood risk (structural and non-structural measures) to be used not only in project activities but also in the future formulation of strategies for flood and river management in Colombia ".

4) Places of Visit

- Ministry of Land, Infrastructure, Transport and Tourism (MLIT), Office of Water Management and Territorial Protection, River Plan Section, International Room
- MLIT, Kanto Region Management Office, Water Disaster Forecast Center
- MLIT, Kanto Region Management Office, Downstream River Office of Arakawa
- MLIT, Kanto Region Management Office, Upstream River Office of Arakawa
- MLIT, Chubu Region Management Office, Tenryu Dam Integral Management Office
- MLIT, Chubu Region Management Office, Office of Integral Development and Works of the Mibu River
- MLIT, Chubu Region Management Office, Upstream River Office of Tenryu River
- MLIT, Chubu Region Management Office, Downstream River Office of Kiso River
- MLIT, Kinki Region Management Office, Yodo River Office
- MLIT, Center of Integral Research of Technological Policy for National Territory, River Research Room
- MLIT, Center of Integral Research of Technological Policy for National Territory, Water-Related Disaster Research Room
- Japan Meteorology Agency, General Affairs Department, Planning Section, International Room
- Nagano Prefecture, Construction Office of Suwa
- Kiotanabe City, Office of City Construction with Safety
- Civil Engineering Research Institute ICHARM
- Civil Engineering Research Centre, Research Centre for Coexistence with Nature
- Centre for Future of the Humanity and Disaster Prevention

5) Training Results

Participants gave a presentation that summarized the results of the training in the final report meeting, on the last day of the training.

Comparing Japan with Colombia, the participants pointed out that Colombia has a decentralization policy and each entity involved takes independent measures without a guideline at the state level, while the Ministry of Land, Infrastructure, Transport and Tourism, a state-level entity, has the leadership in the management of rivers, taking into account each sector in Japan. They also highlighted the need to improve the quality of meteorological and hydrological forecasting and observation to issue more local alerts.

Regarding the objective of the river management plan, they commented that in Japan a term of 20-30 years is defined, while in Colombia the deadlines are much shorter. They expressed their desire to incorporate what they learned in these trainings in the action plans from a long-term point of view.

Regarding the River Law and the "Manual of map elaboration of areas with flood probability" that the participants requested during the trainings, we will continue working with this material in the project, and we will talk about how to use this knowledge in Colombia.

The First Series of Training in Japan (left: downstream the Arakawa River, right: Arakawa River Flood Control Museum)

6) Topics of interest of the participants of the training according to the results of the survey

A survey was carried out under the direction of TIC (Tokyo JICA International Center) after the series of training in Japan, on the results and design of the trainings as well as the learning and knowledge acquired in Japan. The following table shows the topics of interest of the participants according to the results of this survey.

Table 2.31 Topics of Interest of the Participants of the First Series of Training in Japan

Questions	Answers
Which topic was especially beneficial?	✓ Role sharing among relevant entities, collaboration and coordination among the state, prefectures and municipalities. ✓ Warning system, rain forecasting and disaster prediction ✓ River Law in Japan

Which topic was not included in the training and would like it to be included?	✓ Method of participation of residents Flood management in the prefecture
What knowledge, technique or technology did you acquire that can contribute to the solution of problems in your country?	✓ Policies on river development and management, flood risk reduction and disaster reduction Sediment management and works of measures to mitigate floods ✓ Disaster observation and prediction, flood warning management tools ✓ Coordination among the state, prefectures and municipalities under the leadership of the MLIT ✓ Development and distribution of flood hazard maps

7) Monitoring after the trainings

In the workshop held on February 16, 2016 and the JCC held on February 23, 2016, the participants of the first series of training sessions explained and shared the learning, knowledge and experiences acquired in the said capacitations with the C/P entities and relevant people. Likewise, a discussion was held on the ways in which these can be incorporated into flood risk management in Colombia. In a separate space, the participants informed JICA Colombia about what they learned in the said trainings.

With regard to the River Law in Japan, which was the most requested item from C/P in the survey, the expert team translated the English version into Spanish, and this was distributed among C/P. The theme of the River Law was also explained in the workshop held on May 11, 2016. Additionally, regarding the "Manual for the preparation of maps of areas with flood probability", the elaboration methodology was explained in the Manual in the workshop held on July 28, 2016.

< Summary of the Second Series of Training in Japan>

1) Training Period

Novermber 6, 2016 – November 23, 2016 (18 days)

2) Number of Participants

12 persons (4 persons at executive level and 8 technitians)

Table 2.32 List of Participants

	Names	Position	Period of Participation
I	UNGRD		
1	Mr. Martín Mauricio Mazo Villalobos	Specialized Professional of the Knowledge Subdivision	November 6-23
II	IDEAM		
2	Mr. Jorge Andrés Gonzáles Rojas	Specialized Professional of the Working Group of Environmental Networks	November 6-23
3	Mr. Fabio Andres Bernal	Specialized Professional and Assigned Professional to the Project	November 6-23
III	CAR		
4	Mr. Rafael Iván Robles López	Advisor of General Director for Disaster Risk	November 6-23

5	Ms. Maryeny Caraballo Hueso	Environmental Technician for POMCA	November 6-23
IV	Cundinamarca Department		
6	Mr. William Barreto Rodríguez	Deputy Director of Emergency Management and Attention	November 6-23
7	Mr. Wilson Leonard García Fajardo	Sub-director of Infrastructure Institute of Infrastructure and Concessions of Cundinamarca ICUU	November 6-23
V	MADS		
8	Mr. Henry Leonardo Gomez Castiblanco	Coordinator of the Risk Management Group	November 6-23
9	Ms. Luz Francy Navarro	Specialized Professional	November 6-23
VI	Regional Autonomous Corporation of the Great River of Magdalena –CORMAGDALENA		
10	Ms. Claudia Sofia Martinez	Specialized Professional	November 6-23
VII	Scientific Research Center of the Magdalena River Alfonso Palacios Rudas-CIRMAG		
11	Mr. Cesar Garay	Executive Director	November 6-9
VIII	National Planning Department DNP		
12	Mr. Diego Rubio	Professional of Management Support	November 6-23

3) Contents of Training

The goal is to deepen knowledge about the current situation of flood and river management in Japan (policies, strategies, administrative regime, formulation process and content of the river and flood plan, role sharing among entities, measures implemented to reducing flood risk (structural and non-structural measures) to be used not only in project activities but also in the future formulation of strategies for flood and river management in Colombia.

4) Place of Visit

- MLIT, Office of Water Management and Territorial Protection, River Plan Section, International Room
- MLIT, Kanto Region Management Office, Water Disaster Forecast Center
- MLIT, Kanto Region Management Office, Downstream River Office of Arakawa
- MLIT, Kanto Region Management Office, Upstream River Office of Arakawa
- MLIT, Kanto Region Management Office, Shimodate Office
- MLIT, Kanto Region Management Office, Keihin River Office
- MLIT, Chubu Region Management Office, Tenryu Dam Integral Management Office, Miwa Dam Management Section
- MLIT, Chubu Region Management Office, Office of Integral Development and Works of the Mibu River
- MLIT, Chubu Region Management Office, Upstream River Office of Tenryu River
- MLIT, Chubu Region Management Office, Downstream River Office of Kiso River
- MLIT, Center of Integral Research of Technological Policy for National Territory, River Research Room
- Japan Meteorology Agency, General Affairs Department, Planning Section, International Room
- Nagano Prefecture, Construction Office of Suwa
- Kanagawa Prefecture, Prefecture Ordination Office, River and Sewage Section
- Kanagawa Prefecture, Civil Engineering Office of Atsugi

- Yamato City, Hazard Management Section
- Civil Engineering Research Institute ICHARM
- Civil Engineering Research Centre, Research Centre for Coexistence with Nature

Taking into account the comments of C/P in the first series of trainings in Japan, the offices in charge of river administration at the prefecture level (specifically Kanagawa Prefecture) were added to the list of places to visit. Additionally, the sabo content was strengthened (one full day was assigned for the river visit and another full day for the visit to the sabo dam instead of visiting the river and the sabo dam in a single day in the Upstream River Office of Tenryu River). The visit to the flood damage site of 2016 (Kinu River under the jurisdiction of the Shimodate River Office) was also added.

5) Training Results.

Mr. Fabio Andrés Bernal from IDEAM held gave a presentation in English that summarizes the results of the training sessions at the final report meeting, on the last day of the training. After the presentation, each participant commented on the training sessions.

In this presentation, some key words were mentioned for the items learned in this series of training that can be applied or replicated in Colombia. The participants agreed that the introduction of sabo works and the study of the role sharing among the relevant entities are important. Discussions are planned in the remaining period of the project to define details on how to implement these items in Colombia. Regarding the sabo project, as described in 7) on the following page, the expert team explained and provided the manuals related to the purpose of carrying out the sabo project in Colombia. With regard to the role sharing, active discussions were held in the workshop of Output 3 and workshops on other results.

As what they expect from this project in the future, the manual for the sabo dam and the proposal for phase 2 of the project were mentioned.

Finally, as an idea about the content of next year's training for the participants, the relationship between the Ministry of Environment, the Ministry of Agriculture, Forestry and Fisheries and flood control measures as well as contents focused on the sabo works and conservation of the environment were mentioned.


The Second Series of Training in Japan (left: breaking point of the Kinu river dike, right: Wazo sabo dam)

6) Topics of interest of the participants of the training according to the results of the survey

A survey was conducted under the direction of TCI after the series of training in Japan, on the results and the design of the trainings as well as the learning and knowledge acquired in Japan. The following table shows the topics of interest of the participants according to the results of this survey.

Table 2.33 Topics of Interest of the Participants of the First Series of Training in Japan

Questions	Answers
Which topic was especially beneficial?	✓ Role sharing between relevant entities ✓ Works and sabo measures ✓ Monitoring system ✓ Record of past disasters ✓ Municipal measures to prevent disasters ✓ River Law in Japan ✓ Road map for disaster prevention, river recovery
Which topic was not included in the training and would like it to be included?	✓ Issues related to the formulation of IFMP
What knowledge, technique or technology did you acquire that can contribute to the solution of problems in your country?	✓ Observation and forecast using the soil-rainfall index ✓ Long-term infrastructure and investment management ✓ Principles of the protection of human life ✓ Collaboration and cooperation between relevant entities, the river administrator and river administration areas ✓ Measures of flavor and for driftwood, study of environmental impact of different measures and works ✓ Priority of measures to mitigate floods in river administration ✓ Use of river space

7) Monitoring after the Trainings

In the workshop held on February 10, 2017 and the JCC held on February 22, 2017, the participants of the second series of training explained what they learned in those trainings. They shared the knowledge and experiences with the assistants, presented what they learned in each place of visit, what differences exist between Japan and Colombia, what elements can be applied in Colombia, how to apply these elements, what should be implemented in Colombia in the future, and what type of support is required in this project and in the future, etc. Likewise, a discussion was held on the ways in which these can be incorporated in the management of flood risk in Colombia.

In the presentation of the report meeting on the last day of the training as well as in the survey, the participants of the training requested the inclusion of certain items in this project. Within these items, regarding the sabo manual, the Spanish version of the "Technical Criteria for River Works (including-SABO) Practical Guideline for Planning" was distributed among C/P in the workshop held on the 24th of February 2017. In addition, in the workshop held on June 5, 2017, the general content was explained and the Spanish version of "Technical Criteria Guideline to Establish the Sabo Master Plan for Debris Flow and Driftwood "and" The Law Related to the Promotion of Sediment Disaster Prevention Measures" were distributed among C/P.

< Summary of the Third Series of Training in Japan >

1) Training Period

November 5, 2017 - November 18, 2016 (14 days)

2) Number of Participants

7 persons (3 persons at executive level and 4 technicians)

Table 2.34 List of Participants

	Names	Position	Period of Participation
I	UNGRD		
1	Mr. Carlos Ivan Márquez	General Director	November 7-11
2	Mr. Juan Carlos Guzmn	UNGRD Municipal Coordinator	November 5-18
II	IDEAM		
3	Ms. Maria Costanza Rosero	Specialized Professional	November 5-18
4	Ms. Eliana Claritza Castro	Specialized Professional	November 7-18
III	CAR		
5	Mr. Carlos Antonio Bello Quintero	Director of environmental management and assessment	November 5-18
IV	Cundinamarca Department		
6	Ms. Magda Yamile Ruiz	Knowledge sub-director	November 5-18
V	MADS		
7	Ms. Yolanda Calderon Larragaña	Adviser- DGIRH	November 5-18

Mr. Carlos Iván Márquez had planned to participate in the first half of the training series in Japan for 7 days (arrival date: November 5, departure date: November 11) due to his professional commitment in the country of origin, although the series of training lasted for a total of 14 days. However, the arrival of Mr. Márquez was delayed by the intense rain the day before the scheduled departure date in Colombia. Therefore, Mr. Márquez arrived in Japan on November 7 and participated in the training from November 8.

Ms. Eliana Claritza Castro failed to board the planned flight due to this heavy rain in Colombia. Therefore, she arrived on November 7, instead of November 5, which was the expected date of arrival, and she participated in the training from November 8.

3) Contents of Training

The goal is to deepen the knowledge about the current situation of the management of floods and rivers in Japan (policies, strategies, administrative regime, process of formulation and content of the river and flood plan, role sharing between entities, measures implemented for the flood risk reduction (structural and non-structural measures)) to be used not only in project activities but also in the future formulation of strategies for flood and river management in Colombia.

4) Places of Visit

- MLIT, Office of Water Management and Territorial Protection, River Plan Section, International Room
- MLIT, Office of Water Management and Territorial Protection, Disaster Prevention Section, Disaster Mitigation Measures Room
- MLIT, Kanto Region Management Office, Keihin River Office
- MLIT, Chubu Region Management Office, Tenryu Dam Integral Management Office Miwa Dam Support Office
- MLIT, Chubu Region Management Office, Office of Integral Development and Works of the Mibu River
- MLIT, Chubu Region Management Office, Upstream River Office of Tenryu River
- MLIT, Chubu Region Management Office, Downstream River Office of Kiso River
- Ministry of Environment, Natural Environment Office
- Ministry of Agriculture, Forestry and Fisheries, Forestry and Fisheries Office
- Office of the Cabinet, Person responsible for disaster prevention
- Nagano Prefecture, Construction Office of Suwa
- Kanagawa Prefecture, Prefecture Territorial Development Office, Sewage Section
- Kanagawa Prefecture, Civil Engineering Office of Fujisawa
- Yamato City, Crisis Management Section
- JICA, Global Environment Department

Taking into account the requests of C/P, the Ministry of Environment, the Ministry of Agriculture and the Ministry of Agriculture, Forestry and Fisheries were added to the content of the first and second series of trainings, shortening the schedule in order to encourage the participation of persons at executive level.

5) Training Results

The participants gave a presentation in English that summarizes the results of the training in the final report meeting on the last day of the training. Ms. Yolanda Calderón Larragaña gave the presentation on behalf of the participants.

In this presentation, revisiting the mechanism of past disasters in Colombia, a greater clarification was mentioned in the role sharing in Colombia as a future task, through the comparison of the river administration system between Japan and Colombia. In addition, it was proposed a regional forecasting center be established to provide more detailed meteorological services. In addition, although this project is mainly concerned with measures against flooding in the middle basin of Rio Negro, it is necessary to analyze how to promote structural measures, mainly in the river areas of the upper reach, such as the sabo dams, among others. The participants agreed that these issues require additional discussions.

In this series of trainings, interest in learning more details about the role sharing among the Ministry of Land, Infrastructure, Transport and Tourism, the Ministry of the Environment and the Forestry Agency was expressed. Based on the request after last year's training, it is evident that it was positive to include visits to the Ministry of the Environment and the Forestry Agency in this year's visits. It was decided that the information that the participants consider necessary would be shared with them in the course of the project activities in an appropriate manner.

Also representatives of the South American and Central American Department, South America Section, JICA participated in this report meeting. It was suggested that it is necessary to exchange views with the Embassy of Colombia, the Ministry of Foreign Affairs, JICA Colombia, and the Embassy of Colombia in Japan to promote future planning. In addition, the Colombian Embassy in Tokyo, which attended the report meeting, expressed that it would like to contribute to further development of cooperation between the two countries in the future.

The Third Series of Training in Japan (left: retaintion reservoir of river Tsurumi, right: Wazo sabo dam)

6) Topics of interest of the participants of the training according to the results of the survey

A survey was conducted under the direction of TIC after the series of training in Japan, on the results and the design of the trainings as well as the learning and knowledge acquired in Japan. The following table shows the topics of interest of the participants according to the results of this survey.

Table 2.35 Topics of Interest of the Participants of the Third Series of Training in Japan

Questions	Answers
Which topic was especially beneficial?	✓ Administration of rivers in Japan and the Administration System ✓ Structural and non-structural measures ✓ Meteorological forecast ✓ Flood hazard map ✓ Retention reservoirs
Which topic was not included in the training and would like it to be included?	✓ Process of the construction of sabo model and its use ✓ Process of dissemination of information about the work for residents ✓ Hydrological forecast
What knowledge, technique or technology did you acquire that can contribute to the solution of problems in your country?	✓ Sediment control with sabo dams ✓ Principles of the integral flood risk management system ✓ Understanding the characteristics of the area and rivers ✓ Investment for disaster reduction and prevention Issuance of weather forecast and flood warning ✓ Flood hazard map in real time

7) Monitoring after the trainings

Ms. Yolanda Calderón from MADS, the representative of the participants of the third series of training in Japan, explained and shared the learning of the said training and its application in Colombia with the assistants, in the 4th JCC held on November 24 of 2017.

It is considered that it will be important to study methods to share the knowledge and lessons learned in training in Japan from now on. The training materials in Japan that were authorized by the entities that prepared them are expected to share in physical and digital format with the relevant Colombian entities.

(17) Preparation of Progress Report: Completed in January 2018

The work progress report (1st version) was prepared and delivered in January 2016 with a summary of the activities carried out, progress and results achieved between the start of the project (July 2015) and January 2016. The work progress report (2nd version) was prepared and delivered in August 2016 with a summary of the activities carried out up to August 2016. The work progress report (3rd version) is a summary of the activities carried out up to August 2017. The last work progress report (4th version) is a summary of the activities carried out up to January 2018, and was prepared and delivered at the end of January 2018. Only the Japanese version was prepared, and was delivered to JICA.

(18) Preparation of Project Brief Note: Completed in July 2018

In order to achieve a better understanding of the objective, activities and results of this project both in Colombia and the Japanese citizens, the project brief note was elaborated as part of the communicative material. At the beginning of the project, it only contained "Background and Challenges of the Project" and "Approach to Problem Solving". However, in August 2016, "Results of the Approaches" and "Efforts and Lessons in the Project Implementation" were added. In this version (August 2017), the contents of the activities implemented from September 2016 to August 2017 were added. In July 2018, the contents of the activities implemented from September 2016 to August 2017 were added. It was updated with the preparation of the conclusion report. The latest version of the project brief note is attached in Appendix-12.

(19) Monitoring: Completed in March 2018

Periodic monitoring of the project was carried out through the preparation of the monitoring sheet that summarizes the project's inputs, activities and the results achieved. The expert team prepared the draft, explained it and consulted with C/P, the review and correction were made, and then a presentation was given to JICA Colombia. The monitoring was planned for every 6 months initially; however, in August 2015 after the start of the project, the plan was reviewed with JICA and contents of the activities and the activity periods in Colombia were adjusted, and finally 7 monitorings were carried out so far, in November 2015, March 2016, August 2016, November 2016, February 2017, and August 2017 and March 2018. The monitoring sheets are attached in Appendix-13. The last monitoring was carried out in March 2018, and it was decided the results of the project and the degree of achievement of the goals would be confirmed in the conclusion report.

Additionally, in order to obtain approval for the activity plan, confirm the progress and review PDM, JCC was held as presented in the Table 2.36.

Table 2.36 List of JCC

No.	Date	Contents
1	August 13, 2015	· Project Framework · Executive agencies of the project · Monitoring report
2	February 23, 2016	· Approval of new C/P entity · Executive entities of the project · Progress in the project · Dissemination of the experience of training in Japan
3	February 22, 2017	· Progress in the project · Important items for strengthening flood control · Dissemination of the experience of training in Japan · PO correction · Future expectations
4	November 24, 2018	· Progress in the Project and results · Future activities for flood risk management and cooperation of relevant organizations · Share experience in training in Japan · PO Correction · Future perspectives
5	June 28, 2018	· Confirmation of project activities and products · Confirmation of the degree of achievement with the results and the goals of the project · The plan of future activities, the collaboration among the relevant entities and the monitoring in order to achieve the overall goal

In the 5th JCC, the future activities for the achievement of the overall goal were confirmed, and the monitoring plan for this purpose as well as the related indicators for the overall goal in PDM were approved. Additionally, each entity expressed the importance of the implementation of the plan formulated in the project, the use and proliferation of the project outputs at a national level, the continuation and deepening of the activities related to the flood risk management; the agreement on creating a space to discuss the continuation of activities in the future in July, 2018, under the coordination of UNGRD.

Also, MADS reported the official signing of the document of collaboration in future activities among MADS, CORMAGDALENA, and IDEAM and expressed it hoped that the implementation of these activities would continue and that Japan would support them. MADS informed that the Results of the project would be presented in the CARMAC meeting for the Magdalena-Cauca basin on June 29th, the day after the JCC, and that they would be used as inputs for the implementation of the strategic plan.

Additionally, participants discussed the activities to include the formulation of flood control plans in the Magdalena in the national development plan to be formulated upon the inauguration of the new presidency, as well as the incorporation of the activities related to flood risk in each entity's annual plan (to be able to finance the implementation of these activities).

In the seminar after the JCC, C/P explained the products of the project such as IFMP-RP (provisional plan) for the Magdalena River, IFMP-SZ (provisional plan) for the Rio Negro basin, as well as the road map and the corresponding guidelines to the members of the Basin Committee in

Rio Negro and new participants, who were mainly technicians from the Department or CAR, apart from the participants of JCC. They also actively exchanged opinions on the future activities.

The Minutes of JCCs are attached in Appendix-14.

(20) Preparation of Final Report: Completed in 2018

The draft report was prepared in May 2018, and the content was confirmed and discussed with C/P in the workshops between May and June 2018. The correction was made to reflect the content of the JICA discussion and comments, and the final version was prepared in July 2018.

2.1.3.7. Other Works

(A1) Participation in the Regional Platform in the Americas: held in June 2018

The Regional Platform in the Americas was held between June 20 and 22 in June 2018 in the city of Cartagena, Colombia, under the direction of UNISDR and UNGRD. In this event, JICA, along with IDEAM, held a session on flood risk management (Flood Risk Management: River Management (Progress and Pending Challenges), from 15:40-17:10 on the 20th. A stand was set up for the exhibitions during the period of the The expert team participated in the said session and in the management of the PR panel in the stand, where the informative materials about the project were exhibited, and in the distribution of the project brief note. In the session, the project brief note was distributed to the participants as part of the advertising activity. The summary of the session and the photograph of the stand are presented below.

Convention Center of Cartagena where the event was held (left: exterior, right: main auditorium)

The session on flood risk management (left: the session, right: Specialist Baba giving the master presentation)

The JICA stand (left: the stand, right: PR panel of this project)

2.2. Achievements of the Project

2.2.1. Outputs and Indicators (Target values and actual values achieved at completion)

9 indicators were achieved as shown in the Table 2.37, defined for each item in PDM.

Table 2.37 9 Indicators Defined for Each Item in PDM

No.	Indicator	Degree of achievement	Method of measurement
Output 1: Capacity on flood risk assessment is improved and concept of integrated flood management planning and river basin management is introduced			
1-1	Knowledge / understanding at IDEAM and CAR on river planning aspect in a) hydrologic & hydraulic modeling, and b) flood hazard/risk mapping	Achieved	Self-evaluation through surveys
1-2	IDEAM, UNGRD and CAR's capacity enhancement on the technology of flood risk mapping including vulnerability analysis using GIS	Achieved	Self-evaluation through surveys
1-3	Knowledge / understanding at IDEAM, UNGRD, CAR, Department and MADS on river basin wise IFMP	Partially achieved	Existence of reports
Output 2: Capacity on flood forecasting, warning and information dissemination to relevant organizations is improved (mainly IDEAM and UNGRD)			
2-1	Knowledge / understanding at IDEAM and CAR on hydrologic observation and data analysis	Achieved	Self-evaluation through surveys
2-2	Recommendation on improvement of IDEAM's flood forecasting and warning	Achieved	Existence of recommendations
Output 3: Roles and responsibility of the central and local government for flood risk reduction are elucidated and enhanced (mainly UNGRD and IDEAM)			
3-1	Issues clarified and recommendations draw regarding flood risk management among UNGRD, IDEAM, CAR, MADS, department and municipalities.	Achieved	Existence of recommendations
3-2	Matrix of information inventory related to flood management (entity and type of information)	Achieved	Existence of the information location matrix
Output 4: Capacity of flood management planning is enhanced through formulation of integrated flood management plan (IFMP) in the pilot river basin			
4-1	Integrated Flood Management Plan (IFMP) of pilot river basin	Achieved	Existence of IFMP
4-2	IFMP formulation guideline developed	Achieved	Existence of guidelines

As shown in Table 2.37, for indicators 1-1, 1-2, and 2-1, a self-evaluation was performed comparing knowledge before and after the project. This evaluation was carried out in April 2018, before the end of the project, both for the evaluation of the capacities before and after the project. The surveys were distributed via the email on April 11, with the deadline of April 25. An email was sent to the individuals who had not yet turned in the survey a few days before the deadline, requesting that the information be sent. The survey is attached in Appendix-13-2. 30 people were selected to be surveyed, with the requirement of having attended at least 5 workshops in this project. Of these 30 people, 17 people responded to the survey.

Table 2.38 Respondents of the Survey

Entity	Title	Names	Participation of Training in Japan
UNGRD	Officer (specialist)	Joana M. Pérez	No
	Officer (specialist)	Julio González Velandia	1st training in Japan
IDEAM	Hydrology Director	Omar Vargas Martínez	1st training in Japan
	Technician (specialist)	Fabio Andrés Bernal Quiroga	2nd training in Japan
	Technician (specialist)	Nelsy Verdugo	No
CAR	Technician (specialist)	Maryeny Caraballo	2nd training in Japan
	Technician (specialist)	Juan Carlos Loaiza	No
Department of Cundinamarca	Deputy director of the administrative unit of disaster risk management	Wilson Leonard García F.	2nd training in Japan
	Deputy director of the knowledge section of the administrative unit of disaster risk management	William Barreto R.	2nd training in Japan
	Director de la sección del conocimiento de la unidad administrativa de la gestión del riesgo de desastres	Magda Yamile Ruiz	3rd training in Japan
	Officer of the administrative unit of disaster risk management (specialist)	Jaime Matíz Ovalle	1st training in Japan
	Officer of the agriculture section	Onofre Sierra Gómez	No
	Officer of the planning secretariat	María Cristina Ruiz	No
MADS	Technical consultant	Yolanda Calderón	3rd training in Japan
	Technician (specialist)	Luz Francy Navarro	2nd training in Japan
CIRMAG (CORMAGDALENA)	Ex director	Cesar Garay Bohórquez	2nd training in Japan
National University of Colombia	University profesor	Eduardo Bravo	No

Below is the degree of achievement of each indicator.

<u>Indicator No. 1-1: Knowledge / understanding at IDEAM and CAR on river planning aspect in hydrologic & hydraulic modeling, and flood hazard/risk mapping</u>

For this indicator, C/P conducted a self-assessment with a survey and compared the comprehension levels before and after the implementation of (or the participation in) this project.

The survey with the 6 questions in the Table 2.39 was distributed to the respondents, who carried out a self-assessment of the degree of understanding before and after this project.

Table 2.39 Survey on Indicator 1-1

No.	Questions
Hydraulic and hydraulics modeling	
B.1-1-1.	As a preparation work for modeling, methodology of analyses on river characteristic such as 1) methodology of analyses on longitudinal profile of river elevation, longitudinal profile of channel width and longitudinal profile of channel flow capacity, which were explained in the Technical Guideline prepared in the Project, and 2) methodology of field survey on the river
B.1-1-2.	As a preparation work for modeling, methodology of analyses on hydrological conditions such as preparation of data availability table of all stations, preparation of the time series data set for each station, and preparation of list and ranking of past annual maximum value of each station, which were explained in the Technical Guideline prepared in the Project
B.1-1-3.	As a preparation work for modeling, methodology of analyses on flood conditions such as collection and arrangement of data of past flood events, analyses on flood phenomena and/or flood damages in significant flood events, methodology of field survey on flood phenomena, and analysis of relation between flood phenomena and hydrological conditions
B.1-1-4.	Methodology of hydrologic & hydraulic modeling such as theory of modeling, usage of modeling/simulation software like HEC-RAS and/or iRIC, and method of calibration
Flood hazard/risk mapping	
B.1-1-5.	Methodology for the elaboration of hazard maps when calculating the results of the simulation, such as the flood area and/or the flood depths of several return periods
B.1-1-6.	Methodology of utilization of simulation results to planning on river and/or flood risk management, for example, methodology of setting the target flood considering changes of flood area and/or flood water depths depending on changes of return periods

The self-assessment was carried on the scale of 1-5, 1 being the minimum comprehension and 5 being the maximum comprehension. The average of the score of each survey item is shown in the following figure. In all 6 items, increase in the degree of understanding was observed after the implementation of this project. Especially, in the item B. 1-1-3 related to the characteristics of flood, a considerable increase in the degree of understanding is observed through several workshops and field surveys.

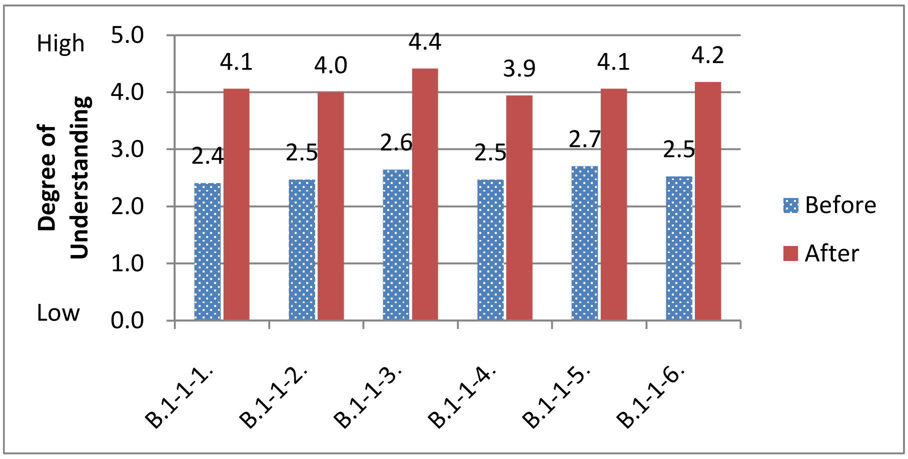
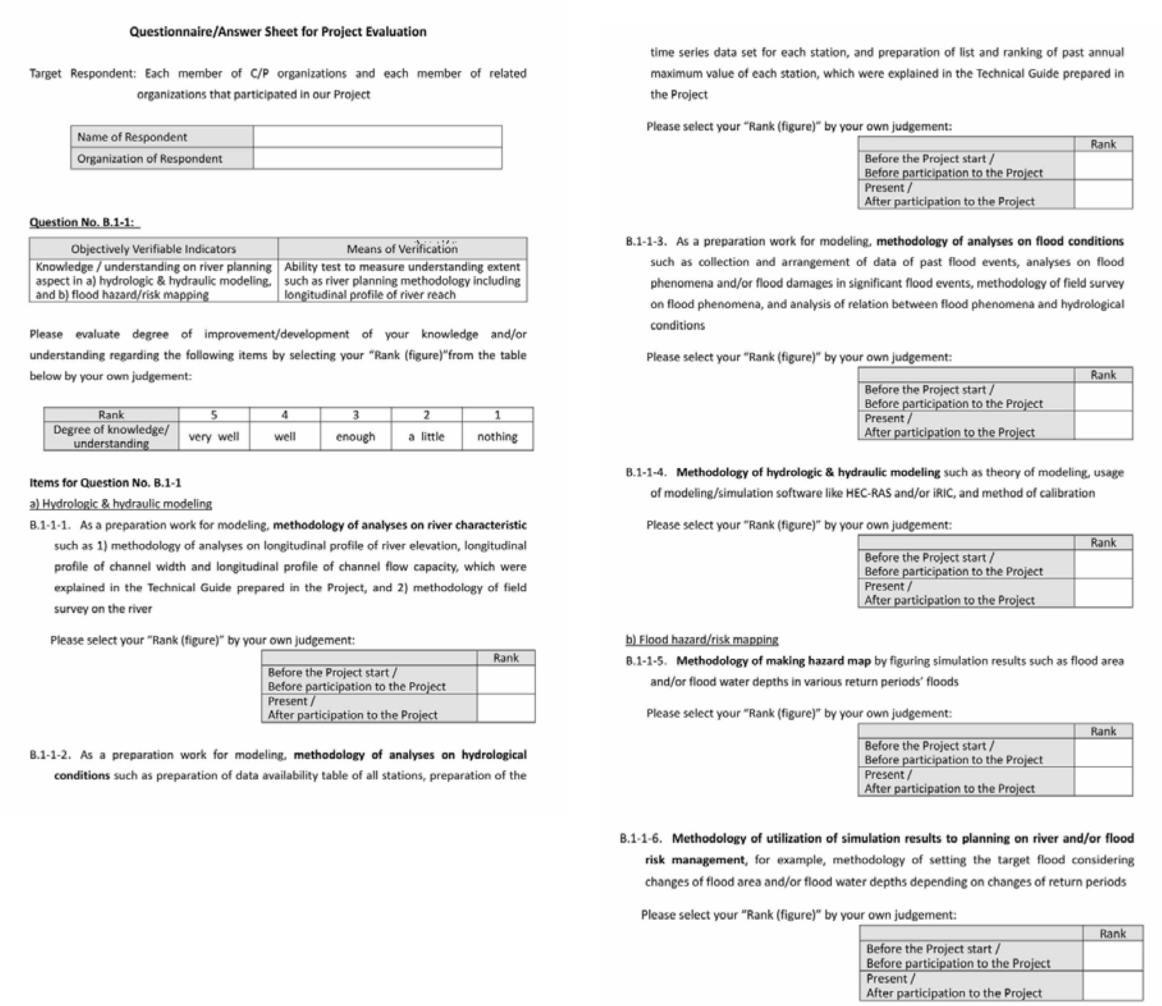


Figure 2.14 Result of the Survey for Indicator 1-1(average of the results of the self-evaluation (N = 17))

The survey used to confirm the degree of understanding is attached as a reference in Figure 2.15.



Questionnaire/Answer Sheet for Project Evaluation

Target Respondent: Each member of C/P organizations and each member of related organizations that participated in our Project

Name of Respondent	
Organization of Respondent	

Question No. B.1-1:

Objectively Verifiable Indicators	Means of Verification
Knowledge / understanding on river planning aspect in a) hydrologic & hydraulic modeling, and b) flood hazard/risk mapping	Ability test to measure understanding extent such as river planning methodology including longitudinal profile of river reach

Please evaluate degree of improvement/development of your knowledge and/or understanding regarding the following items by selecting your "Rank (figure)"from the table below by your own judgement:

Rank	5	4	3	2	1
Degree of knowledge/ understanding	very well	well	enough	a little	nothing

Items for Question No. B.1-1

a) Hydrologic & hydraulic modeling

B.1-1-1. As a preparation work for modeling, **methodology of analyses on river characteristic** such as 1) methodology of analyses on longitudinal profile of river elevation, longitudinal profile of channel width and longitudinal profile of channel flow capacity, which were explained in the Technical Guide prepared in the Project, and 2) methodology of field survey on the river

Please select your "Rank (figure)" by your own judgement:

	Rank
Before the Project start / Before participation to the Project	
Present / After participation to the Project	

B.1-1-2. As a preparation work for modeling, **methodology of analyses on hydrological conditions** such as preparation of data availability table of all stations, preparation of the time series data set for each station, and preparation of list and ranking of past annual maximum value of each station, which were explained in the Technical Guide prepared in the Project

Please select your "Rank (figure)" by your own judgement:

	Rank
Before the Project start / Before participation to the Project	
Present / After participation to the Project	

B.1-1-3. As a preparation work for modeling, **methodology of analyses on flood conditions** such as collection and arrangement of data of past flood events, analyses on flood phenomena and/or flood damages in significant flood events, methodology of field survey on flood phenomena, and analysis of relation between flood phenomena and hydrological conditions

Please select your "Rank (figure)" by your own judgement:

	Rank
Before the Project start / Before participation to the Project	
Present / After participation to the Project	

B.1-1-4. **Methodology of hydrologic & hydraulic modeling** such as theory of modeling, usage of modeling/simulation software like HEC-RAS and/or iRIC, and method of calibration

Please select your "Rank (figure)" by your own judgement:

	Rank
Before the Project start / Before participation to the Project	
Present / After participation to the Project	

b) Flood hazard/risk mapping

B.1-1-5. **Methodology of making hazard map** by figuring simulation results such as flood area and/or flood water depths in various return periods' floods

Please select your "Rank (figure)" by your own judgement:

	Rank
Before the Project start / Before participation to the Project	
Present / After participation to the Project	

B.1-1-6. **Methodology of utilization of simulation results to planning on river and/or flood risk management**, for example, methodology of setting the target flood considering changes of flood area and/or flood water depths depending on changes of return periods

Please select your "Rank (figure)" by your own judgement:

	Rank
Before the Project start / Before participation to the Project	
Present / After participation to the Project	

Figure 2.15 Survey on Indicator 1-1

Indicator No. 1-2: IDEAM, UNGRD and CAR's capacity enhancement on the technology of flood risk mapping including vulnerability analysis using GIS

For this indicator, a survey was distributed among C/P members, who conducted a self-assessment of the degree of understanding before and after this project. The survey contained the following 5 questions in Table 2.40.

Table 2.40 Survey on Indicator 1-2

No.	Questions
B.1-2-1.	Concept and methodology of Japanese flood risk evaluation such as flood control economic survey and B/C analysis
B.1-2-2.	Regarding flood risk evaluation / flood control economic survey, 1) types of necessary data such as assets of houses and buildings in flood prone area, 2) present status of each data in Colombia, and 3) responsible organizations of each data in Colombia
B.1-2-3.	Concrete methods of flood risk evaluation / flood control economic survey by using GIS, such as 1) converting simulated flood area and assets data to mesh data, and 2) analysis by the mesh
B.1-2-4.	Methodology of B/C calculation by comparison of benefit and cost of flood damage reduction measures
B.1-2-5.	Methodology of preparation of disaster risk reduction map (DRR map), which include flood area, shelter, evacuation route, emergency contact information and others

Figure 2.16 shows the average of the score of each survey item. In all the 5 items, increase in the degree of comprehension is observed after the implementation of this project. Especially, the degree of comprehension was improved considerably in the B/C analysis of B.1-2-1 and the disaster risk reduction map in B.1-2-5 after the implementation of this project, and it is considered that the project contributed to the strengthening of the capacities of C/P.

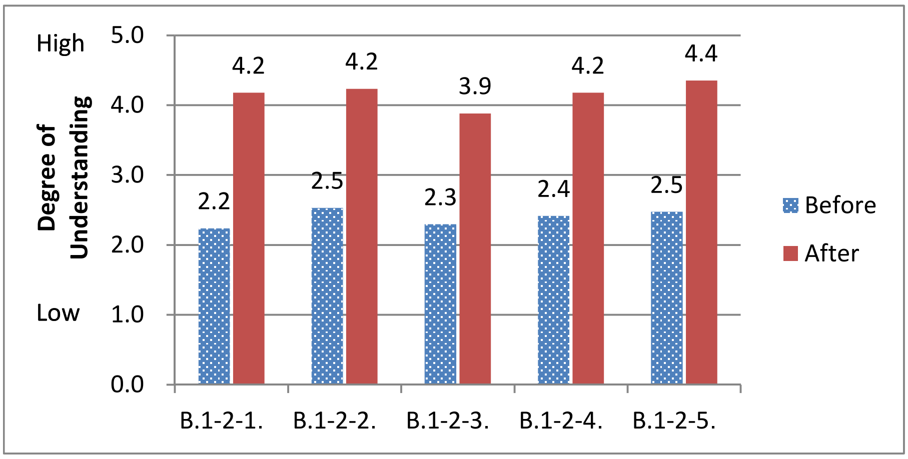
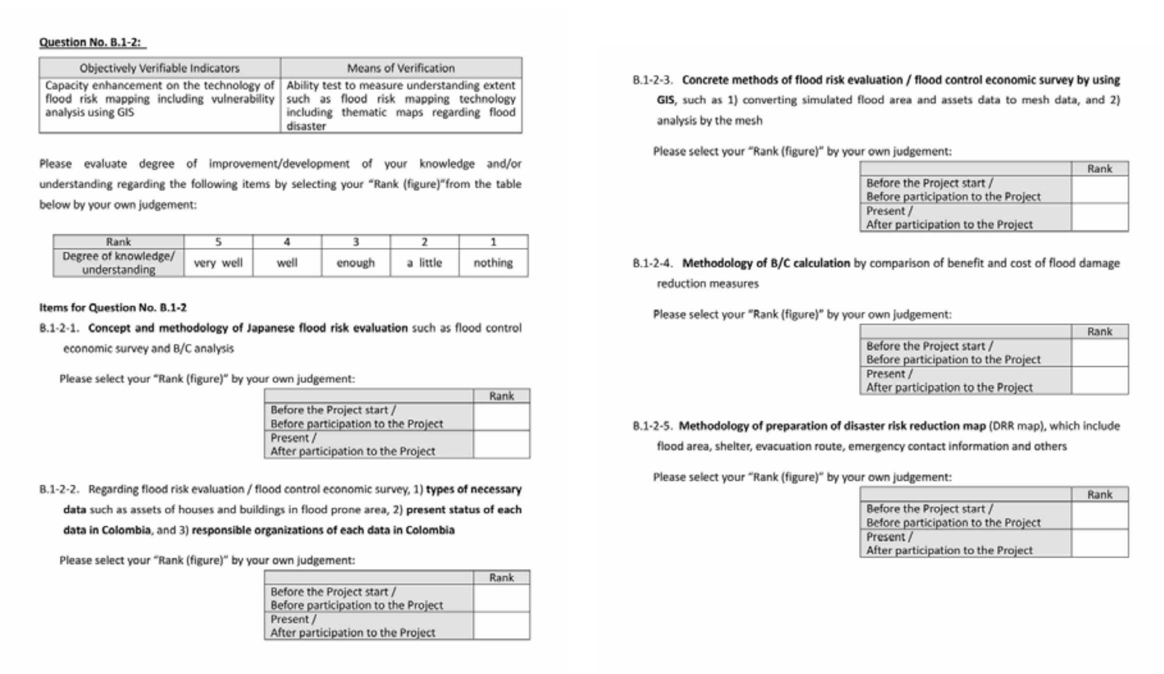


Figure 2.16 Result of the Survey for Indicator 1-2 (average of the results of the self-evaluation (N = 17))

The survey used to confirm the degree of understanding is attached as a reference in Figure 2.17.



Question No. B.1-2:

Objectively Verifiable Indicators	Means of Verification
Capacity enhancement on the technology of flood risk mapping including vulnerability analysis using GIS	Ability test to measure understanding extent such as flood risk mapping technology including thematic maps regarding flood disaster

Please evaluate degree of improvement/development of your knowledge and/or understanding regarding the following items by selecting your "Rank (figure)"from the table below by your own judgement:

Rank	5	4	3	2	1
Degree of knowledge/ understanding	very well	well	enough	a little	nothing

Items for Question No. B.1-2

B.1-2-1. **Concept and methodology of Japanese flood risk evaluation** such as flood control economic survey and B/C analysis

Please select your "Rank (figure)" by your own judgement:

	Rank
Before the Project start / Before participation to the Project	
Present / After participation to the Project	

B.1-2-2. Regarding flood risk evaluation / flood control economic survey, 1) **types of necessary data** such as assets of houses and buildings in flood prone area, 2) **present status of each data in Colombia**, and 3) **responsible organizations of each data in Colombia**

Please select your "Rank (figure)" by your own judgement:

	Rank
Before the Project start / Before participation to the Project	
Present / After participation to the Project	

B.1-2-3. **Concrete methods of flood risk evaluation / flood control economic survey by using GIS**, such as 1) converting simulated flood area and assets data to mesh data, and 2) analysis by the mesh

Please select your "Rank (figure)" by your own judgement:

	Rank
Before the Project start / Before participation to the Project	
Present / After participation to the Project	

B.1-2-4. **Methodology of B/C calculation** by comparison of benefit and cost of flood damage reduction measures

Please select your "Rank (figure)" by your own judgement:

	Rank
Before the Project start / Before participation to the Project	
Present / After participation to the Project	

B.1-2-5. **Methodology of preparation of disaster risk reduction map** (DRR map), which include flood area, shelter, evacuation route, emergency contact information and others

Please select your "Rank (figure)" by your own judgement:

	Rank
Before the Project start / Before participation to the Project	
Present / After participation to the Project	

Figure 2.17 Survey on Indicator 1-2

<u>Indicator No. 1-3: Knowledge / understanding at IDEAM, UNGRD, CAR, Department and MADS on river basin wise IFMP</u>

For this indicator, the progress was evaluated by confirming whether or not there is an evaluation report (or reports) based on the knowledge acquired in this project in each C/P entity.

Upon confirming with the C/P entities, it was learned that all the C P entities prepared reports on the participation in the training in Japan carried out in this project; however, it was not possible to confirm the preparation of other types of reports. As for the reports on training in Japan, a copy of 3 reports was obtained in UNGRD, 4 reports in IDEAM, 2 reports in CAR and 1 report in MADS. It is hoped that these reports will share knowledge not only among the participants of training in Japan but also among other officials in the entities. However, in the Department it was not possible to obtain copies of these reports; it is feared that there is not a sufficient system to share the reports internally. In order to share the knowledge acquired in this project with as many people as possible, it is hoped the control system for the reports would be strengthened. Since it was only possible to obtain copies of the reports of certain entities, although we were informed that the reports were prepared in all the C/P entities, it was concluded that the degree of achievement is "partially achieved"..

<u>Indicator No. 2-1: Knowledge / understanding at IDEAM and CAR on hydrologic observation and data analysis</u>

For this indicator, a survey was distributed among C/P members, who conducted a self-assessment of the degree of understanding before and after this project. The survey contained the 5 questions in Table 2.41.

Table 2.41 Survey on Indicator 2-1

No.	Questions
B.2-1-1.	Expected/necessary accuracy (observation frequency and/or installation density of observation stations) of hydrological observation and flood forecast & early warning corresponding to flood phenomena in each river basin scale (slow flood in principal river like Magdalena River, flash flood or debris flow in Hydrographic Subzone like Rio Negro basin, etc.)
B.2-1-2.	Calculation method of time lag of high water levels (flood wave propagation velocity) from upstream to downstream through analyzing water level data or using empirical formula, and its utilization for early warning through collaboration between upstream and downstream municipalities
B.2-1-3.	Quantitative consideration on interval time from issuance of flood warning to evacuation completion (Estimation of required time for warning dissemination and evacuation)
B.2-1-4.	Validation on accuracy of hydrological data and the analysis results through making interview with residents and/or summarizing the past disaster records
B.2-1-5.	Characteristics/differences of rainfall phenomena observed by weather radar depending on type/specification (wave length, spatial resolution, etc.) of the radar

The average of the score of each survey item is shown in Figure 2.18. In all 5 items, an increase in the degree of understanding was observed after the implementation of this project. Especially, the degree of comprehension about the lead time in the evacuation was greatly improved in B.2-1-3 and the analysis of the hydrological data in B.2-1-4 after the implementation of this project, and it is considered that the project contributed to the strengthening of C/P capacities. Regarding meteorological radars in B.2-1-5, the level of understanding is relatively low, although an improvement was observed before and after the project. This item requires reinforcement in the future.

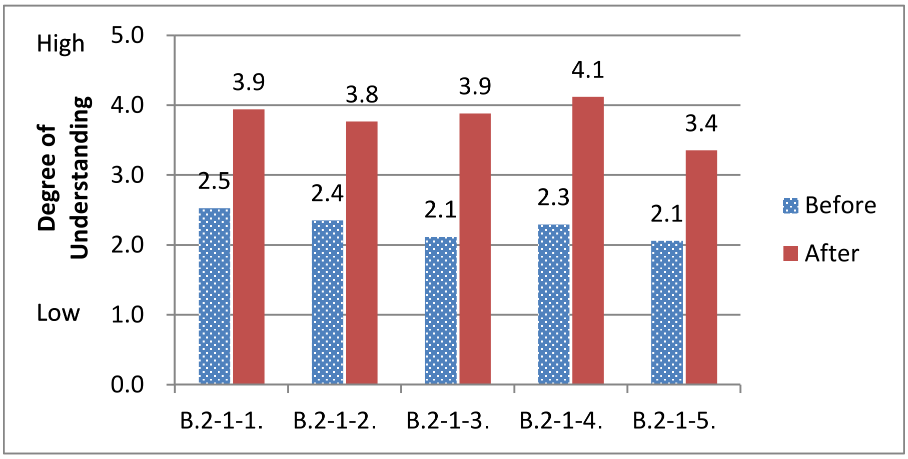
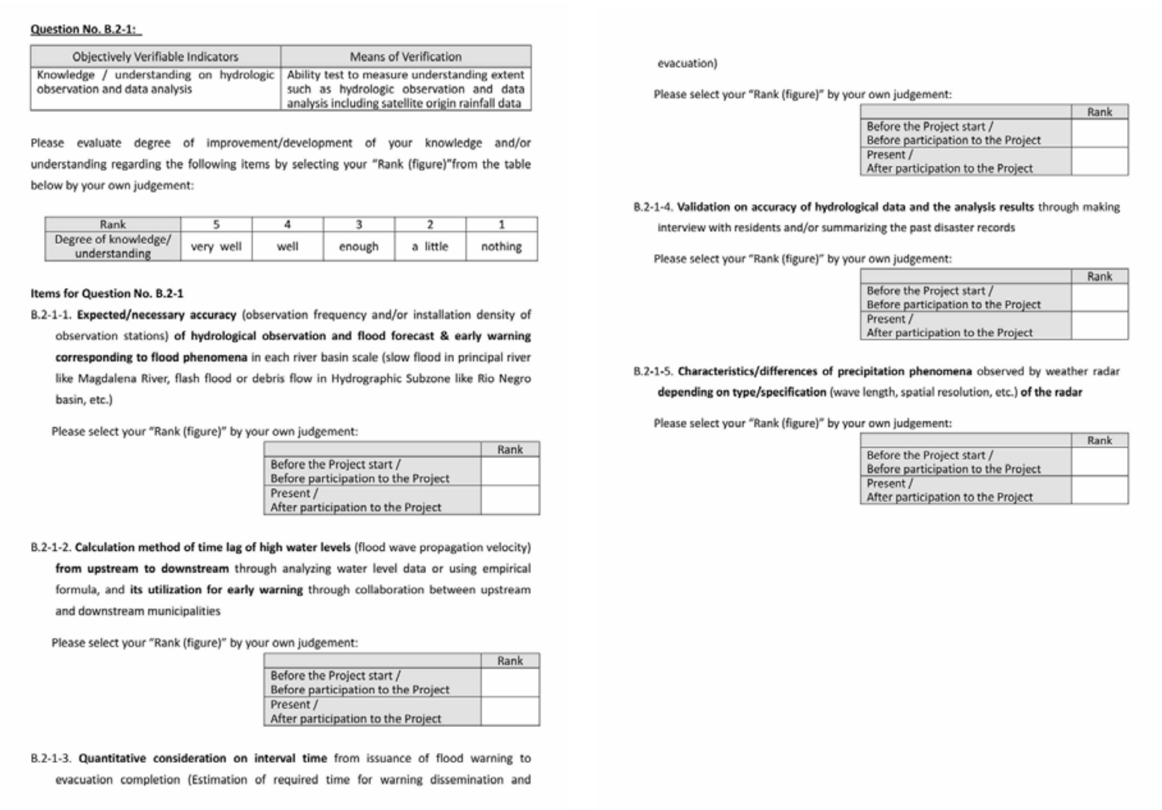


Figure 2.18 Result of the Survey for Indicator 2-1 (average of the results of the self-evaluation (N = 17))

The survey used to confirm the degree of understanding is attached as a reference in Figure 2.19.



Question No. B.2-1:

Objectively Verifiable Indicators	Means of Verification
Knowledge / understanding on hydrologic observation and data analysis	Ability test to measure understanding extent such as hydrologic observation and data analysis including satellite origin rainfall data

Please evaluate degree of improvement/development of your knowledge and/or understanding regarding the following items by selecting your "Rank (figure)"from the table below by your own judgement:

Rank	5	4	3	2	1
Degree of knowledge/ understanding	very well	well	enough	a little	nothing

Items for Question No. B.2-1

B.2-1-1. **Expected/necessary accuracy** (observation frequency and/or installation density of observation stations) **of hydrological observation and flood forecast & early warning corresponding to flood phenomena** in each river basin scale (slow flood in principal river like Magdalena River, flash flood or debris flow in Hydrographic Subzone like Rio Negro basin, etc.)

Please select your "Rank (figure)" by your own judgement:

	Rank
Before the Project start / Before participation to the Project	
Present / After participation to the Project	

B.2-1-2. **Calculation method of time lag of high water levels** (flood wave propagation velocity) **from upstream to downstream** through analyzing water level data or using empirical formula, and **its utilization for early warning** through collaboration between upstream and downstream municipalities

Please select your "Rank (figure)" by your own judgement:

	Rank
Before the Project start / Before participation to the Project	
Present / After participation to the Project	

B.2-1-3. **Quantitative consideration on interval time** from issuance of flood warning to evacuation completion (Estimation of required time for warning dissemination and evacuation)

Please select your "Rank (figure)" by your own judgement:

	Rank
Before the Project start / Before participation to the Project	
Present / After participation to the Project	

B.2-1-4. **Validation on accuracy of hydrological data and the analysis results** through making interview with residents and/or summarizing the past disaster records

Please select your "Rank (figure)" by your own judgement:

	Rank
Before the Project start / Before participation to the Project	
Present / After participation to the Project	

B.2-1-5. **Characteristics/differences of precipitation phenomena** observed by weather radar **depending on type/specification** (wave length, spatial resolution, etc.) **of the radar**

Please select your "Rank (figure)" by your own judgement:

	Rank
Before the Project start / Before participation to the Project	
Present / After participation to the Project	

Figure 2.19 Survey on Indicator 2-1

<u>Indicator No. 2-2: Recommendation on improvement of IDEAM's flood forecasting and warning</u>

The indicator for this item evaluates the progress based on recommendations elaborated by the expert team for the improvement of IDEAM's flood forecasts and warnings. These recommendations are found in Appendix-4.

Indicator No. 3-1: Issues clarified and recommendations draw regarding flood risk management among UNGRD, IDEAM, CAR, MADS, department and municipalities.

The indicator for this item evaluates the progress based on recommendations elaborated by the expert team for the improvement of the role sharing. These recommendations are found in Appendix-5.

Indicator No. 3-2: Matrix of information inventory related to flood management (entity and type of information)

The indicator for this item evaluates the progress based on whether the information inventory matrix is organized. This matrix was organized in Guideline for Formulation of IFMP-SZ and is attached in Appendix-11.

Indicator No. 4-1: Integrated Flood Management Plan (IFMP) of pilot river basin

The indicator for this item evaluates the progress based on the elaboration of the Integrated Flood Risk Management Plan. These plans are found in Appendix-6 and 8.

Indicator No. 4-2: IFMP formulation guideline developed

The indicator for this item evaluates the progress based on the creation of the guideline for the elaboration of the Integrated Flood Risk Management Plan. These guidelines are found in Appendix-10 and 11.

<Degree of Achievement of the Outputs>

According to the evaluation of the degree of achievement of each indicator, the degree of achievement of each Output can be evaluated as follows.

Table 2.42 Degree of Achievement of Each Output

Output	Degree of achievement
Output 1: Capacity on flood risk assessment is improved and concept of integrated flood management planning and river basin management is introduced	Partially achieved
Output 2: Capacity on flood forecasting, warning and information dissemination to relevant organizations is improved (mainly IDEAM and UNGRD)	Achieved
Output 3: Roles and responsibility of the central and local government for flood risk reduction are elucidated and enhanced (mainly UNGRD and IDEAM)	Achieved
Output 4: Capacity of flood management planning is enhanced through formulation of integrated flood management plan (IFMP) in the pilot river basin	Achieved

2.2.2. Project Purpose and Indicators (Target values and actual values achieved at completion)

The project purpose is "capacity of Colombian institutions in flood management is enhanced." The Table 2.43 shows the four indicators defined for this purpose, which indicate that in general the project purpose was achieved.

Table 2.43 Four Indicators Defined in PDM for Project Purpose and its Degree of Achievement

No.	Indicatores	Logro
1.	Planning capacity regarding flood management	Partially achieved
2.	Capacity of flood forecasting and warning	Achieved
3.	Effective use and share of data for flood management	Achieved
4.	IFMP formulation guideline developed	Achieved

Indicator No. 1: Planning capacity regarding flood management

For this indicator, the progress was evaluated by confirming whether or not there is an evaluation report (or reports) in each C/P entity.

Upon confirming with the C/P entities, it was learned that all the C P entities prepared reports on the participation in the training in Japan carried out in this project; however, it was not possible to confirm the preparation of other types of reports. As for the reports on training in Japan, a copy of 3 reports was obtained in UNGRD, 4 reports in IDEAM, 2 reports in CAR and 1 report in MADS. It is hoped that these reports will share knowledge not only among the participants of training in Japan but also among other officials in the entities. However, in the Department it was not possible to obtain copies of these reports; it is feared that there is not a sufficient system to share the reports internally. In order to share the knowledge acquired in this project with as many people as possible, it is hoped the control system for the reports would be strengthened.

Since it was only possible to obtain copies of the reports of certain entities, although we were informed that the reports were prepared in all the C/P entities, it was concluded that the degree of achievement is "partially achieved".

Indicator No. 2: Capacity of flood forecasting and warning

For this indicator, the progress was evaluated confirming the status of the hydrological stations for the flood early warning system. During the project, it was confirmed that IDEAM has installed 36 new hydrological stations at the national level. Although the installation of new stations was not confirmed in other C/P entities, it was confirmed that the Department of Cundinamarca is studying the plan to strengthen the early warning system through the installation of real-time stations within the department.

Indicator No. 3: Effective use and share of data for flood management

For this indicator, the progress was evaluated through a survey on the exchange and the frequency of use of the data among the participating and relevant entities and of this project. The survey was distributed among the main C/P entities; MADS, UNGRD, and CAR responded an improved collaboration between participating and relevant entities through this project. Below is the response of MADS as a reference.

"At the beginning of the project, MADS was not collaborating with other entities in a meaningful manner, and the project strengthened the relations among MADS and other entities. Relevant information for the implementation of the project was shared through the representatives of the entities, and the relation among relevant entities was improved ".

The survey used to confirm the degree of understanding of indicators 1, 2 and 3 is attached as a reference in Figure 2.20.

Questionnaire/Answer Sheet for Project Evaluation

Target Respondent: Leaders of each C/P organization members and Leaders of organization members that participated in our Project

Name of Respondent	
Organization of Respondent	

Question No. A.1:

Objectively Verifiable Indicators	Means of Verification
Planning capacity regarding flood management	Evaluation report of professional staff from all the institutions' understanding of integrated flood management planning and river basin management

1) Did you/your organization prepare any report of professional staff (C/P members) regarding their' understanding of integrated flood management planning and river basin management ? For example, a report after training in Japan.

Yes	No
Please put "X" in either column	

2) If yes, please share such a report to the Project Team.

Question No. A.2:

Objectively Verifiable Indicators	Means of Verification
Capacity of flood forecasting and warning	Coverage and number of hydrological station for flood forecasting and warning

1) Is there any change regarding coverage and number of hydrological station which your organization manages/managed for flood forecasting and warning?

Yes	No
Please put "X" in either column	

2) If yes, please share lists of hydrological stations before the Project start (List of 2014 or early 2015) and present (end of 2017 or early 2018).

Necessary information of the lists are "Name of stations, code of stations, location (coordinate), type of station, installation year".

Question No. A.3:

Objectively Verifiable Indicators	Means of Verification
Effective use and share of data for flood management	Data exchange/ user agencies, quantity of data use

1) As for data/information related to flood risk management, is there any change regarding conditions on 1) data exchange and/or 2) quantity of data utilization among organizations which participated or related to the Project?

Yes	No
Please put "X" in either column	

2) If yes, pleas describe how change the conditions before the Project (early 2015) and present (2018).

Description:

Figure 2.20 Survey on Indicators 1, 2 y 3

Indicator No. 4: IFMP formulation guideline developed by the project

The indicator for this item evaluates the progress based on the creation of the guideline for the elaboration of the Integrated Flood Risk Management Plan. These guides are found in Appendix-10 and 11.

<Degree of Achievement of the Project Purpose>

According to the evaluation of the degree of achievement of each indicator, the degree of achievement of Project Purpose can be evaluated as "Generally Achieved".

2.3. History of PDM Modification

In the first Joint Coordination Committee (JCC) held on August 13, 2015, each PDM indicator was confirmed, and the first version of PDM was approved.

In the second JCC held on February 23, 2016, it was decided that MADS will join the project as a new C/P entity. Therefore, the PDM was modified with the addition of MADS, and the second version of PDM was approved.

In the fifth and last JCC celebrated on June 28, 2018, the indicators of the overall goal that must be monitored according to the content agreed in the monitoring plan were confirmed, and the third version of PDM was approved.

The PDMs are attached in Appendix-14.

Additionally, the Operation Plan (OP) was developed according to the progress of the project activities; its content was updated and was approved in the JCCs.

3. Results of Joint Review

3.1. Results of the Review based on DAC Evaluation Criteria

In this section, an evaluation is conducted based on 5 criteria (relevance, effectiveness, efficiency, impact and sustainability).

Relevance: High

1) Laws and Decrees in Colombia

The Colombian government has created the following laws and relevant decrees, and the project has carried out the activities according to them.

- Decree 4147 of 2011 regarding responsibility of the National Unit for Disaster Risk Management (UNGRD)
- Law 1523 of 2012 regarding adaptation of the national policy on disaster risk management and establishment of the National System for Disaster Risk Management (SNGRD)
- Decree 1640 of 2012 regarding formulation of Watershed Management and Development Plan (POMCA)
- Resolution 1907 of 2013 the Ministry of Environment, and Sustainable Development (MADS) regarding technical guideline for formulation of POMCA
- Decree 1807 of 2014 regarding incorporation of risk management in Land Management Plan (POT)

MADS is an entity that does not perform on-site management but formulates the policy, and is responsible for establishing the standards for risk management methodology in flood risk management. MADS is formulating the Protocol for the risk management component of POMCA, and the possibility of incorporating in it the guide for the formulation of IFMP-SZ, a product of this project, is being studied. The materials related to IFMP, which are products of this project, have no legal link in Colombia; however, these products meet the expectation of C/P on Japanese knowledge and are appropriate for the current situation, in which this Protocol is in the process of elaboration, in the sense that the products of this project will be incorporated in the work corresponding to the C/P entities that has legal force.

2) Contribution to the Sendai Framework for Disaster Risk Reduction

The Sendai Framework for Disaster Risk Reduction 2015-2030, adopted on March 18, 2014, requires actions focused on the following 4 priorities from the countries, in a sectoral and intersectoral manner, at local, national, regional and global levels.

Sendai Framework 2015-2030 Priorities for Action

Priority 1: Understanding disaster risk
Priority 2: Strengthening disaster risk governance to manage disaster risk
Priority 3: Investing in disaster risk reduction for resilience
Priority 4: Enhancing disaster preparedness for effective response and to "Build Back Better" in recovery, rehabilitation and reconstruction (Build Back Better)

This project contributes to Priority 1 through the collection, analysis, administration and use of relevant data as well as the preparation of the disaster risk reduction map, to Priority 2 through discussions on the role sharing among entities related to the integral management of flood risk.

3) Japanese Cooperation Policy

The project corresponds to the Japanese policy of cooperation such as the "Development Support Scheme" adopted by the Cabinet in February 2015 and the Japan Support Scheme for Colombia. This project is positioned in the development task 2-1 (specific goal) "Development of communities resilient to national disasters" in the "Environment and Disaster Prevention" (general goal), within the Support Scheme of Japan to Colombia.

Effectiveness：High

1) C/P Capacity Enhancement

As a result of the evaluation of the capacities of the members of the C/P entities to whom the project seeks to transfer the technique, it was confirmed that the capacities of C/P have been increased after the completion of the project in all the items of the survey compared to before the start of the project. The detailed results are found in Section 2.2 (1).

2) Achievement of Project Purpose

The degree of achievement of the project purpose was confirmed through a survey for C/P, and it was confirmed that it was met in general terms, as explained in Section 2.2.

Efficiency：High

1) General Inputs

The inputs planned at the beginning of the project did not change in terms of the duration of the project, nor were human resources or equipment and materials increased; everything was conducted according to the initial plan.

2) Project Office and Equipment

The project office was located within the IDEAM facilities in the city of Bogotá, where the activities were carried out. Although at the beginning of the project, it was planned to relocate the project office according to the progress of the activities and the change in the target area, this did not happen since it was convenient both for the expert team and for the C/P entities to continue the activities in the office in IDEAM, Bogotá. Due to this, only 1 photocopier and 1 ink jet printer were purchased, although the initial plan was to acquire 2 units of each item.

Impact：High

1) Efforts by the Relevant Entities for the Project

In the workshops during the project, the need for the participation of several entities such as MADS, CORMAGDALENA, CIRMAG, DNP as C/P was mentioned, apart from the initial C/P entities, which are IDEAM, UNGRD, CAR and in the Department of Cundinamarca. As a result, after the second JCC held in February 2016, MADS was approved as an official C/P entity of this project. Regarding CORMAGDALENA, CIRMAG and DNP, it was decided not to bring them on board as official C/P entities after consultation with C/P; however, it was decided that they would continue to participate in activities in this project, and they participated n in workshops and training in Japan.

2) Public Policy for Disaster Risk Management of Cundinamarca

In the Department of Cundinamarca, the disaster risk management policy began to be formulated in 2016, and the formulation was finalized in June 2018.. Based on the Sendai Framework for Disaster Risk Reduction, this policy incorporates the knowledge obtained from this project, and as one of the elements of this policy, the possibility of strengthening the early warning system through the installation of real-time observation stations in the Department of Cundinamarca is studied.

3) Internal C/P Meetings

In addition to five formal C/P entities, this project involves different entities such as CORMAGDALENA, CIRMAG, and DNP. Apart from the activities of this project with the expert team, C/P held internal meetings separately, only among the C/P institutions on several occasions, and made adjustments related to the decision making among the entities of C/P. Although the relationship among the C/P entities involved in this project was weak at the beginning of the project, it has been strengthened through the activities of this project.

4) iRIC Seminar

During 4 days in October 2017, a seminar was held on hydraulic analysis, flood analysis, sediment transport analysis method, and the use of an analysis software (iRIC) to perform these analyzes, as one of the activities for the Output 1: "Capacity on flood risk assessment is improved". The lecturers were Professor Shimizu of Hokkaido University, Associate Professor Takebayashi of Kyoto University, and Dr. Baba, a JICA Specialist. A total of 30 people, including 20 people from the C/P and relevant entities and 10 people from the university, participated in this seminar. It is considered that the participants' understanding of analytical methods and software improved greatly through this seminar. It is hoped this would be useful for these analyzes in Colombia in the future.

5) Participation in the Regional Platform

The expert team and specialist Baba participated in the Regional Platform held in the city of Cartagena in June 2018. In the session, specialist Baba gave a presentation for officials related to disasters in Latin America on Japanese knowledge and introduced the efforts in Japan. In the stand of the exhibition, the information this project was shared using a panel that summarized the results of this project.

Sustainability：High

1) Signing of the Collaboration Agreement for Future Activities

Due to the progress in the formulation of IFMP-RP for the Magdalena River and the study of the road map, MADS, CORMAGDALENA and IDEAM held discussions for the preparation and signing of the document of collaboration agreement for future activities. In the 5th and final JCC held on June 28, 2018, the official signing of this document by MADS, CORMAGDALENA, and IDEAM was announced. This is expected to contribute to continuation of activities and the achievement of the project's overall goal in a meaningful manner.

2) Protocol for the Risk Management Component in POMCA

As mentioned above, MADS is formulating the Protocol for the risk management component of POMCA, and the possibility of incorporating in it the guideline for the formulation of IFMP-SZ, a product of this project, is being studied. If this incorporation is achieved, the knowledge acquired in the project is expected to be applied to other basins, apart from the pilot basin of Rio Negro.

3) Formulation and Implementation of IFMP (principal plan)

In this project, the IFMP (provisional plan) was formulated for both the Rio Negro basin and the Rio Magdalena basin, and the road map for the formulation of the principal version of each was created. Relevant entities must collaborate and continue with the activities for the formulation of the principal plan going forward. Additionally, in the provisional plan, there are items that can be implemented without waiting for the principal plan, such as the promotion of non-structural measures. Therefore, it is necessary to advance the implementation of measures to mitigate floods, such as non-structural measures, in parallel with the formulation of the principal plan.

4) Guaranteeing Budget and Implementation of the Works in the Municipalities

In this project, IFMP (provisional plan) was developed with the C/P entities. The implementation of the works to mitigate floods and the guarantee of the budget after the finalization of the principal plan will be carried out by the municipalities. For an effective implementation of the works, it is important for the municipalities to recognize the need for the works and ensure the budget from now on. The construction of a system, through which autonomous regional corporations provide technical support, is also considered necessary, given that the municipalities have limited technical capacity for the implementation of the works.

3.2. Key Factors Affecting Implementation and Outcomes

(1) Appointment of C/P per Output

1) Key factor

At the information meeting for IC/R in July 2016 and JCC in August 2015, the expert team asked C/P for the appointment of person in charge per Output. However, it was difficult to achieve the C/P appointment per Output. This is because in these entities there are workers with a permanent contract (full-time) and contractors for specific projects, which are the majority, and who cannot work on this project due to contractual obligation.

2) Solution and evaluation

The main C/P entities nominated persons to act as contact persons for the expert team in order to coordinate the allocation of additional human resources necessary for the activities of each Output and share the knowledge acquired in this project within each entity. The expert team accepted this proposal.

Throughout the project, the routine of organizing meetings and participating in the workshops during the visit by the experts was established in each entity, and the C/P members participated in the workshops in actively under the coordination of the C/P contact persons (See Appendix-2, List of Participants). The activities of each C/P such as data collection and formulation of IFMP were carried out actively under the coordination of C/P contact persons, and IDEAM also studied the possibility of hiring additional workers for the hydraulic study of the Magdalena River. It can be concluded that effective activities were carried out to strengthen capacities since C/P actively participated in these activities, although in the end the C/P appointment per Output was not carried out.

(2) Participation of Relevant Entities in the Project

1) Key factor

Apart from the counterpart entities which are IDEAM, UNGRD, CAR and the Department of Cundinamarca, C/P pointed out the need for MADS, CORMAGDALENA, CIRMAG, CORPOBOYACÁ (Autonomous Corporation that has jurisdiction over the lower pilot basin of Rio Negro) and DNP to participate in the project as C/P.

MADS is the entity responsible for formulating strategic policy for the Magdalena River basin and for developing guidelines to incorporate flood risks in POMCA for each hydrographic sub-area. Therefore, IDEAM, UNGRD, CAR and the Department of Cundinamarca as C/P expressed that the participation of MADS in this project would be effective in the workshops from October-November 2015.

Similarly, the importance the participation of CORMAGDALENA for concrete discussions on the Magdalena River was expressed in workshops from October to November.

CIRMAG, the entity responsible for the technical aspect (research and study) of CORMAGDALENA, has submitted a letter on August 10, 2016 requesting its official participation in the project as C/P.

It was necessary to build an effective system for the implementation of the project, studying and making decisions on the participation of several relevant entities described above.

2) Solution and evaluation

After discussions with JICA Colombia, MADS was officially linked to the project as C/P in the second JCC held in February 2016.

As for CORMAGDALENA, through the mediation of IDEAM, its participation in the workshop on Output 3 was achieved in February 2016. Later, in the C/P discussions, it was agreed that neither CORMAGDALENA nor CIRMAG would be invited as official C/P, since almost half of the project had already been completed in November 2016 and most activities related to the Magdalena River had been carried out, although both entities were going to continue participating in the activities of this project. It was also agreed they would participate as C/P in case the second phase of the project materializes. In the second series of trainings in Japan held in November 2016, a person from CORMAGDALENA and a person from CIRMAG participated, in order to contribute to the progress of the project.

In addition, CORPOBOYACA participated in activities in May 2016, and CORPOBOYACA also verbally expressed interest in being linked to this project as C/P. However, it was decided not to link it as official C/P since no communication on this subject was taken afterward.

Regarding DNP, one person from the entity participated in the second series of training in Japan held in November 2016.

In terms of the efforts by the relevant entities, importance was given to the criteria of the C/P entities from the point of view of continuing flood management activities in Colombia in the future. The C/P entities conducted the discussion on their own initiatives, holding meetings to discuss the issue with each other. Especially UNGRD, the main C/P entity in this project that has the function of coordinating disaster prevention activities in Colombia, assumed a central role in the coordination and execution of meetings and in the preparation of the report of these meetings.

(3) Creating a Collaboration System among the Relevant Entities and guaranteeing a System for the Continuity of Activities after the Completion of the Project

1) Key factor

In Colombia, the responsible entity for flood control is not clearly defined and there is little awareness of the need and effectiveness of flood control. Given this context, we consider it is important to carry out the activities of the project in such a way as to guarantee the continuity of the activities after the completion of the project.

2) Solution and evaluation

As explained in Numeral (2), several entities were involved in addition to C/P, and discussions were held on the role sharing related to Output 3. Likewise, the entity responsible for each item of the plan was clarified. Discussions on the IFMP-RP formulation for the Magdalena River (provisional plan) and IFMP-SZ for the Rio Negro basin (provisional plan) as well as the discussions on the road map.

It is considered that giving importance to the opinions and the active participation of C/P and the relevant entities in the discussions and conducting diverse discussions deepened the knowledge about the flood control of the relevant entities, and created an environment that allows for free discussions when carrying out activities.

Through these activities, participants' knowledge on flood control and the river plan was deepened. The coordination among entities related to flood management in Colombia was also strengthened through the workshops where the 5 entities of C/P, CORMAGDALENA, responsible for administering the Magdalena River, and other relevant entities participated, exchanged opinions and discussed common challenges.

In addition, as the studies for the formulation of the IFMP-RP for the Magdalena River (provisional plan) and the road map were advanced in this project, the C/P expressed the need to sign an agreement among them for the future activities related to the Magdalena River after the completion of this project. This discussion was held among MADS, CORMAGDALENA, and IDEAM as main entities. MADS made a report on the content and progress of the agreement in the 4th JCC in November 2017, and in the 5th and final JCC held on June 28, 2018, the official signing of this document by MADS, CORMAGDALENA and IDEAM was announced by MADS. This is expected to contribute to continuation of activities and the achievement of the project's overall goal in a meaningful manner.

3.3. Evaluation on the results of the Project Risk Management

The external conditions of this project stipulated in PDM were "vulnerability to flood disasters does not increase dramatically" for the project purpose and "hydrological and meteorological networks of IDEAM and CAR are neither degraded nor diluted" for the Outputs and activities of the draft. During the period of activity of this project, none of the external conditions changed (the hydrological and meteorological network of IDEAM did not get worse, but rather it was improved), and had no influence on the project.

3.4. Lessons Learnt

(1) Appointment of C/P per Output

It was difficult to appoint C/P per Output as anticipated due to C/P's internal situations. In addition, it can be considered an appropriate measure under the current circumstances, as long as the techniques and knowledge acquired in the project could be disseminated and maintained in each entity. The expert team considers it is essential to build a realistic and most effective implementation system for the project through sufficient discussion and agreement with C/P to carry out activities to improve C/P capabilities.

(2) Participation of Relevant Entities in the Project

Although MADS had already begun to participate in the activities of this project (workshops) from October-November 2015, after MADS joined the project as C/P, the same officials actively participated in the workshops, and the entity played an important role in the project.

CORMAGDALENA and CIRMAG actively exchanged opinions and shared information in the activities related to the Magdalena River in particular, and also participated in the workshops related to the Rio Negro in a continuous and active fashion.

A DNP official participated continuously in the workshops in Colombia after the second series of training in Japan. He provided valuable information in a timely manner and participated in the discussions both in the workshops and in JCC.

The goal of this project is to strengthen the capacities of flood risk management in Colombia, and the advance in the coordination among entities related to flood risks through the project contributes to this goal greatly. It is considered important to continue encouraging the relevant entities to actively participate in project activities, regardless of whether they are C/P entities or not in order to maximize project activities.

(3) Creating a Collaboration System among the Relevant Entities and Guaranteeing a System for the Continuity of Activities after the Completion of the Project

To guarantee the continuity of the activities after the completion of the project, it is necessary to achieve a mutual understanding of Colombia's challenges and of the activities necessary to overcome them; it is necessary to create a system where the relevant entities as C/P of the target country can to hold discussions on their own initiative about the specific details of continuous activities in the future and the need for these activities. Although the expert team provides the opportunity for discussion and proposes ideas, the main actors in this matter are C/P and relevant entities in Colombia. It is considered important to implement project activities taking into account a system where the expert team can support this process.

(4) Appropriate Proposal for the Political System (Decentralized) of the Target Country

The role sharing for the implementation of the plan was a very important topic in the discussion on the content of the plan (IFMP), the role sharing in the formulation of the plan and the construction of the system for formulating the plan.

In Colombia, where the political system is decentralized, municipalities are responsible for defining flood mitigation measures and the decision to implement them (including budget approval). Since the instructions of the national entities cannot determine these elements, it was necessary to build a system in which the managers of the municipalities can understand the content and the need for the flood mitigation measures.

Therefore, it was concluded in the guideline for the formulation of IFMP-RP that the flood mitigation measures will be discussed in CARMAC, an entity established by law in each macro-basin. CARMAC has national entities, departments and CARs as its members; the process of studying the measures will be communicated to the municipalities through the departments.

For the proposals to be feasible, it is important to create these proposals taking into account the legal framework of the target country. Therefore, it is important to conduct sufficient discussions to obtain the approval of the relevant entities.

4. For the Achievement of Overall Goal after the Project Completion

4.1. Prospects to achieve Overall Goal

The Overall goal is the reduction of flood risk in Colombia.

To achieve flood risk reduction, it is necessary to first assess the risks adequately, then implement concrete measures and plans to reduce the risks, conduct the review of the plan continually, and operate and maintain the structures appropriately. So far in this project, trainings were carried out on methods to assess the risks appropriately as well as to formulate concrete plans. Discussions were held on the role sharing and the study of the plan taking into account the training and discussions on the subject to carry out risk assessment and implement concrete measures. C/P always kept in mind what is necessary to implement measures or activities for flood management that are adapted to the physical characteristics of the country and to people's mentality, comparing it with Japan; they also considered how they can apply the knowledge acquired in the activities of this project to flood management in Colombia in the future. During the project, some specific activities mentioned in section 4.2 were already initiated, and the general direction of the activities explained in section 4.3 was confirmed, so it is determined that the superior goal will be fulfilled if these activities are implemented.

4.2. Plan of Operation and Implementation Structure of the Colombian side to achieve Overall Goal

Due to the progress in the formulation of IFMP-RP for the Magdalena River and the study of the road map, MADS, CORMAGDALENA and IDEAM held discussions for the preparation and signing of the document of collaboration agreement for future activities. In the 5th and final JCC held on June 28, 2018, the official signing of this document by MADS, CORMAGDALENA and IDEAM was announced by MADS. It is expected that the C/P entities and relevant entities would continue with the activities within and outside the project.

Additionally, if the activities for each entity are managed according to the role sharing in the relevant entities summarized in Part D of IFMP-SZ (provisional plan) for the Rio Negro basin discussed within the activities for Output 3 and in the recommendations for Output 3, this is also expected to contribute to the achievement of the overall goal.

4.3. Recommendations for the Colombian side

The recommendations for flood early warning and for improving the role sharing related to flood risk management between local governments and the central government were elaborated as outputs of the activities of Output 2 and Output 3 and are attached in Appendixes-4 and 5. Additionally, one of the suggestions for achieving the overall goal is the future organization of laws and guidelines on which the necessary activities for flood management will be based, and the incorporation of the project results into the POMCA Protocol for the development of the risk management component. In the future, the activities proposed in the recomendations are expected be implemented.

4.4. Monitoring plan from the end of the Project to the Ex-post Evaluation

The recommendations for flood early warning and for improving the role sharing related to flood risk management between local governments and the central government were elaborated as results of the activities of Output 2 and Output 3 attached in Appendix-4 and 5. Additionally, one of the suggestions for achieving the overall goal is the future organization of laws and guidelines on which the necessary activities for flood management will be based, and the incorporation of the project results into the POMCA Protocol for the formulation of the risk management component. Future the activities proposed in the recomendations are expected to be implemented.

The first draft of IFMP-SZ (provisional plan) for the Rio Negro basin was prepared, and work to complete this is being carried out. Regarding this IFMP-SZ for the Rio Negro basin, given that the plan formulated in this project is a provisional plan, it is necessary to organize the necessary items for the formulation of a principal plan, and a road map was prepared in the project and was approved by the relevant entities. However, with respect to non-structural measures, some of these measures proposed in the provisional IFMP-SZ can be implemented without additional activities although other activities (topographic surveys, geological studies, etc.) will be require the specific design, etc. of structural measures. From now on, it is necessary for the responsible entities to implement the activities in accordance with this road map and the activities to formulate principal IFMP-SZ. At the same time, it is necessary for the responsible entity established in the plan to secure the budget and carry out other activities for the measures that can be carried out under the contents of the provisional plan, and the related organizations should support them as needed. C/P considers this IFMP-SZ formulation activity for the Rio Negro basin to be a pilot project to learn the formulation process, and there are parts in the implementation of the proposed measures that have no emphasis. However, the activities for the formulation of the principal plan and the implementation of the proposed measures are expected to be implemented, including the pilot basin for the activities of flood risk management.

Additionally, in order to achieve continuous implementation of activities related to flood risk reduction that use the results of this project, it is necessary to incorporate the results of this project into the legal framework related to flood risk management in Colombia. Examples of specific activities for this purpose are the incorporation of the project results (especially the guideline for the formulation of IFMP-SZ) into the POMCA Protocol for the preparation of the risk management component, and the incorporation of the results of the project (especially IFMP-SZ for the Rio Negro basin (provisional plan)) in POMCA (text) of the Rio Negro basin. Ideally, these activities are implemented as a first step. The second ideal step is for IFMP to be formulated in other large rivers and sub-basins, or for similar studies to be carried out as part of POMCA in other sub-basins.

The following are the activities that Colombia (C/P entities) ideally carry out after the end of the project.

1. Activities for the formulation of the IFMP-RP of the Magdalena River (principal plan) (activity according to the road map)

2. Activities for the formulation of IFMP-SZ (principal plan) for the Rio Negro basin (based on the provisional plan activities according to the road map)

3. Implementation of specific activities based on the content of IFMP-SZ for the Rio Negro basin (provisional plan)

   (For example, if any of the planned non-structural measure options are being implemented)

4. Activities for the incorporation of the results of the project in the existing legal instruments (an example is the state of incorporation of the contents of the guideline in the POMCA protocol for the preparation of the risk management component)

5. Activities for the incorporation of the results of the project (studies and plans of IFMP-SZ for the Rio Negro basin (provisional plan)) in the existing POMCA for the Rio Negro basin

6. IFMP formulation activities in other principal rivers or hydrographic subzones, the incorporation of the methodologies of this project in the study and analysis as well as the incorporation of these in POMCA

7. Collaborative activities among relevant entities related to flood risk management (exchange of opinions, discussions, and implementation of concrete measures)

In the monitoring plan from the end of the project to the subsequent evaluation, progress will be monitored on the items listed above that can be achieved within 3 years after the end of the project, when the subsequent evaluation will be carried out. The frequency of the monitoring will be approximately once a year, and JICA Colombia will send the check sheet to UNGRD, the representative entity of C/P, who will verify the situation in each C/P entity and send the answers back to JICA Colombia with support from IDEAM. Table 4.1 is the monitoring sheet. The monitoring items match the indicators of the overall goal in PDM. In the 5th and the final JCC held on June 28th, 2018, relevant entities agreed on this monitoring plan.

Table 4.1 Monitoring Check Sheet

Monitoring Items		Degree of Achievement of the Goals for the Ex-post Evaluation			
		Not started	In progress	Description(The degree of progress (%) and specific explanation and information on the status of implementation*)	Finished
1.	Number of coordination meetings between entities for the implementation of indicators 2, 3 and 4. (To confirm the state of continuity of collaborative activities among the entities related to flood risk management (exchange of opinions, discussions, and the implementation of concrete measures))	☐	☐		☐
2.	There is a protocol for the incorporation of in POMCAS that involves the concept of integrated flood management. (To confirm the status of implementation of the activities for the incorporation of the results of the project in the existing legal instruments)	☐	☐		☐
3.	Number of POMCAs that introduce the concept of integrated flood management.(To confirm the status of implementation of the activities for the incorporation of the project results (studies and plans of IFMP-SZ for the Rio Negro basin (provisional plan)) in the existing POMCA for the Rio Negro basin and to confirm the status of implementation of IFMP formulation activities in other hydrographic subzones, the incorporation of the methodologies of this project in the study and analysis as well as their incorporation in POMCA)	☐	☐		☐
4.	Number of reduction measures implemented in the pilot basin of the project.(To confirm the status of implementation of specific activities based on the content of IFMP-SZ (structural and non-structural measures) for the Rio Negro basin (provisional plan))	☐	☐		☐

* In case there are problems in the implementation, provide an explanation.

Appendix-1 List of Collected Materials

List of Collected Data

No.	Title	Date of issue	Publisher/Copyright	Copy	Note
1	Normatividad del Sistema Nacional de Gestión del Riesgo de Desastre	2012	UNGRD	Book	Obtained 30 Jul. 2015
2	Estadísticas de Cundinamarca 2011-2013	2014	Gobernación de Cundinamarca	Book	Obtained 4 Aug. 2015
3	Lineamientos para formulación de cartografía de los planes de ordenamiento territorial	Jul. 2013	Departamento de Cundinamarca	Book	Obtained 4 Aug. 2015
4	Mapa vial año 2013 (Escale 1:325,000)	2013	Departamento de Cundinamarca	Map sheet	Obtained 4 Aug. 2015
5	Mapa división veredal 2013 (Escale 1:325,000)	2013	Departamento de Cundinamarca	Map sheet	Obtained 4 Aug. 2015
6	Política Nacional Recurso Hídrico	2010	MADS	Book	Obtained 6 Aug. 2015
7	Guía técnica para la formulación de los Planes de Ordenación y Manejo de Cuencas Hidrográficas	2014	MADS	Book	Obtained 6 Aug. 2015
8	Guía técnica para la formulación de los Planes de Ordenación y Manejo de Cuencas Hidrográficas	2014	MADS	DVD	Obtained 6 Aug. 2015
9	PROTOCOLO PARA LA INCORPORACIÓN DE LA GESTIÓN DEL RIESGO EN LOS PLANES DE ORDENACIÓN Y MANEJO DE CUENCAS HIDROGRÁFICAS	Nov. 2014	MADS	PDF	Obtained 6 Aug. 2015
10	PLAN ESTRATÉGICO MACROCUENCA MAGDALENA - CAUCA Capítulo 1 LÍNEA BASE Capítulo 2 DIAGNÓSTICO Capítulo 3 ANÁLISIS ESTRATÉGICO	–	MADS	PDF	Obtained 6 Aug. 2015
11	Atlas Ambiental CAR 50 años 1961-2011	Jul. 2012	CAR	Book	Obtained 14 Aug. 2015
12	ANEXO. ALCANCES TÉCNICOS CONSULTORÍA PARA EL AJUSTE DEL PLAN DE ORDENACIÓN Y MANEJO DE LA CUENCA DEL RÍO ALTO SUAREZ NSS (2401-01)	Nov. 2014	CAR	PDF	Obtained 14 Aug. 2015
13	ANEXO. ALCANCES TÉCNICOS CONSULTORÍA PARA EL AJUSTE DEL PLAN DE ORDENACIÓN Y MANEJO DE LA CUENCA DEL RÍO BOGOTÁ (2120)	Nov. 2014	CAR	PDF	Obtained 14 Aug. 2015
14	Bases del Plan Nacional de Desarrollo 2014-2018	-	DNP	PDF	Obtained 24 July 2015
15	LEY 1753 DEL 09 DE JUNIO DE 2015	2015	DNP	PDF	Obtained 24 July 2015
16	List of Disaster 1998 to 2014	2015	UNGRD	Digital file (Excel)	Obtained 30 July 2015
17	River basin boundary 2013	2013	IDEAM	Digital file (Shape)	Obtained 4 August 2015
18	Criterios metodológicos mínimos para la elaboración e interpretación cartográfica de zonificaciones de amenaza por inundaciones fluviales para el territorio colombiano con una aplicación práctica de dos áreas piloto (Inundaciones lentas y súbitas) Fase I Informe Final	Aug. 2010	Universidad Nacional de Colombia	PDF	Obtained 6 August 2015
19	List of Flood event 1970 to 2010	–	IDEAM	Digital file (Excel)	Obtained 8 August 2015
20	Estudio Nacional del Agua 2014	May 2015	IDEAM	Book and PDF	Obtained 21 August 2015
21	Documents of POT in Rio Negro Basin	–	Departamento de Cundinamarca	Digital file (Word)	Obtained 24 August 2015
22	Maps for POT in Rio Negro Basin	–	Departamento de Cundinamarca	Dgital file (dwg)	Obtained 24 August 2015
23	Map data with 1/25,000 scale in Rio Negro Basin	–	Departamento de Cundinamarca	Digital file (shape)	Obtained 24 August 2015
24	Map data with 1/10,000 scale in Rio Negro Basin	–	Departamento de Cundinamarca	Digital file (geodatabase and PDF)	Obtained 24 August 2015
25	Various theme's Map data	–	Departamento de Cundinamarca	Digital file (shape)	Obtained 24 August 2015

No.	Title	Date of issue	Publisher/Copyright	Copy	Note
26	MAPA DE AMENAZAS GEOLÓGICAS POR REMOCIÓN EN MASA Y EROSIÓN DEL DEPARTAMENTO DE CUNNDINAMARCA FASE II - INFORME FINAL	1998	Departamento de Cundinamarca	Digital file (Word and Excel)	Obtained 24 August 2015
27	POMCA in Rio Negro	2009	CAR	Digital file (Word, PDF, GIS	Obtained 24 August 2015
28	Reports for various plan, design and constrction works	−	CAR	PDF	Obtained 24 August 2015
29	Data for flood and sediment disaters	2014	CAR	Digital file (shape)	Obtained 24 August 2015
30	Hydrological and meteorological data	2015	CAR	Digital file (Excel)	Obtained 24 August 2015
31	LIDAR data	2009	CAR	Digital file (tif, jpg and etc.)	Obtained 24 August 2015
32	Diagnóstico de la Gestión del Riesgo y Análisis de la Cooperación en Colombia en Gestión del Riesgo	2012	JICA Colombia	PDF	Obtained 11 September 2015
33	コロンビアにおける危機管理の現状及び危機管理に関する対コロンビア協力の状況	2012	JICA Colombia	PDF	Obtained 11 September 2015
34	Atlas cuenca del rio magdalena	−	CORMAGDALENA-IDEAM	PDF	Obtained August 2015
35	Atlas de Cundinamrca	−	Departamento de Cundinamarca	Book	Obtained August 2015
36	Estudio Ambiental de la Cuenca Magdalena-Cauca y elementos para su ordenamiento territorial Segundo informe de avance	1999	IDEAM-CORMAGDALENA	PDF	Obtained August 2015
37	Estudio Ambiental de la Cuenca Magdalena-Cauca y elementos para su ordenamiento territorial Resumen Ejecutivo	Nov. 2001	IDEAM-CORMAGDALENA	PDF	Obtained August 2015
38	Estudio de Demanda y Plan para la Recuperacion del Transporte Fluvial en el Rio Magdalena Resumen Ejecutivo	2002	CORMAGDALENA	PDF	Obtained August 2015
39	Various data on meteorology, hydrology, hydraulics, flood, river structure and so on	−	IDEAM	Digital file (Word, Excel, shape, txt and etc.)	Obtained August 2015
40	WorldDEM TM	2015	PASCO	Digital file (Geotif)	Obtained October 2015
41	PLAN DE MANEJO DE LA CUENCA DEL RÍO MAGDALENA - CAUCA (Spanish)	2007	CORMAGDALENA	PDF	Obtained March 2016
42	The Republic of Colombia, The Magdalena River Master Plan	2013	CORMAGDALENA	PDF	Obtained March 2016
43	The Magdalena River, The Master Plan of Exploitation, Appendix 1 Hydrological Analysis	2013	CORMAGDALENA	Digital file (Word)	Obtained March 2016
44	SISTEMA DE ALERTA TEMPRANA DE INUNDACIONES DE LA QUEBRADA LIMAS LOCALIDAD CIUDAD BOLÍVAR, INFORME FINAL	2007	DPAE	PDF	Obtained March 2016
45	RIO TUNJUELO – SISTEMA DE ALERTA TEMPRANA DE INUNDACIONES –	2006	DPAE	PDF	Obtained March 2016
46	PROYECTO COLOMBO-HOLANDES, PLAN DE REGULACION FLUVIAL Y DEFENSA CONTA LAS INUNDACIONES CUENCA MAGDALENA-CAUCA, PLAN DE OPERACIONES	1975 y 1976	MINISTERIO DE AGRICULTURA	PDF	Obtained March 2016
47	PROYECTO COLOMBO-HOLANDES, PLAN DE REGULACION FLUVIAL Y DEFENSA CONTA LAS INUNDACIONES CUENCA MAGDALENA-CAUCA, EL PROYECTO MAGDALENA-CAUCA Y LA HIDROLOGIA	−	MINISTERIO DE AGRICULTURA	PDF	Obtained March 2016
48	Manual on Flood Forecasting and Warning	2011	WMO	PDF	Obtained March 2016

No.	Title	Date of issue	Publisher/Copyright	Copy	Note
49	GUÍA DE REFERENCIA PARA SISTEMAS DE ALERTA TEMPRANA DE CRECIDAS REPENTINAS	2012	NOAA	PDF	Obtained March 2016
50	PROYECTO COLOMBO-HOLANDES, PLAN DE REGULACION FLUVIAL Y DEFENSA CONTA LAS INUNDACIONES CUENCA MAGDALENA-CAUCA, INFORME ANUAL DE ACTIVIDADES	1973	MINISTERIO DE AGRICULTURA	PDF	Obtained March 2016
51	PROYECTO COLOMBO-HOLANDES, PLAN DE REGULACION FLUVIAL Y DEFENSA CONTA LAS INUNDACIONES CUENCA MAGDALENA-CAUCA, INFORME TRIMESTRAL DE ACTIVIDADES	1973	MINISTERIO DE AGRICULTURA	PDF	Obtained March 2016
52	PROYECTO PLAN DE REGULACION FLUVIAL Y DEFENSA CONTA LAS INUNDACIONES CUENCA MAGDALENA-CAUCA, PLAN DE OPERACIONES Y ACUERDO ADMINISTRATIVO	–	MINISTERIO DE AGRICULTURA	PDF	Obtained March 2016
53	PROYECTO PLAN DE REGULACION FLUVIAL Y DEFENSA CONTA LAS INUNDACIONES CUENCA MAGDALENA-CAUCA, TRABAJOS REALIZADOS HASTA DICIEMBRE DE 1974	–	MINISTERIO DE AGRICULTURA	PDF	Obtained March 2016
54	GIS data of Magdalena river	–	CORMAGDALENA	Digital file (shape)	Obtained March 2016
55	Proyecto de Investigación Rio Magdalena y Canal del Dique	1973	–	PDF	Obtained March 2016
56	PLAN DE ORDENAMIENTO Y MANEJO INTEGRAL DE LA CUENCA DEL RIO GRANDE DE LA MAGDALENA –POMIM-	2003	CORMAGDALENA	PDF	Obtained March 2016
57	CORPORACIÓN AUTÓNOMA REGIONAL DE CUNDINAMARCA - C.A.R. Resolucion. No.0776 (Resolucion Comités)	2008	CAR	PDF/Digital file (Word)	Obtained April 2016
58	CRITERIOS TÉCNICOS ORIENTADORES PARA EL ACOTAMIENTO DE LAS RONDAS HÍDRICAS EN COLOMBIA	2016	MADS	PDF	Obtained May 2016
59	CRITERIOS PARA EL ACOTAMIENTO DE LAS RONDAS HÍDRICAS (RIBERAS) EN COLOMBIA	2016	MADS	PDF	Obtained May 2016
60	INFORME FINAL “PLAN MUNICIPAL PARA LA GESTIÓN DEL RIESGO EN EL AREA URBANA DEL MUNICIPIO DE BARRANCABERMEJA”	2013	ALCALDÍA DE BARRANCABERMEJA	PDF	Obtained July 2016
61	INFORME TÉCNICO METODOLOGÍA Y PROCESO DE INCORPORACIÓN DE LA GESTIÓN DEL RIESGO EN LA REVISIÓN EXCEPCIONAL DE POT	2015	ALCALDÍA DE BARRANCABERMEJA	PDF	Obtained July 2016
62	Revisión y Ajuste del Plan de Ordenamiento Territorial de Barrancabermeja	2015	ALCALDÍA DE BARRANCABERMEJA	PDF	Obtained July 2016
63	Utica Firemen Logbook April & June, 2011	2011	Fire Department in Utica	PDF/Digital file	Obtained July 2016
64	PROGRAMA DE MODELACIÓN PERMANENTE DEL RÍO MAGDALENA	2016	CIRMAG	Digital file (PPT)	Obtained August 2016
65	Proyecto de Recuperación de la Navegabilidad del Río Magdalena	2016	CORMAGDALENA	Digital file (PPT)	Obtained August 2016
66	DECRETO 2811 DE 1974	1974	Colombian Government	PDF	Obtained October 2016
67	GUIA METODOLÓGICA PARA LA DELIMITACIÓN DE ZONAS DE RONDA EN LA JURISDICCIÓN DE LA CORPORACIÓN AUTÓNOMA REGIONAL DE CUNDINAMARCA - CAR	-	CAR	PDF	Obtained October 2016
68	Resolución 608	2014	CAR	PDF	Obtained October 2016
69	CRITERIOS TÉCNICOS PARA EL ACOTAMIENTO DE LAS RONDAS HÍDRICAS EN COLOMBIA	2016	MADS	Digital file (PPT)	Obtained October 2016

No.	Title	Date of issue	Publisher/Copyright	Copy	Note
70	PROYECTO: Modelación hidrológica e hidráulica y el análisis geomorfológico, ecosistémico y socioeconó mico de las zonas urbanas y suburbanas de los municipios ribereños del río magdalena en su cuenca alta y media, en desarrollo del proyecto piloto que tiene por objeto el acotamiento de la ronda hídrica y la identificación de zonas de riesgo por inundación. Segunda Etapa de la Fase II. INFORME FINAL VOLUMEN 0. INTRODUCCIÓN Y METODOLOGÍA GENERAL	2015	MADS	PDF	Obtained October 2016
71	PROYECTO: ditto (same as No. 70) INFORME FINAL VOLUMEN 1, 8-13	2015	MADS	PDF	Obtained October 2016
72	Una propuesta técnica para el fortalecimiento de la normatividad colombiana en relación con la definición de ronda hidráulica	2015	Mónica Sarache Silva Universidad Nacional de Colombia	PDF	Obtained October 2016
73	List of Disaster 2005 to 2016	2016	Departamento de Cundinamarca	Digital file (Excel)	Obtained November 2016
74	Aerial photos	−	IGAC	Digital file (tif, jpg)	Obtained May 2016
75	ACUERDO No. 17 DEL 8 DE JULIO DE 2009 " POR MEDIO DEL CUAL SE DETERMINA LA ZONA DE RONDA DE PROTECCIÓN DEL RÍO BOGOTÁ"	2009	CAR	PDF	Obtained November 2016
76	Digital maps	−	IGAC	PDF	Obtained November 2016
77	PLAN GENERAL ESTRATÉGICO Y DE INVERSIONES 2016 – 2020 " SIEMPRE EN MOVIMIENTO"	2017	Departamento de Cundinamarca	PDF	Obtained February 2017
78	Investment amount for disaster risk reduction in municipalities from 2011 to 2015	−	DNP	Digital file (Excel)	Obtained February 2017
79	Plan de Desarrollo Cundinamarca 2016-2020	2016	Departamento de Cundinamarca	Book	Obtained February 2017
80	Guia para la implementación de Sistemas de alerta temprana	-	UNGRD	PDF	Obtained February 2017
81	Colombia´s rural property areas distribution (Atlas de la distribución de la propiedad rural en Colombia)	2012	IGAC	PDF	Obtained February 2017
82	Registros 1 y 2 e información Predial urbana de los municipios de Pto Salgar, Guaduas, Utica, La Peña, Nimaima, Supatá, Quebradanegra, Nocaima, La Vega, San Francisco, Villeta, Sasaima, El Peñón, Pacho y Guayabal de Siquima del Depto de Cundinamarca (Urban information about the properties in the Municipalities of Rio Negro)	2017	Departamento de Cundinamarca	Digital file (shape)	Obtained April 2017
83	Record histórico de eventos Municipios en la cuenca de Río Negro	2017	DNP	Digital file (shape)	Obtained May 2017
84	Adecuación Hidráulica y Recuperación Ambiental Río Bogotá	-	CAR	PDF	Obtained May 2017
85	Daily Rainfall and Discharge data in Rio Negro Basin	-	IDEAM	Digital file (Excel)	Obtained May 2017
86	Price of properties in Colombia	2010	IGAC	Digital file (Excel)	Obtained May 2017
87	Use of houses in both residential or commercial	2010	IGAC	Digital file (Excel)	Obtained May 2017
88	Population data of total of men and women in different age ranges, and number of people by house and number of houses of the urban area	2005	DANE	Digital file (Excel)	Obtained May 2017
89	Predominant construction material from the urban areas and rural areas	2010	IGAC	Digital file (Excel)	Obtained May 2017
90	Construction cost for roads, urbanism, streets, public facilities, electricity, aqueduct, sewage, internet services etc.. in each Municipality	2017	ICCU	Digital file (Excel)	Obtained May 2017
91	Number and location of tecnhnical schools in Cundinamarca	2017	Secretary of Education	Digital file (Excel)	Obtained May 2017

No.	Title	Date of issue	Publisher/Copyright	Copy	Note
92	Number and location of schools in Cundinamarca	2017	Secretary of Education	Digital file (Excel)	Obtained May 2017
93	Number and location of hospitals in Cundinamarca	2017	Cundinamarca hospitals network	Digital file (Excel)	Obtained May 2017
94	Example of cost of construction and manteinance of enbankments and other hydraulic works	2012	CAR	PDF	Obtained June 2017
95	Data of population, educational level, poverty ratio and etc. in the Rural area	2014	DANE (2014) Agriculture National Census	Digital file (Excel)	Obtained July 2017
96	PLAN DE DESARROLLO MUNICIPAL, 2016-2019, GUADUAS	May 2016	ALCALDÍA DE GUADUAS	PDF	Obtained September 2017
97	PLAN DE DESARROLLO MUNICIPAL, 2016-2019, PUERTO SALGAR	June 2016	ALCALDÍA DE PUERTO SALGAR	PDF	Obtained September 2017
98	PLAN DE DESARROLLO MUNICIPAL, 2016-2019, UTICA	-	ALCALDÍA DE UTICA	PDF	Obtained September 2017
99	PLAN DE DESARROLLO MUNICIPAL, 2016-2019, CAPARRAPI	May 2016	ALCALDÍA DE CAPARRAPI	PDF	Obtained September 2017
100	AJUSTE DEL PLAN DE ORDENACIÓN Y MANEJO DE LA CUENCA DEL RÍO BOGOTÁ VOLUMEN V – GESTIÓN DEL RIESGO	Aug. 2017	HUITACA	PDF	Obtained November 2017
101	Information regarding CARMAC	-	MADS	PDF	Obtained March 2018

Appendix-2 List of Workshops

List of Workshop

			Type of Activity		Meeting	Field Trip	1st JCC	Field Trip	WS	WS	Field Trip	WS	WS	Training	Meeting	Meeting	Meeting	Field Trip
			Main Theme		Explanation of ICR	Rio Negro, Utica	JCC on IC/R and means of verification in PDM	Magdalena River and Rio Negro River	River Planning and Relevant Organs	River Planning and Role Sharing of Relevant Organs	Rio Negro, Villeta city	Role Sharing of Relevant Organs	Presentation on Sediment Disaster	Training in Japan	Explanation of Future activity plan and discussion of new C/p	Explanation of the Project and Future activity to new C/P of Dep. Cundinamarca	Present policy and activity of MADS	Rio Negro, Pacho municipality
			Date		29-Jul-15	1-Aug-15	13-Aug-15	19-20-Oct-15	23-Oct-15	3-Nov-15	5-Nov-15	10-Nov-15	12-Nov-15	Nov-Dec, 2015	3-Feb-16	9-Feb-16	9-Feb-16	10-Feb-16
"Colombian Side"			Total Attend. No.		23	8	37	5	6	19	7	16	11	5	14	7	14	3
<Counterpart Agency>																		
NAME	SEX	ENTITY	Position (English)	Attended Number	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance
Carlos Iván Marquez Perez	M	UNGRD	Director General	1														
Richard Vargas	M	UNGRD	General Sub-Director	1			Attend											
Diego Peña Lopez	M	UNGRD	Sub-Director of Risk Knowledge	2	Attend		Attend											
Lina Dorado	F	UNGRD	Knowledge Sub-director	7														
Julio González Velandia	M	UNGRD	Specialized Professional – Sub-Direction of Risk Knowledge	42	Attend	Attend	Attend		Attend	Attend		Attend		Attend			Attend	
Joana M. Perez	F	UNGRD	Specialized Professional	35														
Gerardo Jaramillo	M	UNGRD	General Secretary	1			Attend											
Cristian Fernandez	M	UNGRD	Sub-Direction of Risk Knowledge	1											Attend			
Antonio López Reales	M	UNGRD	Representative of Cooperation Office	10			Attend								Attend			
Camila Chaparro	F	UNGRD	International Cooperation	1			Attend											
Kulio Cesar	M	UNGRD	Specialized Professional	1	Attend													
Stefania Benavide Escobar	F	UNGRD	International Cooperation	1	Attend													
Ivan H. Caicedo	M	UNGRD	Subdirector of SRR	1														
Claudia Cante	F	UNGRD	Contractor of SRR	6						Attend								
Andrés Salazar	M	UNGRD	Contractor	1														
Rafael Saenz Perez	M	UNGRD	Specialized Professional	1														
Margarita Arias	F	UNGRD	Coordinator of International Cooperation	2														
Isabel C. Gonzalez	F	UNGRD	Professional Technical Support	1														
Gabriel Garcia	M	UNGRD	Specialized Professional	1														
Marianella Botta Serrano	F	UNGRD	Specialized Professional-	1														
Juan Camilo Olaya	M	UNGRD	Knowledge Sub-direction Engineer	1														
Lina Paola Martinez	F	UNGRD	International Cooperation	2														
Luis Ignacio Muñoz	M	UNGRD	International Cooperation	2														
Claudia Lorena Barajas	F	UNGRD	Specialized Professional-Hydraulic Modelling Assistant	4														
Andres Sanabria	M	UNGRD	Specialized Professional	4														
Nidia Cristina Reyes	F	UNGRD	Hydraulic Assistant	4														
MariaTeresa Martínez	F	UNGRD	Contractor	1														
Mario Germán Trujillo	M	UNGRD	Student	4														
Omar Franco Torres	M	IDEAM	General Director	3														
Omar Vargas Martinez	M	IDEAM	Hydrology Sub-Director (Geologist - Water Resources Specialist)	15	Attend		Attend		Attend					Attend				
Christian Euscátegui	M	IDEAM	Forecast and Warnings Service Chief	2			Attend											
Estefania Salas	F	IDEAM	International Cooperation Office	7														
Diana Maria Quimbay Velencia	F	IDEAM	International Cooperation Advisor	8	Attend		Attend								Attend			
Fabio Andrés Bernal Quiroga	M	IDEAM	Assigned Professional to the Project	73	Attend	Attend	Attend			Attend		Attend	Attend		Attend		Attend	
Juan David Rondon	M	IDEAM	Specialized Professional	2														
Oscar Martínez	M	IDEAM	Specialized Professional	6	Attend		Attend					Attend	Attend					
Clara Lamo	F	IDEAM	International Cooperation Contractor	3	Attend		Attend								Attend			
Catherine Fonseca	F	IDEAM	International Cooperation Contractor	4														
Wilson Becerra	M	IDEAM	Specialized Professional- Communications Office	1			Attend											
Natalia Soto	F	IDEAM	Specialized Professional- Communications Office	1			Attend											
Alberto Pardo Ojeda	M	IDEAM	Warnings Coordinator	2			Attend											
Guillermo Olaya Triana	M	IDEAM	Hydrology Specialized Professional	5	Attend			Attend					Attend					
Nelson Obregon	M	IDEAM	Director of Mojana Project	1						Attend								
Ana Campille Pérez	F	IDEAM	Hydrology	1									Attend					
Freddy Garrido H.	M	IDEAM	Hydrology	3									Attend					
Henry A. Romero	M	IDEAM	Hydrology	1									Attend					
Hernando Wilches Suárez	M	IDEAM	Hydrology	2									Attend					
Nelsy Verdugo	F	IDEAM	Specialized Professional	6														
Maria Costanza Rosero	F	IDEAM	Specialized Professional	13														
Ivan Camilo Peña	M	IDEAM	Hydrology Contractor	2														
Enrique Rodríguez	M	IDEAM	Contractor	1														
Adriana Maria Rojas	F	IDEAM	Contractor	1														
Jorge Gonzalez	M	IDEAM	Specialized Professional	7														
Angela Paola Chia	F	IDEAM	International Cooperation	1														
Minjung Kim	F	IDEAM	Trainee in International Cooperation	1											Attend			
Julian Arbelaez	M	IDEAM	Contractor	3														
Juan Pablo Urrego	M	IDEAM	Contractor	4														
Fabian Mauricio Caicedo	M	IDEAM	Contractor	4														
Claudia Contreras	F	IDEAM	Hydrology	2														
Nestor Franco	M	CAR	Director General	1														
Carlos Manuel Montaño	M	CAR	Director of Environmental Management and Territorial Planning	1			Attend											
Cesar Clavijo Rios	M	CAR	Technical Director	2										Attend				
Heidy Milena Castillo	F	CAR	Assigned Professional to the Project	45	Attend		Attend		Attend	Attend		Attend	Attend	Attend	Attend			
Carolina Cárdenas	F	CAR	International Cooperation Advisor	1			Attend											
Magda Suárez Ramírez	F	CAR	Specialized Professional of POMCAS	9			Attend			Attend		Attend						
Humberto Hernández Roa	M	CAR	Specialized Professional	2						Attend		Attend						
Hector H. Leguizamon	M	CAR	Specialized Professional	5														
John A. Sanchez	M	CAR	Specialized Professional	3														
Carlos Andrés Rodriguez	M	CAR	Water Resources Engineer	12														
Alexandra Forero	F	CAR	Technical POMCAS	2						Attend		Attend						
Maria Cristina Reyes	F	CAR	Specialized Professional	4														
Juan Filiberto Cotrino G.	M	CAR	International Cooperation Advisor	2														
Juan Carlos Loaiza	M	CAR	Contractor	30														
Juan Camilo Pinzon	M	CAR	Intern	1														
Andres Mauricio Rodríguez	M	CAR	Intern	3														
Rafael Iván Robles López	M	CAR	Advisor of General Direction Topic Risk Management	12														
Maryeny Caraballo	F	CAR	Technical POMCAS	43														
Andrés Camilo Rincón	M	CAR	Intern	3														
José Sebastián Cifuentes	M	CAR	Intern	4														
Raul Ernesto Celis	M	CAR	Contractor	4														
Fernando Ospina	M	CAR	Contractor	9														
Yuri Ulloa Sanchez	M	CAR	Contractor	1														
Juan Camilo Acosta	M	CAR	Contractor	4														
Miguel Alejandro Diaz	M	CAR	Contractor	1														
Jenny Rico M.	F	CAR	Contractor	1														
Oscar Santos	M	CAR	Contractor	9														
Carolina Pérez	F	CAR	Contractor	2														
Diana Carolina Perez	F	CAR	Contractor	1														
Ana Maria Escobar	F	CAR	Contractor	1														
Jaime Matiz Ovalle	M	Department of Cundinamarca	Assigned Professional to the Project	55	Attend		Attend	Attend	Attend	Attend	Attend	Attend		Attend	Attend	Attend	Attend	Attend
Onofre Sierra Gómez	M	Department of Cundinamarca	Specialized Professional – Agriculture Secretary	5			Attend			Attend		Attend						
Juan Manuel Acero	M	Department of Cundinamarca	Specialized Professional (Biologist)	3						Attend		Attend						
Maria Cristina Ruiz	F	Department of Cundinamarca	University professional	22						Attend		Attend						
Alvaro Sanchez (Ing.)	M	Department of Cundinamarca	University professional	3						Attend		Attend						
Genmán Ribero	M	Department of Cundinamarca	UAEGRD Director	1														
William Barreto R.	M	Department of Cundinamarca	UAEGRD Sub-director	37						Attend		Attend	Attend					
Nancy Patricia Venegas Gualtero	F	Department of Cundinamarca	UAEGRD Knowledge Sub.	4												Attend	Attend	
Ana María Torres	F	Department of Cundinamarca	UAEGRD Knowledge Sub.	1												Attend		
Helmut Alexander Tequia	M	Department of Cundinamarca	UAEGRD Office Adviser	5												Attend		
Diana Robles	F	Department of Cundinamarca	UAEGRD SIS Eng.	2												Attend	Attend	
Jose Elvis Triviño	M	Department of Cundinamarca	UAEGRD	1														
Jerónimo Gordillo N.	M	Department of Cundinamarca	Government Secretary (In Charge)	1			Attend											
Lina Paola Mora Navarro	F	Department of Cundinamarca	Director International Cooperation Office	2	Attend		Attend											
Ayza Trujillo	F	Department of Cundinamarca	Technician	1			Attend											
David Fernando Rodríguez	M	Department of Cundinamarca	Manager of UAEGRD	2	Attend	Attend												
Antonio Alfonso Moreno	M	Department of Cundinamarca	Consultant	1														
Andrés Mauricio Rodriguez	M	Department of Cundinamarca	Practice	2														
Jairo López Puentes	M	Department of Cundinamarca	Practice	2														
Campo Elias Vega	M	Department of Cundinamarca	International Cooperation	1														
Christian Cruz	M	Department of Cundinamarca	International Cooperation	4														
Jose Manote Rugio Olaya	M	Department of Cundinamarca	Contractor	1	Attend													
Wilson Leonard Garcia F.	M	Department of Cundinamarca	Assistant Manager Infrastructure ICUU	5														
Magda Yamile Ruiz	F	Department of Cundinamarca	UAEGRD Risk Management Technical Sub-Director	10														
Diana Paola Garcia	F	Department of Cundinamarca	International Cooperation	2														
Eduardo Contreras Ramirez	M	Department of Cundinamarca	Environment Secretary	1														
Carlos Manuel Montaño	M	Department of Cundinamarca	Agriculture Secretary	1														
Cesar Augusto Carrillo	M	Department of Cundinamarca	Planning Secretary	3														
Julio Roberto Machado	M	Department of Cundinamarca	Contractor	2														
Jeffer Siatoba B	M	Department of Cundinamarca	Contractor	2														
Rubiela Sanchez	F	Department of Cundinamarca	Press	2														
Vladimir Boris Mora	M	Department of Cundinamarca	Project	2														
Ricardo Cifuentes	M	Department of Cundinamarca	International Cooperation	4														
Yexon Alexis Mojica	M	Department of Cundinamarca	International Cooperation	3														
Erika Elizabeth Sabogal	F	Department of Cundinamarca	Minning, Energry Secretary	1														
Luis Alfonso Escobar	M	MADS (C/P from Feb. 2016)	Director(DGIRH)	2													Attend	
Jairton Diez Diaz	M	MADS (C/P from Feb. 2016)	Director(DGIRH)	2														
Carolina González	F	MADS (C/P from Feb. 2016)	International Affair Office	3													Attend	
Raimundo Tamayo	M	MADS (C/P from Feb. 2016)	Adviser	1													Attend	
Mauricio Bayona	M	MADS (C/P from Feb. 2016)	Adviser	1													Attend	
Yolanda Calderon	F	MADS (C/P from Feb. 2016)	Adviser	54						Attend		Attend			Attend		Attend	
Luz Francy Navarro	F	MADS (C/P from Feb. 2016)	Specialized Professional	71						Attend					Attend		Attend	
Sergio Salazar	M	MADS (C/P from Feb. 2016)	Adviser	15											Attend		Attend	
Diego Montes	M	MADS (C/P from Feb. 2016)	International Cooperation	2														
Orinana Blandon	F	MADS (C/P from Feb. 2016)	Contractor	1														
Linda Irene Gomez	F	MADS (C/P from Feb. 2016)	Specialized Professional	1														
				889	15	3	24	2	4	16	1	14	9	5	11	5	12	1
<Other Agency>																		
Cesar Garay Bohórquez	M	CIRMAG (CORMAGDALENA)	Executive Director	37														
Diana Vargas Rodriguez	F	CORMAGDALENA	Adviser, Watershed Management Plan, Master Plan Achievement	24														
Carlos Andrés Quiza	M	CORMAGDALENA	Sustainable Development and Navigation Sub Director	1														
Vanessa Juliao	F	CORMAGDALENA	Advisor	1														
Viviana Barrera	F	CORMAGDALENA	Environmental Advisor	6														
Claudia Martinez	F	CORMAGDALENA	Specialized Professional	2														
Ana Maria Barreiro	F	CORMAGDALENA	Advisor	7														
Nathaly Triumo	F	CIRMAG	Investigator (Engineer)	1														
Jose Oliveros Acosta	M	CIRMAG	Investigator (Engineer)	1														
Jorge Luis Sánchez Lozano	M	CIRMAG	Investigator (Engineer)	1														
Aura Elena Becerra	F	CORPOBOYACA	University Professional Grade 8	2														
Maria Carolina Obando	F	CORPOBOYACA	Specialized Professional	1														
Félix Márquez	M	CORPOBOYACA	Specialized Professional	1														
Eduardo Bravo	M	UNIVERSIDAD NACIONAL	Profesor	8														
Erasmo Rodriguez	M	UNIVERSIDAD NACIONAL	Profesor	1														
Andrés Reyes	M	SERVICIO GEOLOGICO COLOMBIANO	Specialized Professional	4														
Claudia Avendaño	F	CDM SMITH	Specialized Professional	4														
Andrés Uribe Orozco	M	APC	Demand Management Director	2			Attend											
Liliana Sánchez	F	APC	Japan´s Desk Commissioned	2			Attend											
Catalina Jiménez	F	APC	GRD´s Link	1			Attend											
Santiago Molina Alvarez	M	APC	Demand Management	3														
Juan Sandoval Plata	M	APC	Demand Management	5														
Lina Maria Ibata	F	DNP	Advisor	6														
Carolina Diaz	F	DNP	Risk Management Coordinator	1														
Diego Rubio	M	DNP	Professional of Management Support	11														
Luz Villoman	F	EMGESA	GRD´s Link	1														
Catalina Camacho	F	MIN-MINAS	Contractor	1														
Jaime Martinez	M	Villeta Municipality	Firefighter	1							Attend							
Sergio Andres Murcia Salamarca	M	Villeta Municipality	Planning	1							Attend							
Deizy Anita	F	Villeta Municipality	Planning	1							Attend							
John Avila	M	Utica Municipality	Major´s Advisor	1														
Mauricio Zarate	M	Utica Municipality	Fire house commander	3														
Municipalities in Rio Negro Bas	-	-	-	24														
Students/Nacional/Javeriana	-	-	-	28														
Vitoria Ginja	F	WFP	Deputy Country Director	1														
Chiara Trozzo	F	WFP	Technical Officer	1														
Cundinamarca´s Department/Municipalities	-	-	-	26														
Laura Berrocal	F	WFP	Communication and Patership Officer	1														
				223	0	0	3	0	0	0	3	0	0	0	0	0	0	0
"Japanese Side"																		
<Project Team>																		
Kenji Morita	M	JICA Project Team	Chief-Advisor/Flood Management	63	Attend	Attend	Attend								Attend	Attend	Attend	Attend
Kazunori Inoue	M	JICA Project Team	Vice-Chief Advisor/Hydraulic and Flood Forecast	23	Attend	Attend	Attend	Attend	Attend	Attend	Attend	Attend	Attend					
Masaki Todo	M	JICA Project Team	Expert/River Planning	34	Attend	Attend	Attend	Attend	Attend	Attend	Attend							
Masato Fujimoto	M	JICA Project Team	Expert/Warning Information Dissemination and Evacuation	27											Attend	Attend	Attend	Attend
Akihiro Furuta	M	JICA Project Team	Expert/Flood Risk Mapping, Flood Risk Assessment and GIS	19	Attend	Attend	Attend											
Hirotada Hasegawa	M	JICA Project Team	Expert/Disaster Risk Management Policy	10	Attend	Attend	Attend			Attend	Attend	Attend	Attend					
Takeshi Katayama	M	JICA Project Team	Expert/Disaster Risk Management Policy	8														
				184	5	5	5	2	2	3	3	2	2	0	2	2	2	2
<JICA>																		
Hitoshi Baba	M	JICA	JICA´s Expert	12			Attend											
Ginga Nakadai	F	JICA	JICA´s Expert	1			Attend											
Yasuyuki Shimizu	M	JICA	Professor	4														
Hiroshi Takebayashi	M	JICA	Professor	4														
Hidemitsu Sakurai	M	JICA Colombia	Resident Representative	1			Attend											
Satoshi Murosawa	M	JICA Colombia	Resident Representative	4														
Yuki Kuraoka	F	JICA Colombia	Project Formulation Adviser	4	Attend													
Catalina Maria Bastidas Grijalba	F	JICA Colombia	Program Officer, Technical and Finance Cooperation Area	15	Attend		Attend								Attend			
Masamichi Sunada	M	JICA Colombia	Cooperation Program Advisor	4														
Masami Ikuta	F	JICA Colombia	Cooperation Program Coordinator	2														
Mari Asano	F	JICA Colombia	Administration and Accounting Coordinator	2														
Valeria Reinosa	F	JICA Colombia	Program Officer,	1														
Diego Alejandro Martinez	M	JICA Colombia	Program Officer	3														
Jose Marie Sanchez	M	JICA	Advisor	3														
Yoshiharu Furuyama	M	JICA Senior Volunteer	IDEAM	4	Attend			Attend										
				64	3	0	4	1	0	0	0	0	0	0	1	0	0	0
<Japanese Embassy>																		
Osamu Inagaki	M	Japanese embassy	Director International Cooperation Office	1			Attend											
Takatoshi Yamamoto	M	Japanese embassy	First Secretary	2														
				3	0	0	1	0	0	0	0	0	0	0	0	0	0	0

List of Workshop

			WS	WS	Meeting	2nd JCC	Meeting	WS	Meeting	WS	WS	WS	WS	WS	WS	WS	WS	WS	Meeting	Meeting
			Introduction of training in Japan, Japanese standard for early warning	Role Sharing of Relevant Organs	Introduction of Japanese methodology for evaluation of flood control project as a part of risk assessment	JCC on new C/P	Introduction of the Project and Interview on activity of CORMAGDALENA	Field reconnaissance on good practice of early warning in Soacha municipality	Detailed explanation of Japanese methodology for evaluation of flood control project as a part of risk assessment	Role Sharing of Relevant Organs for Magdalena basin	Role Sharing of Relevant Organs for Rio Negro basin	Evaluation of flood control project as a part of risk assessment, and good practices on early warning	Coordinate with the gr	Meeting on Schedule and Review on Collected Data/Information since Aug.2015	Discussion on Magdalena´s floods. River planning benefits. Role sharing	River Law /Urban Flood Risk Law in Japan/Discussion on flood events Magdalena/River Planning Magdalena /Explanation flood issues R. Negro/River planning R. Negro	Progress River Planning in R.Magdalena Medio. Method of Diagnosis of River Channel Preparation work for River Planning R.Negro. Schedule River Planning in R. Negro.Timeline Action April11 Flood Disaster in Utica	Site Visit, Meeting with Municipality's authorities.Fact Finding	Monitoring Sheet Review	Agenda Review Site visit Nomination Training
			Morning, 16-Feb-16	Afternoon, 16-Feb-16	19-Feb-16	23-Feb-16	24-Feb-16	25-Feb-16	29-Feb-16	Morning, 2-Mar-16	Afternoon, 2-Mar-16	9-Mar-16	18-Apr-16	27-Apr-16	4-May-16	11-May-16	17-May-16	18-19-20 May-16	25-May-16	7-Jul-16
"Colombian Side"			26	16	11	21	7	10	14	14	12	16	12	15	28	26	14	8	8	9
<Counterpart Agency>																				
NAME	SEX	ENTITY	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance
Carlos Iván Marquez Perez	M	UNGRD				Attend														
Richard Vargas	M	UNGRD																		
Diego Peña Lopez	M	UNGRD																		
Lina Dorado	F	UNGRD																		
Julio González Velandia	M	UNGRD	Attend	Attend	Attend	Attend		Attend	Attend		Attend	Attend	Attend	Attend	Attend	Attend	Attend	Attend	Attend	
Joana M. Perez	F	UNGRD																		
Gerardo Jaramillo	M	UNGRD																		
Cristian Fernandez	M	UNGRD																		
Antonio López Reales	M	UNGRD	Attend	Attend																
Camila Chaparro	F	UNGRD																		
Kulio Cesar	M	UNGRD																		
Stefania Benavide Escobar	F	UNGRD																		
Ivan H. Caicedo	M	UNGRD	Attend																	
Claudia Cante	F	UNGRD			Attend			Attend	Attend	Attend										
Andrés Salazar	M	UNGRD													Attend					
Rafael Saenz Perez	M	UNGRD														Attend				
Margarita Arias	F	UNGRD				Attend														
Isabel C. Gonzalez	F	UNGRD															Attend			
Gabriel Garcia	M	UNGRD																		
Marianella Botta Serrano	F	UNGRD											Attend							
Juan Camilo Olaya	M	UNGRD																		
Lina Paola Martinez	F	UNGRD																		
Luis Ignacio Muñoz	M	UNGRD																		
Claudia Lorena Barajas	F	UNGRD																		
Andres Sanabria	M	UNGRD																		
Nidia Cristina Reyes	F	UNGRD																		
MariaTeresa Martinez	F	UNGRD																		
Mario Germán Trujillo	M	UNGRD																		
Omar Franco Torres	M	IDEAM																		
Omar Vargas Martinez	M	IDEAM	Attend	Attend		Attend	Attend									Attend				Attend
Christian Euscátegui	M	IDEAM																		
Estefania Salas	F	IDEAM																		
Diana Maria Quimbay Velencia	F	IDEAM				Attend														
Fabio Andrés Bernal Quiroga	M	IDEAM	Attend	Attend	Attend	Attend	Attend		Attend	Attend	Attend	Attend	Attend	Attend	Attend	Attend	Attend		Attend	Attend
Juan David Rondon	M	IDEAM																		
Oscar Martínez	M	IDEAM													Attend					
Clara Lamo	F	IDEAM																		
Catherine Fonseca	F	IDEAM																		
Wilson Becerra	M	IDEAM																		
Natalia Soto	F	IDEAM																		
Alberto Pardo Ojeda	M	IDEAM	Attend																	
Guillermo Olaya Triana	M	IDEAM	Attend																	
Nelson Obregon	M	IDEAM																		
Ana Campillo Pérez	F	IDEAM																		
Freddy Garrido H.	M	IDEAM	Attend	Attend																
Henry A. Romero	M	IDEAM																		
Hernando Wilches Suárez	M	IDEAM	Attend																	
Nelsy Verdugo	F	IDEAM	Attend																	
Maria Costanza Rosero	F	IDEAM	Attend	Attend												Attend				
Ivan Camilo Peña	M	IDEAM	Attend	Attend																
Enrique Rodriguez	M	IDEAM																		
Adriana Maria Rojas	F	IDEAM																		
Jorge Gonzalez	M	IDEAM	Attend	Attend					Attend			Attend				Attend				
Angela Paola Chia	F	IDEAM	Attend																	
Minjung Kim	F	IDEAM																		
Julian Arbelaez	M	IDEAM																		
Juan Pablo Urrego	M	IDEAM																		
Fabian Mauricio Caicedo	M	IDEAM																		
Claudia Contreras	F	IDEAM																		
Nestor Franco	M	CAR				Attend														
Carlos Manuel Montaño	M	CAR																		
Cesar Clavijo Rios	M	CAR				Attend														
Heidy Milena Castillo	F	CAR	Attend	Attend	Attend	Attend			Attend		Attend	Attend	Attend	Attend	Attend	Attend	Attend	Attend	Attend	Attend
Carolina Cárdenas	F	CAR																		
Magda Suárez Ramírez	F	CAR													Attend	Attend				
Humberto Hernández Roa	M	CAR																		
Hector H. Leguizamon	M	CAR	Attend					Attend				Attend	Attend		Attend					
John A. Sanchez	M	CAR	Attend	Attend				Attend												
Carlos Andrés Rodriguez	M	CAR						Attend				Attend	Attend	Attend	Attend	Attend	Attend			
Alexandra Forero	F	CAR																		
Maria Cristina Reyes	F	CAR							Attend		Attend	Attend			Attend					
Juan Filiberto Cotrino G.	M	CAR										Attend							Attend	
Juan Carlos Loaiza	M	CAR										Attend	Attend	Attend	Attend	Attend				
Juan Camilo Pinzon	M	CAR														Attend				
Andres Mauricio Rodríguez	M	CAR													Attend	Attend	Attend			
Rafael Iván Robles López	M	CAR																		
Maryeny Caraballo	F	CAR							Attend		Attend	Attend	Attend		Attend	Attend	Attend			
Andrés Camilo Rincón	M	CAR																		
José Sebastián Cifuentes	M	CAR																		
Raul Ernesto Celis	M	CAR											Attend	Attend	Attend					
Fernando Ospina	M	CAR																		
Yuri Ulloa Sanchez	M	CAR																		
Juan Camilo Acosta	M	CAR																		
Miguel Alejandro Diaz	M	CAR																		
Jenny Rico M.	F	CAR																		
Oscar Santos	M	CAR																		
Carolina Pérez	F	CAR																		
Diana Carolina Perez	F	CAR																		
Ana Maria Escobar	F	CAR																		
Jaime Matiz Ovalle	M	Department of Cundinamarca	Attend	Attend	Attend	Attend		Attend	Attend				Attend	Attend	Attend	Attend	Attend	Attend	Attend	Attend
Onofre Sierra Gómez	M	Department of Cundinamarca																		
Juan Manuel Acero	M	Department of Cundinamarca									Attend									
Maria Cristina Ruiz	F	Department of Cundinamarca														Attend	Attend	Attend		
Alvaro Sanchez (Ing.)	M	Department of Cundinamarca																		
Genmán Ribero	M	Department of Cundinamarca																		
William Barreto R.	M	Department of Cundinamarca			Attend								Attend	Attend	Attend	Attend		Attend		
Nancy Patricia Venegas Gualtero	F	Department of Cundinamarca																		Attend
Ana María Torres	F	Department of Cundinamarca																		
Helmut Alexander Tequia	M	Department of Cundinamarca																		
Diana Robles	F	Department of Cundinamarca																		
Jose Elvis Triviño	M	Department of Cundinamarca						Attend												
Jerónimo Gordillo N.	M	Department of Cundinamarca																		
Lina Paola Mora Navarro	F	Department of Cundinamarca																		
Ayza Trujillo	F	Department of Cundinamarca																		
David Fernando Rodriguez	M	Department of Cundinamarca																		
Antonio Alfonso Moreno	M	Department of Cundinamarca																		
Andrés Mauricio Rodriguez	M	Department of Cundinamarca																		
Jairo López Puentes	M	Department of Cundinamarca																		
Campo Elias Vega	M	Department of Cundinamarca																		
Christian Cruz	M	Department of Cundinamarca																		
Jose Manote Rugio Olaya	M	Department of Cundinamarca																		
Wilson Leonard Garcia F.	M	Department of Cundinamarca																		
Magda Yamile Ruiz	F	Department of Cundinamarca																		
Diana Paola Garcia	F	Department of Cundinamarca																		
Eduardo Contreras Ramirez	M	Department of Cundinamarca																		
Carlos Manuel Montaño	M	Department of Cundinamarca																		
Cesar Augusto Carrillo	M	Department of Cundinamarca																		
Julio Roberto Machado	M	Department of Cundinamarca																		
Jeffer Siatoba B	M	Department of Cundinamarca																		
Rubiela Sanchez	F	Department of Cundinamarca																		
Vladimir Boris Mora	M	Department of Cundinamarca																		
Ricardo Cifuentes	M	Department of Cundinamarca																		
Yexon Alexis Mojica	M	Department of Cundinamarca																		
Erika Elizabeth Sabogal	F	Department of Cundinamarca																		
Luis Alfonso Escobar	M	MADS (C/P from Feb. 2016)				Attend														
Jairton Diez Diaz	M	MADS (C/P from Feb. 2016)																		
Carolina González	F	MADS (C/P from Feb. 2016)				Attend														
Raimundo Tamayo	M	MADS (C/P from Feb. 2016)																		
Mauricio Bayona	M	MADS (C/P from Feb. 2016)																		
Yolanda Calderon	F	MADS (C/P from Feb. 2016)	Attend	Attend	Attend	Attend			Attend	Attend	Attend	Attend	Attend	Attend	Attend			Attend	Attend	
Luz Francy Navarro	F	MADS (C/P from Feb. 2016)	Attend	Attend					Attend	Attend	Attend	Attend	Attend	Attend	Attend	Attend	Attend	Attend	Attend	Attend
Sergio Salazar	M	MADS (C/P from Feb. 2016)	Attend	Attend	Attend				Attend	Attend	Attend	Attend			Attend					
Diego Montes	M	MADS (C/P from Feb. 2016)																		
Orinana Blandon	F	MADS (C/P from Feb. 2016)																		
Linda Irene Gomez	F	MADS (C/P from Feb. 2016)																		
			21	14	8	13	2	7	11	5	9	13	12	11	18	17	10	7	7	6
<Other Agency>																				
Cesar Garay Bohórquez	M	CIRMAG (CORMAGDALENA)					Attend			Attend					Attend	Attend				
Diana Vargas Rodriguez	F	CORMAGDALENA					Attend			Attend										
Carlos Andrés Quiza	M	CORMAGDALENA																		
Vanessa Juliao	F	CORMAGDALENA																		
Viviana Barrera	F	CORMAGDALENA								Attend					Attend	Attend	Attend			
Claudia Martinez	F	CORMAGDALENA																		
Ana Maria Barreiro	F	CORMAGDALENA																		
Nathaly Triumo	F	CIRMAG								Attend										
Jose Oliveros Acosta	M	CIRMAG								Attend										
Jorge Luis Sánchez Lozano	M	CIRMAG								Attend										
Aura Elena Becerra	F	CORPOBOYACA												Attend	Attend					
Maria Carolina Obando	F	CORPOBOYACA													Attend					
Félix Márquez	M	CORPOBOYACA													Attend					
Eduardo Bravo	M	UNIVERSIDAD NACIONAL													Attend					
Erasmo Rodriguez	M	UNIVERSIDAD NACIONAL																		
Andrés Reyes	M	SERVICIO GEOLOGICO COLOMBIANO																		
Claudia Avendaño	F	CDM SMITH																		
Andrés Uribe Orozco	M	APC				Attend														
Liliana Sánchez	F	APC				Attend														
Catalina Jiménez	F	APC																		
Santiago Molina Alvarez	M	APC																		
Juan Sandoval Plata	M	APC																		
Lina Maria Ibata	F	DNP																		
Carolina Diaz	F	DNP																		
Diego Rubio	M	DNP																		
Luz Villoman	F	EMGESA	Attend																	
Catalina Camacho	F	MIN-MINAS	Attend																	
Jaime Martinez	M	Villeta Municipality																		
Sergio Andres Murcia Salamarca	M	Villeta Municipality																		
Deizy Anita	F	Villeta Municipality																		
John Avila	M	Utica Municipality																		
Mauricio Zarate	M	Utica Municipality									Attend									
Municipalities in Rio Negro Basi	-	-																		
Students/Nacional/Javeriana	-	-																		
Vitoria Ginja	F	WFP																		
Chiara Trozzo	F	WFP																		
Cundinamarca´s Department/Municipalities	-	-																		
Laura Berrocal	F	WFP																		
			2	0	0	2	2	0	0	6	0	1	0	1	6	2	1	0	0	0
"Japanese Side"																				
<Project Team>																				
Kenji Morita	M	JICA Project Team	Attend	Attend	Attend	Attend	Attend	Attend	Attend	Attend	Attend									
Kazunori Inoue	M	JICA Project Team												Attend	Attend	Attend	Attend	Attend	Attend	Attend
Masaki Todo	M	JICA Project Team												Attend	Attend	Attend	Attend			Attend
Masato Fujimoto	M	JICA Project Team	Attend	Attend	Attend	Attend	Attend	Attend	Attend	Attend	Attend	Attend								
Akihiro Furuta	M	JICA Project Team			Attend	Attend	Attend	Attend	Attend	Attend	Attend	Attend								
Hirotada Hasegawa	M	JICA Project Team												Attend	Attend	Attend				
Takeshi Katayama	M	JICA Project Team																		
			2	2	3	3	3	3	3	3	3	2	0	3	3	3	2	1	1	2
<JICA>																				
Hitoshi Baba	M	JICA													Attend	Attend	Attend			
Ginga Nakadai	F	JICA																		
Yasuyuki Shimizu	M	JICA																		
Hiroshi Takebayashi	M	JICA																		
Hidemitsu Sakurai	M	JICA Colombia																		
Satoshi Murosawa	M	JICA Colombia				Attend														
Yuki Kuraoka	F	JICA Colombia				Attend														
Catalina Maria Bastidas Grijalba	F	JICA Colombia				Attend										Attend				Attend
Masamichi Sunada	M	JICA Colombia																		
Masami Ikuta	F	JICA Colombia																		
Mari Asano	F	JICA Colombia																		
Valeria Reinosa	F	JICA Colombia																		
Diego Alejandro Martinez	M	JICA Colombia																		
Jose Marie Sanchez	M	JICA														Attend				
Yoshiharu Furuyama	M	JICA Senior Volunteer	Attend													Attend				
			1	0	0	3	0	0	0	0	0	0	0	0	1	4	1	0	0	1
<Japanese Embassy>																				
Osamu Inagaki	M	Japanese embassy																		
Takatoshi Yamamoto	M	Japanese embassy																		
			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

List of Workshop

NAME	SEX	ENTITY	WS	WS	WS	WS	Meeting	Meeting	Meeting	WS	Meeting/WS	Meeting	WS	WS	Meeting	Meeting	Meeting	WS	WS	WS
			Analysis Site Visit Quebrada Negra, River Planning Magdalena River and EWA	Site Visit, Barrancabermeja-Puerto Wilches	Review Site Visit Barrancabermeja/ River Planning Magdalena River/EWS Magdalena River	Historical Events Critical points Rio Negro Basin/EWS in Utica/Hazard Map in Japan/Progress Analysis Rio Magdalena	Monitoring Sheet Review	Agenda Review C/P's activity confirmation New C/P Member consultation-CORMAGDALENA & CIRMAG	Briefing Session Training in Japan	Magdalena Over flow, output image analysis, introduction policy or mitigation /preservation method	Introduction of the Methodology of Ronda Hídrica by CAR/ River Planning Magdalena River	Discussion on new C/P member - CORMAGDALENA y CIRMAG	Introduction Ronda Hídrica MADS and Car, Analysis Magdalena River and Flood Risk Assesment	Flood Risk Assessment and necessary data	Monitoring Sheet Review	Activities Agenda's Review	Project's Introduction to Cundinamarca's Governor	Discussion Draft River Planning Magdalena River/Explanation BMP Rio Negro Basin/Activity Progress/Training Experience Sharing	Early Warning Alert-Guaduas	Discussion future activities River Planning Rio Magdalena / Activity progress Rio Negro
			15-Jul-16	19-Jul-16	22-Jul-16	28-Jul-16	4-Aug-16	5-Oct-16	10-Oct-16	13-Oct-16	19-Oct-16	28-Oct-16	31-Oct-16	9-Nov-16	11-Nov-16	7-Feb-17	8-Feb-17	10-Feb-17	17-Feb-17	20-Feb-17
"Colombian Side"			18	12	12	15	13	13	14	16	11	4	15	11	3	21	16	14	15	14
<Counterpart Agency>																				
NAME	SEX	ENTITY	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance
Carlos Iván Marquez Perez	M	UNGRD																		
Richard Vargas	M	UNGRD																		
Diego Peña Lopez	M	UNGRD																		
Lina Dorado	F	UNGRD																		
Julio González Velandia	M	UNGRD	Attend	Attend		Attend	Attend	Attend	Attend	Attend	Attend	Attend	Attend	Attend		Attend	Attend	Attend		Attend
Joana M. Perez	F	UNGRD																	Attend	
Gerardo Jaramillo	M	UNGRD																		
Cristian Fernandez	M	UNGRD																		
Antonio López Reales	M	UNGRD														Attend				
Camila Chaparro	F	UNGRD																		
Kulio Cesar	M	UNGRD																		
Stefania Benavide Escobar	F	UNGRD																		
Ivan H, Caicedo	M	UNGRD																		
Claudia Cante	F	UNGRD																	Attend	
Andrés Salazar	M	UNGRD																		
Rafael Saenz Perez	M	UNGRD																		
Margarita Arias	F	UNGRD																		
Isabel C. Gonzalez	F	UNGRD																		
Gabriel Garcia	M	UNGRD																	Attend	
Marianella Botta Serrano	F	UNGRD																		
Juan Camilo Olaya	M	UNGRD																		
Lina Paola Martinez	F	UNGRD																		
Luis Ignacio Muñoz	M	UNGRD																		
Claudia Lorena Barajas	F	UNGRD																		
Andres Sanabria	M	UNGRD																		
Nidia Cristina Reyes	F	UNGRD																		
MariaTeresa Martínez	F	UNGRD																		
Mario Germán Trujillo	M	UNGRD																		
Omar Franco Torres	M	IDEAM																		
Omar Vargas Martinez	M	IDEAM																		
Christian Euscátegui	M	IDEAM																		
Estefania Salas	F	IDEAM																		
Diana Maria Quimbay Velencia	F	IDEAM														Attend				
Fabio Andrés Bernal Quiroga	M	IDEAM	Attend	Attend	Attend	Attend	Attend	Attend	Attend	Attend	Attend	Attend	Attend			Attend	Attend	Attend		Attend
Juan David Rondon	M	IDEAM																		
Oscar Martínez	M	IDEAM									Attend									
Clara Lamo	F	IDEAM																		
Catherine Fonseca	F	IDEAM																		
Wilson Becerra	M	IDEAM																		
Natalia Soto	F	IDEAM																		
Alberto Pardo Ojeda	M	IDEAM																		
Guillermo Olaya Triana	M	IDEAM	Attend																	
Nelson Obregon	M	IDEAM																		
Ana Campille Pérez	F	IDEAM																		
Freddy Garrido H.	M	IDEAM																		
Henry A. Romero	M	IDEAM																		
Hernando Wilches Suárez	M	IDEAM																		
Nelsy Verdugo	F	IDEAM	Attend																	
Maria Costanza Rosero	F	IDEAM																		
Ivan Camilo Peña	M	IDEAM																		
Enrique Rodríguez	M	IDEAM				Attend														
Adriana Maria Rojas	F	IDEAM				Attend														
Jorge Gonzalez	M	IDEAM							Attend											
Angela Paola Chia	F	IDEAM																		
Minjung Kim	F	IDEAM																		
Julian Arbelaez	M	IDEAM																		
Juan Pablo Urrego	M	IDEAM																		
Fabian Mauricio Caicedo	M	IDEAM																		
Claudia Contreras	F	IDEAM																		
Nestor Franco	M	CAR																		
Carlos Manuel Montaño	M	CAR																		
Cesar Clavijo Rios	M	CAR																		
Heidy Milena Castillo	F	CAR	Attend	Attend	Attend	Attend	Attend	Attend	Attend	Attend	Attend		Attend	Attend	Attend	Attend	Attend	Attend	Attend	Attend
Carolina Cárdenas	F	CAR																		
Magda Suárez Ramírez	F	CAR	Attend	Attend	Attend	Attend														
Humberto Hernández Roa	M	CAR																		
Hector H. Leguizamon	M	CAR																		
John A. Sanchez	M	CAR																		
Carlos Andrés Rodriguez	M	CAR								Attend										
Alexandra Forero	F	CAR																		
Maria Cristina Reyes	F	CAR																		
Juan Filiberto Cotrino G.	M	CAR																		
Juan Carlos Loaiza	M	CAR	Attend			Attend				Attend	Attend		Attend					Attend		Attend
Juan Camilo Pinzon	M	CAR																		
Andres Mauricio Rodríguez	M	CAR																		
Rafael Iván Robles López	M	CAR						Attend	Attend	Attend			Attend							
Maryeny Caraballo	F	CAR						Attend	Attend				Attend			Attend		Attend	Attend	Attend
Andrés Camilo Rincón	M	CAR												Attend		Attend				Attend
José Sebastián Cifuentes	M	CAR												Attend		Attend		Attend		Attend
Raul Ernesto Celis	M	CAR																		
Fernando Ospina	M	CAR																		
Yuri Ulloa Sanchez	M	CAR																	Attend	
Juan Camilo Acosta	M	CAR																		
Miguel Alejandro Diaz	M	CAR																		
Jenny Rico M.	F	CAR																		
Oscar Santos	M	CAR																		
Carolina Pérez	F	CAR																		
Diana Carolina Perez	F	CAR																		
Ana Maria Escobar	F	CAR																		
Jaime Matiz Ovalle	M	Department of Cundinamarca	Attend		Attend		Attend	Attend	Attend					Attend	Attend	Attend	Attend	Attend	Attend	
Onofre Sierra Gómez	M	Department of Cundinamarca								Attend			Attend							
Juan Manuel Acero	M	Department of Cundinamarca																		
Maria Cristina Ruiz	F	Department of Cundinamarca	Attend		Attend	Attend	Attend	Attend		Attend	Attend		Attend	Attend						
Alvaro Sanchez (Ing.)	M	Department of Cundinamarca								Attend										
Genmán Ribero	M	Department of Cundinamarca																		
William Barreto R.	M	Department of Cundinamarca	Attend			Attend	Attend	Attend	Attend							Attend	Attend	Attend	Attend	Attend
Nancy Patricia Venegas Gualtero	F	Department of Cundinamarca	Attend																	
Ana María Torres	F	Department of Cundinamarca																		
Helmut Alexander Tequia	M	Department of Cundinamarca					Attend							Attend		Attend				
Diana Robles	F	Department of Cundinamarca																		
Jose Elvis Triviño	M	Department of Cundinamarca																		
Jerónimo Gordillo N.	M	Department of Cundinamarca																		
Lina Paola Mora Navarro	F	Department of Cundinamarca																		
Ayza Trujillo	F	Department of Cundinamarca																		
David Fernando Rodríguez	M	Department of Cundinamarca																		
Antonio Alfonso Moreno	M	Department of Cundinamarca	Attend																	
Andrés Mauricio Rodriguez	M	Department of Cundinamarca	Attend			Attend														
Jairo López Puentes	M	Department of Cundinamarca			Attend	Attend														
Campo Elias Vega	M	Department of Cundinamarca					Attend													
Christian Cruz	M	Department of Cundinamarca														Attend				
Jose Manote Rugio Olaya	M	Department of Cundinamarca																		
Wilson Leonard Garcia F.	M	Department of Cundinamarca							Attend								Attend		Attend	
Magda Yamile Ruiz	F	Department of Cundinamarca														Attend		Attend		Attend
Diana Paola Garcia	F	Department of Cundinamarca															Attend			
Eduardo Contreras Ramirez	M	Department of Cundinamarca															Attend			
Carlos Manuel Montaño	M	Department of Cundinamarca															Attend			
Cesar Augusto Carrillo	M	Department of Cundinamarca															Attend			
Julio Roberto Machado	M	Department of Cundinamarca																	Attend	
Jeffer Siatoba B	M	Department of Cundinamarca																	Attend	
Rubiela Sanchez	F	Department of Cundinamarca																	Attend	
Vladimir Boris Mora	M	Department of Cundinamarca																	Attend	
Ricardo Cifuentes	M	Department of Cundinamarca																		
Yexon Alexis Mojica	M	Department of Cundinamarca																		
Erika Elizabeth Sabogal	F	Department of Cundinamarca															Attend			
Luis Alfonso Escobar	M	MADS (C/P from Feb. 2016)																		
Jairton Diez Diaz	M	MADS (C/P from Feb. 2016)																		
Carolina González	F	MADS (C/P from Feb. 2016)																		
Raimundo Tamayo	M	MADS (C/P from Feb. 2016)																		
Mauricio Bayona	M	MADS (C/P from Feb. 2016)																		
Yolanda Calderon	F	MADS (C/P from Feb. 2016)		Attend			Attend	Attend		Attend		Attend	Attend	Attend						
Luz Francy Navarro	F	MADS (C/P from Feb. 2016)	Attend	Attend	Attend	Attend	Attend	Attend	Attend	Attend			Attend			Attend	Attend	Attend		Attend
Sergio Salazar	M	MADS (C/P from Feb. 2016)											Attend							
Diego Montes	M	MADS (C/P from Feb. 2016)																		
Orinana Blandon	F	MADS (C/P from Feb. 2016)																		
Linda Irene Gomez	F	MADS (C/P from Feb. 2016)																		
			14	6	7	12	10	10	10	11	6	3	11	8	2	14	12	10	13	10
<Other Agency>																				
Cesar Garay Bohórquez	M	CIRMAG (CORMAGDALENA)							Attend	Attend	Attend		Attend			Attend		Attend		Attend
Diana Vargas Rodriguez	F	CORMAGDALENA			Attend									Attend				Attend		Attend
Carlos Andrés Quiza	M	CORMAGDALENA																		
Vanessa Juliao	F	CORMAGDALENA																		
Viviana Barrera	F	CORMAGDALENA			Attend									Attend						
Claudia Martinez	F	CORMAGDALENA		Attend					Attend											
Ana Maria Barreiro	F	CORMAGDALENA																		
Nathaly Triumo	F	CIRMAG																		
Jose Oliveros Acosta	M	CIRMAG																		
Jorge Luis Sánchez Lozano	M	CIRMAG																		
Aura Elena Becerra	F	CORPOBOYACA																		
Maria Carolina Obando	F	CORPOBOYACA																		
Félix Márquez	M	CORPOBOYACA																		
Eduardo Bravo	M	UNIVERSIDAD NACIONAL									Attend									Attend
Erasmo Rodriguez	M	UNIVERSIDAD NACIONAL																		
Andrés Reyes	M	SERVICIO GEOLOGICO COLOMBIANO																		
Claudia Avendaño	F	CDM SMITH																		
Andrés Uribe Orozco	M	APC																		
Liliana Sánchez	F	APC																		
Catalina Jiménez	F	APC																		
Santiago Molina Alvarez	M	APC																		
Juan Sandoval Plata	M	APC														Attend				
Lina Maria Ibata	F	DNP														Attend		Attend		
Carolina Diaz	F	DNP														Attend				
Diego Rubio	M	DNP								Attend			Attend							
Luz Villoman	F	EMGESA																		
Catalina Camacho	F	MIN-MINAS																		
Jaime Martinez	M	Villeta Municipality																		
Sergio Andres Murcia Salamarca	M	Villeta Municipality																		
Deizy Anita	F	Villeta Municipality																		
John Avila	M	Utica Municipality																		
Mauricio Zarate	M	Utica Municipality				Attend														
Municipalities in Rio Negro Basi	-	-																	24	
Students/Nacional/Javeriana	-	-																		
Vitoria Ginja	F	WFP																		
Chiara Trozzo	F	WFP																		
Cundinamarca´s Department/Municipalities	-	-																		
Laura Berrocal	F	WFP																		
			0	1	2	1	0	0	2	2	2	0	2	2	0	4	0	3	1	3
"Japanese Side"																				
<Project Team>																				
Kenji Morita	M	JICA Project Team						Attend	Attend	Attend	Attend	Attend				Attend	Attend	Attend	Attend	Attend
Kazunori Inoue	M	JICA Project Team	Attend	Attend	Attend															
Masaki Todo	M	JICA Project Team	Attend	Attend	Attend	Attend		Attend	Attend	Attend	Attend		Attend							
Masato Fujimoto	M	JICA Project Team	Attend	Attend	Attend	Attend	Attend													
Akihiro Furuta	M	JICA Project Team											Attend	Attend	Attend					
Hirotada Hasegawa	M	JICA Project Team																		
Takeshi Katayama	M	JICA Project Team																		
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<JICA>																				
Hitoshi Baba	M	JICA								Attend	Attend						Attend			
Ginga Nakadai	F	JICA																		
Yasuyuki Shimizu	M	JICA																		
Hiroshi Takebayashi	M	JICA																		
Hidemitsu Sakurai	M	JICA Colombia																		
Satoshi Murosawa	M	JICA Colombia															Attend			
Yuki Kuraoka	F	JICA Colombia														Attend				
Catalina Maria Bastidas Grijalba	F	JICA Colombia		Attend			Attend	Attend								Attend	Attend			
Masamichi Sunada	M	JICA Colombia																		
Masami Ikuta	F	JICA Colombia																		
Mari Asano	F	JICA Colombia																		
Valeria Reinosa	F	JICA Colombia																		
Diego Alejandro Martínez	M	JICA Colombia																		
Jose Marie Sanchez	M	JICA	Attend	Attend																
Yoshiharu Furuyama	M	JICA Senior Volunteer																		
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<Japanese Embassy>																				
Osamu Inagaki	M	Japanese embassy																		
Takatoshi Yamamoto	M	Japanese embassy																		
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List of Workshop

			3rd JCC	Meeting	Meeting	Meeting	Meeting	WS	WS	WS	WS	WS	WS	Meeting	WS	WS	WS	Meeting	WS	WS
			JCC -Update Activities	Monitoring Sheet Review	C/P -Training Topics Revision	C/P -Proposal for 2nd phase of the project	Activities Agenda´s Review	Getting acquainted with Rio Negro through a game	Hydrologic Aspect for River Plan - Rio Negro	River Planning Process Review	River Plannig Rio Negro	Flood Part of River Plan for Magdalena River Road map for the formulation of Magdalena River Plan	River Plannig Rio Negro Road map for the formulation of Magdalena River Plan	Activities Agenda´s Review	River Planning Rio Negro- Early Warning System	Site Visit Puerto Libre/El Dindal	Features and use of metheorological radar in Japan, Rio Magdalena Stragegy, Road Map, Design Scale	Introduction of the Project to WFP	Site Visit Có rdoba/Guadueros	Early Warning System Planning for Rio Negro/Road Map dicussion for Magdalena River/Design Scale
			22-Feb-17	23-Feb-17	6-Mar-17	17-Mar-17	17-Apr-17	25-Apr-17	2-May-17	9-May-17	26-May-17	30-May-17	5-Jun-17	11-Jul-17	19-Jul-17	24-Jul-17	26-Jul-17	27-Jul-17	28-Jul-17	2-Aug-17
"Colombian Side"			27	4	11	10	9	15	10	10	11	9	9	13	12	10	14	10	3	19
<Counterpart Agency>																				
NAME	SEX	ENTITY	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance
Carlos Iván Marquez Perez	M	UNGRD																		
Richard Vargas	M	UNGRD																		
Diego Peña Lopez	M	UNGRD																		
Lina Dorado	F	UNGRD				Attend	Attend						Attend	Attend						
Julio González Velandia	M	UNGRD	Attend	Attend	Attend	Attend														
Joana M. Perez	F	UNGRD							Attend	Attend	Attend	Attend				Attend		Attend		Attend
Gerardo Jaramillo	M	UNGRD																		
Cristian Fernandez	M	UNGRD																		
Antonio López Reales	M	UNGRD	Attend											Attend						
Camila Chaparro	F	UNGRD																		
Kulio Cesar	M	UNGRD																		
Stefania Benavide Escobar	F	UNGRD																		
Ivan H, Caicedo	M	UNGRD																		
Claudia Cante	F	UNGRD																		
Andrés Salazar	M	UNGRD																		
Rafael Saenz Perez	M	UNGRD																		
Margarita Arias	F	UNGRD	Attend																	
Isabel C. Gonzalez	F	UNGRD																		
Gabriel Garcia	M	UNGRD																		
Marianella Botta Serrano	F	UNGRD																		
Juan Camilo Olaya	M	UNGRD						Attend												
Lina Paola Martinez	F	UNGRD																		
Luis Ignacio Muñoz	M	UNGRD																Attend		
Claudia Lorena Barajas	F	UNGRD																		
Andres Sanabria	M	UNGRD																		
Nidia Cristina Reyes	F	UNGRD																		
MariaTeresa Martínez	F	UNGRD																		
Mario Germán Trujillo	M	UNGRD																		
Omar Franco Torres	M	IDEAM																		
Omar Vargas Martinez	M	IDEAM	Attend																	
Christian Euscátegui	M	IDEAM																		
Estefania Salas	F	IDEAM	Attend			Attend	Attend							Attend				Attend		
Diana Maria Quimbay Velencia	F	IDEAM	Attend															Attend		
Fabio Andrés Bernal Quiroga	M	IDEAM	Attend	Attend	Attend	Attend	Attend	Attend	Attend	Attend	Attend	Attend	Attend	Attend	Attend		Attend			Attend
Juan David Rondon	M	IDEAM																		
Oscar Martinez	M	IDEAM																		
Clara Lamo	F	IDEAM																		
Catherine Fonseca	F	IDEAM																		
Wilson Becerra	M	IDEAM																		
Natalia Soto	F	IDEAM																		
Alberto Pardo Ojeda	M	IDEAM																		
Guillermo Olaya Triana	M	IDEAM																		
Nelson Obregon	M	IDEAM																		
Ana Campille Pérez	F	IDEAM																		
Freddy Garrido H.	M	IDEAM																		
Henry A. Romero	M	IDEAM																		
Hernando Wilches Suárez	M	IDEAM																		
Nelsy Verdugo	F	IDEAM																		
Maria Costanza Rosero	F	IDEAM						Attend									Attend			Attend
Ivan Camilo Peña	M	IDEAM																		
Enrique Rodriguez	M	IDEAM																		
Adriana Maria Rojas	F	IDEAM																		
Jorge Gonzalez	M	IDEAM	Attend																	
Angela Paola Chia	F	IDEAM																		
Minjung Kim	F	IDEAM																		
Julian Arbelaez	M	IDEAM																		
Juan Pablo Urrego	M	IDEAM																		
Fabian Mauricio Caicedo	M	IDEAM																		
Claudia Contreras	F	IDEAM																		
Nestor Franco	M	CAR																		
Carlos Manuel Montaño	M	CAR																		
Cesar Clavijo Rios	M	CAR																		
Heidy Milena Castillo	F	CAR	Attend	Attend	Attend		Attend	Attend												
Carolina Cárdenas	F	CAR																		
Magda Suárez Ramirez	F	CAR																		
Humberto Hernández Roa	M	CAR																		
Hector H. Leguizamon	M	CAR																		
John A. Sanchez	M	CAR																		
Carlos Andrés Rodriguez	M	CAR																		
Alexandra Forero	F	CAR																		
Maria Cristina Reyes	F	CAR																		
Juan Filiberto Cotrino G.	M	CAR																		
Juan Carlos Loaiza	M	CAR						Attend	Attend	Attend	Attend	Attend	Attend		Attend	Attend	Attend		Attend	Attend
Juan Camilo Pinzon	M	CAR																		
Andres Mauricio Rodriguez	M	CAR																		
Rafael Iván Robles López	M	CAR	Attend				Attend									Attend				
Maryeny Caraballo	F	CAR	Attend		Attend	Attend		Attend	Attend		Attend		Attend	Attend	Attend	Attend				Attend
Andrés Camilo Rincón	M	CAR																		
José Sebastián Cifuentes	M	CAR																		
Raul Ernesto Celis	M	CAR	Attend																	
Fernando Ospina	M	CAR												Attend	Attend	Attend	Attend			Attend
Yuri Ullos Sanchez	M	CAR																		
Juan Camilo Acosta	M	CAR																		
Miguel Alejandro Diaz	M	CAR																		
Jenny Rico M.	F	CAR																		
Oscar Santos	M	CAR																		
Carolina Pérez	F	CAR																		
Diana Carolina Perez	F	CAR																		
Ana Maria Escobar	F	CAR																		
Jaime Matiz Ovalle	M	Department of Cundinamarca	Attend		Attend			Attend			Attend									
Onofre Sierra Gómez	M	Department of Cundinamarca																		
Juan Manuel Acero	M	Department of Cundinamarca																		
Maria Cristina Ruiz	F	Department of Cundinamarca									Attend	Attend	Attend		Attend		Attend			Attend
Alvaro Sanchez (Ing.)	M	Department of Cundinamarca																		
Germán Ribero	M	Department of Cundinamarca																		
William Barreto R.	M	Department of Cundinamarca	Attend			Attend		Attend		Attend	Attend				Attend		Attend			Attend
Nancy Patricia Venegas Gualtero	F	Department of Cundinamarca																		
Ana Maria Torres	F	Department of Cundinamarca																		
Helmut Alexander Tequia	M	Department of Cundinamarca																		
Diana Robles	F	Department of Cundinamarca																		
Jose Elvis Triviño	M	Department of Cundinamarca																		
Jerónimo Gordillo N.	M	Department of Cundinamarca																		
Lina Paola Mora Navarro	F	Department of Cundinamarca																		
Ayza Trujillo	F	Department of Cundinamarca																		
David Fernando Rodriguez	M	Department of Cundinamarca																		
Antonio Alfonso Moreno	M	Department of Cundinamarca																		
Andrés Mauricio Rodriguez	M	Department of Cundinamarca																		
Jairo López Puentes	M	Department of Cundinamarca																		
Campo Elias Vega	M	Department of Cundinamarca																		
Christian Cruz	M	Department of Cundinamarca	Attend		Attend					Attend										
Jose Manote Rugio Olaya	M	Department of Cundinamarca																		
Wilson Leonard Garcia F.	M	Department of Cundinamarca	Attend																	
Magda Yamile Ruiz	F	Department of Cundinamarca	Attend		Attend		Attend													Attend
Diana Paola Garcia	F	Department of Cundinamarca																		
Eduardo Contreras Ramirez	M	Department of Cundinamarca																		
Carlos Manuel Montaño	M	Department of Cundinamarca																		
Cesar Augusto Carrillo	M	Department of Cundinamarca																		
Julio Roberto Machado	M	Department of Cundinamarca																		
Jeffer Siatoba B	M	Department of Cundinamarca																		
Rubiela Sanchez	F	Department of Cundinamarca																		
Vladimir Boris Mora	M	Department of Cundinamarca																		
Ricardo Cifuentes	M	Department of Cundinamarca																		
Yexon Alexis Mojica	M	Department of Cundinamarca																		
Erika Elizabeth Sabogal	F	Department of Cundinamarca																		
Luis Alfonso Escobar	M	MADS (C/P from Feb. 2016)																		
Jairton Diez Diaz	M	MADS (C/P from Feb. 2016)																		
Carolina González	F	MADS (C/P from Feb. 2016)	Attend																	
Raimundo Tamayo	M	MADS (C/P from Feb. 2016)																		
Mauricio Bayona	M	MADS (C/P from Feb. 2016)																		
Yolanda Calderon	F	MADS (C/P from Feb. 2016)			Attend	Attend		Attend	Attend	Attend		Attend	Attend	Attend	Attend	Attend	Attend			Attend
Luz Francy Navarro	F	MADS (C/P from Feb. 2016)	Attend		Attend	Attend	Attend	Attend	Attend	Attend	Attend	Attend	Attend	Attend	Attend	Attend	Attend			Attend
Sergio Salazar	M	MADS (C/P from Feb. 2016)																		
Diego Montes	M	MADS (C/P from Feb. 2016)																		
Orinana Blandon	F	MADS (C/P from Feb. 2016)																		
Linda Irene Gomez	F	MADS (C/P from Feb. 2016)														Attend				
			19	3	9	8	7	10	6	7	8	6	7	8	8	7	9	4	1	11
<Other Agency>																				
Cesar Garay Bohórquez	M	CIRMAG (CORMAGDALENA)	Attend		Attend	Attend	Attend	Attend	Attend	Attend	Attend	Attend	Attend	Attend	Attend	Attend	Attend			Attend
Diana Vargas Rodriguez	F	CORMAGDALENA	Attend			Attend		Attend		Attend		Attend		Attend			Attend			Attend
Carlos Andrés Quiza	M	CORMAGDALENA																		
Vanessa Juliao	F	CORMAGDALENA																		
Viviana Barrera	F	CORMAGDALENA																		
Claudia Martinez	F	CORMAGDALENA																		
Ana Maria Barreiro	F	CORMAGDALENA																		
Nathaly Triumo	F	CIRMAG																		
Jose Oliveros Acosta	M	CIRMAG																		
Jorge Luis Sánchez Lozano	M	CIRMAG																		
Aura Elena Becerra	F	CORPOBOYACA																		
Maria Carolina Obando	F	CORPOBOYACA																		
Félix Márquez	M	CORPOBOYACA																		
Eduardo Bravo	M	UNIVERSIDAD NACIONAL																		
Erasmo Rodriguez	M	UNIVERSIDAD NACIONAL																		
Andrés Reyes	M	SERVICIO GEOLOGICO COLOMBIANO																		
Claudia Avendaño	F	CDM SMITH																		
Andrés Uribe Orozco	M	APC																		
Liliana Sánchez	F	APC																		
Catalina Jiménez	F	APC																		
Santiago Molina Alvarez	M	APC	Attend																	
Juan Sandoval Plata	M	APC	Attend																	
Lina Maria Ibata	F	DNP						Attend	Attend		Attend									Attend
Carolina Diaz	F	DNP																		
Diego Rubio	M	DNP	Attend		Attend			Attend						Attend	Attend		Attend			Attend
Luz Villoman	F	EMGESA																		
Catalina Camacho	F	MIN-MINAS																		
Jaime Martinez	M	Villeta Municipality																		
Sergio Andres Murcia Salamarca	M	Villeta Municipality																		
Deizy Anita	F	Villeta Municipality																		
John Avila	M	Utica Municipality							Attend											
Mauricio Zarate	M	Utica Municipality																		
Municipalities in Rio Negro Bas	-	-																		
Students/Nacional/Javeriana	-	-																		
Vitoria Ginja	F	WFP																Attend		
Chiara Trozzo	F	WFP																Attend		
Cundinamarca´s Department/Municipalities	-	-																		
Laura Berrocal	F	WFP																Attend		
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"Japanese Side"																				
<Project Team>																				
Kenji Morita	M	JICA Project Team	Attend	Attend							Attend	Attend	Attend	Attend	Attend	Attend	Attend	Attend	Attend	Attend
Kazunori Inoue	M	JICA Project Team					Attend	Attend	Attend	Attend										
Masaki Todo	M	JICA Project Team																		
Masato Fujimoto	M	JICA Project Team												Attend	Attend	Attend	Attend	Attend	Attend	Attend
Akihiro Furuta	M	JICA Project Team																		
Hirotada Hasegawa	M	JICA Project Team																		
Takeshi Katayama	M	JICA Project Team																		
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<JICA>																				
Hitoshi Baba	M	JICA																		
Ginga Nakadai	F	JICA																		
Yasuyuki Shimizu	M	JICA																		
Hiroshi Takebayashi	M	JICA																		
Hidemitsu Sakurai	M	JICA Colombia																		
Satoshi Murosawa	M	JICA Colombia																		
Yuki Kuraoka	F	JICA Colombia	Attend																	
Catalina Maria Bastidas Grijalba	F	JICA Colombia	Attend															Attend		Attend
Masamichi Sunada	M	JICA Colombia																		Attend
Masami Ikuta	F	JICA Colombia																		
Mari Asano	F	JICA Colombia																		
Valeria Reinosa	F	JICA Colombia																		
Diego Alejandro Martínez	M	JICA Colombia																		
Jose Marie Sanchez	M	JICA																		
Yoshiharu Furuyama	M	JICA Senior Volunteer																		
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<Japanese Embassy>																				
Osamu Inagaki	M	Japanese embassy																		
Takatoshi Yamamoto	M	Japanese embassy																		
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List of Workshop

			Meeting	Meeting	WS	WS	WS	WS	WS	Seminar	Seminar	Seminar	Seminar	WS	WS	WS	4th JCC	Meeting	Meeting	Meeting
			Monitoring Sheet Revision- Road Map Discussion-Main Actors Agreement	Activities Agenda´s Review	Flood Risk Assessment	River Planning Process- Map Preparation and countermeasurements analysis	Road Map Discussion-Main Actors Agreement	Hydrological Analysis 2011 Flood,Latest Hydraulic Model,Structural and Non-Structural Countermeasures	Finalize Road Map Magdalena, Level Design definition, Apropiate Role Distribution	iRIC	iRIC	iRIC	iRIC	Analysis IFMP Rio Negro/Roles and Responsabilities	First Draft IFMP Rio Negro	IFMP Incorporation into POMCA	JCC -Update Activities	Activity Report Review	C/P´s Meeting Discussion about including IFMP to POMCA	Activities Agenda´s Review
			9-Aug-17	4-Sep-17	13-Sep-17	22-Sep-17	27-Sep-17	4-Oct-07	12-Oct-17	17-Oct-17	18-Oct-17	19-Oct-17	20-Oct-17	25-Oct-17	1-Nov-17	22-Nov-17	24-Nov-17	28-Nov-17	20-Dec-17	6-Feb-18
"Colombian Side"			10	7	8	9	12	11	8	33	31	30	30	10	9	13	25	7	6	8
<Counterpart Agency>																				
NAME	SEX	ENTITY	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance
Carlos Iván Marquez Perez	M	UNGRD																		
Richard Vargas	M	UNGRD																		
Diego Peña Lopez	M	UNGRD																		
Lina Dorado	F	UNGRD															Attend			
Julio González Velandia	M	UNGRD																		
Joana M. Perez	F	UNGRD	Attend	Attend	Attend	Attend	Attend		Attend	Attend	Attend	Attend	Attend	Attend	Attend	Attend	Attend	Attend		Attend
Gerardo Jaramillo	M	UNGRD																		
Cristian Fernandez	M	UNGRD																		
Antonio López Reales	M	UNGRD															Attend			
Camila Chaparro	F	UNGRD																		
Kulio Cesar	M	UNGRD																		
Stefania Benavide Escobar	F	UNGRD																		
Ivan H, Caicedo	M	UNGRD																		
Claudia Cante	F	UNGRD																		
Andrés Salazar	M	UNGRD																		
Rafael Saenz Perez	M	UNGRD																		
Margarita Arias	F	UNGRD																		
Isabel C. Gonzalez	F	UNGRD																		
Gabriel Garcia	M	UNGRD																		
Marianella Botta Serrano	F	UNGRD																		
Juan Camilo Olaya	M	UNGRD																		
Lina Paola Martinez	F	UNGRD		Attend													Attend			
Luis Ignacio Muñoz	M	UNGRD																		
Claudia Lorena Barajas	F	UNGRD								Attend	Attend	Attend	Attend							
Andres Sanabria	M	UNGRD								Attend	Attend	Attend	Attend							
Nidia Cristina Reyes	F	UNGRD								Attend	Attend	Attend	Attend							
MariaTeresa Martínez	F	UNGRD																		
Mario Germán Trujillo	M	UNGRD								Attend	Attend	Attend	Attend							
Omar Franco Torres	M	IDEAM															Attend			
Omar Vargas Martinez	M	IDEAM	Attend																	
Christian Euscátegui	M	IDEAM																		
Estefania Salas	F	IDEAM		Attend													Attend			
Diana Maria Quimbay Velencia	F	IDEAM																		
Fabio Andrés Bernal Quiroga	M	IDEAM	Attend						Attend	Attend	Attend	Attend			Attend	Attend		Attend	Attend	Attend
Juan David Rondon	M	IDEAM						Attend						Attend						
Oscar Martínez	M	IDEAM																		
Clara Lamo	F	IDEAM																		
Catherine Fonseca	F	IDEAM																		Attend
Wilson Becerra	M	IDEAM																		
Natalia Soto	F	IDEAM																		
Alberto Pardo Ojeda	M	IDEAM																		
Guillermo Olaya Triana	M	IDEAM																		
Nelson Obregon	M	IDEAM																		
Ana Campille Pérez	F	IDEAM																		
Freddy Garrido H.	M	IDEAM																		
Henry A. Romero	M	IDEAM																		
Hernando Wilches Suárez	M	IDEAM																		
Nelsy Verdugo	F	IDEAM								Attend	Attend	Attend	Attend							
Maria Costanza Rosero	F	IDEAM			Attend	Attend		Attend						Attend		Attend	Attend	Attend		
Ivan Camilo Peña	M	IDEAM																		
Enrique Rodríguez	M	IDEAM																		
Adriana Maria Rojas	F	IDEAM																		
Jorge Gonzalez	M	IDEAM																		
Angela Paola Chia	F	IDEAM																		
Minjung Kim	F	IDEAM																		
Julian Arbelaez	M	IDEAM								Attend	Attend		Attend							
Juan Pablo Urrego	M	IDEAM								Attend	Attend	Attend	Attend							
Fabian Mauricio Caicedo	M	IDEAM								Attend	Attend	Attend	Attend							
Claudia Contreras	F	IDEAM										Attend	Attend							
Nestor Franco	M	CAR																		
Carlos Manuel Montaño	M	CAR																		
Cesar Clavijo Rios	M	CAR																		
Heidy Milena Castillo	F	CAR																		
Carolina Cárdenas	F	CAR																		
Magda Suárez Ramírez	F	CAR																		
Humberto Hernández Roa	M	CAR																		
Hector H. Leguizamon	M	CAR																		
John A. Sanchez	M	CAR																		
Carlos Andrés Rodriguez	M	CAR								Attend	Attend	Attend	Attend							
Alexandra Forero	F	CAR																		
Maria Cristina Reyes	F	CAR																		
Juan Filiberto Cotrino G.	M	CAR																		
Juan Carlos Loaiza	M	CAR					Attend	Attend		Attend	Attend	Attend			Attend	Attend				
Juan Camilo Pinzon	M	CAR																		
Andres Mauricio Rodríguez	M	CAR																		
Rafael Iván Robles López	M	CAR														Attend	Attend			
Maryeny Caraballo	F	CAR					Attend	Attend	Attend	Attend	Attend	Attend			Attend	Attend	Attend	Attend	Attend	
Andrés Camilo Rincón	M	CAR																		
José Sebastián Cifuentes	M	CAR																		
Raul Ernesto Celis	M	CAR																		
Fernando Ospina	M	CAR	Attend			Attend												Attend	Attend	
Yuri Ulloa Sanchez	M	CAR																		
Juan Camilo Acosta	M	CAR								Attend	Attend	Attend	Attend							
Miguel Alejandro Diaz	M	CAR								Attend										
Jenny Rico M.	F	CAR																	Attend	
Oscar Santos	M	CAR																		
Carolina Pérez	F	CAR																		
Diana Carolina Perez	F	CAR																		
Ana Maria Escobar	F	CAR																		
Jaime Matiz Ovalle	M	Department of Cundinamarca	Attend		Attend			Attend	Attend							Attend	Attend			
Onofre Sierra Gómez	M	Department of Cundinamarca																		
Juan Manuel Acero	M	Department of Cundinamarca																		
Maria Cristina Ruiz	F	Department of Cundinamarca																		
Alvaro Sanchez (Ing.)	M	Department of Cundinamarca																		
Genmán Ribero	M	Department of Cundinamarca																		
William Barreto R.	M	Department of Cundinamarca			Attend	Attend								Attend	Attend					
Nancy Patricia Venegas Gualtero	F	Department of Cundinamarca																		
Ana María Torres	F	Department of Cundinamarca																		
Helmut Alexander Tequia	M	Department of Cundinamarca																		
Diana Robles	F	Department of Cundinamarca																		
Jose Elvis Triviño	M	Department of Cundinamarca																		
Jerónimo Gordillo N.	M	Department of Cundinamarca																		
Lina Paola Mora Navarro	F	Department of Cundinamarca																		
Ayza Trujillo	F	Department of Cundinamarca																		
David Fernando Rodríguez	M	Department of Cundinamarca																		
Antonio Alfonso Moreno	M	Department of Cundinamarca																		
Andrés Mauricio Rodriguez	M	Department of Cundinamarca																		
Jairo López Puentes	M	Department of Cundinamarca																		
Campo Elias Vega	M	Department of Cundinamarca																		
Christian Cruz	M	Department of Cundinamarca																		
Jose Manote Rugio Olaya	M	Department of Cundinamarca																		
Wilson Leonard Garcia F.	M	Department of Cundinamarca															Attend			
Magda Yamile Ruiz	F	Department of Cundinamarca															Attend			
Diana Paola Garcia	F	Department of Cundinamarca																		
Eduardo Contreras Ramirez	M	Department of Cundinamarca																		
Carlos Manuel Montaño	M	Department of Cundinamarca																		
Cesar Augusto Carrillo	M	Department of Cundinamarca																		
Julio Roberto Machado	M	Department of Cundinamarca																		
Jeffer Siatoba B	M	Department of Cundinamarca																		
Rubiela Sanchez	F	Department of Cundinamarca																		
Vladimir Boris Mora	M	Department of Cundinamarca																		
Ricardo Cifuentes	M	Department of Cundinamarca															Attend			
Yexon Alexis Mojica	M	Department of Cundinamarca															Attend			
Erika Elizabeth Sabogal	F	Department of Cundinamarca																		
Luis Alfonso Escobar	M	MADS (C/P from Feb. 2016)																		
Jairton Diez Diaz	M	MADS (C/P from Feb. 2016)															Attend			
Carolina González	F	MADS (C/P from Feb. 2016)																		
Raimundo Tamayo	M	MADS (C/P from Feb. 2016)																		
Mauricio Bayona	M	MADS (C/P from Feb. 2016)																		
Yolanda Calderon	F	MADS (C/P from Feb. 2016)	Attend			Attend	Attend	Attend	Attend							Attend	Attend		Attend	Attend
Luz Francy Navarro	F	MADS (C/P from Feb. 2016)	Attend	Attend	Attend	Attend	Attend	Attend		Attend	Attend	Attend	Attend	Attend	Attend	Attend	Attend	Attend	Attend	Attend
Sergio Salazar	M	MADS (C/P from Feb. 2016)								Attend	Attend	Attend	Attend							
Diego Montes	M	MADS (C/P from Feb. 2016)																		
Orinana Blandon	F	MADS (C/P from Feb. 2016)																		
Linda Irene Gomez	F	MADS (C/P from Feb. 2016)																		
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<Other Agency>																				
Cesar Garay Bohórquez	M	CIRMAG (CORMAGDALENA)	Attend	Attend	Attend	Attend	Attend			Attend	Attend	Attend	Attend		Attend	Attend				
Diana Vargas Rodriguez	F	CORMAGDALENA	Attend		Attend		Attend	Attend									Attend			
Carlos Andrés Quiza	M	CORMAGDALENA															Attend			
Vanessa Juliao	F	CORMAGDALENA															Attend			
Viviana Barrera	F	CORMAGDALENA																		
Claudia Martinez	F	CORMAGDALENA																		
Ana Maria Barreiro	F	CORMAGDALENA					Attend	Attend	Attend					Attend		Attend				
Nathaly Triumo	F	CIRMAG																		
Jose Oliveros Acosta	M	CIRMAG																		
Jorge Luis Sánchez Lozano	M	CIRMAG																		
Aura Elena Becerra	F	CORPOBOYACA																		
Maria Carolina Obando	F	CORPOBOYACA																		
Félix Márquez	M	CORPOBOYACA																		
Eduardo Bravo	M	UNIVERSIDAD NACIONAL					Attend			Attend	Attend	Attend	Attend							
Erasmo Rodriguez	M	UNIVERSIDAD NACIONAL								Attend										
Andrés Reyes	M	SERVICIO GEOLOGICO COLOMBIANO								Attend	Attend	Attend	Attend							
Claudia Avendaño	F	CDM SMITH								Attend	Attend	Attend	Attend							
Andrés Uribe Orozco	M	APC																		
Liliana Sánchez	F	APC																		
Catalina Jiménez	F	APC																		
Santiago Molina Alvarez	M	APC																		
Juan Sandoval Plata	M	APC															Attend			
Lina Maria Ibata	F	DNP																		
Carolina Diaz	F	DNP																		
Diego Rubio	M	DNP					Attend										Attend			
Luz Villoman	F	EMGESA																		
Catalina Camacho	F	MIN-MINAS																		
Jaime Martinez	M	Villeta Municipality																		
Sergio Andres Murcia Salamanca	M	Villeta Municipality																		
Deizy Anita	F	Villeta Municipality																		
John Avila	M	Utica Municipality																		
Mauricio Zarate	M	Utica Municipality																		
Municipalities in Rio Negro Bas	-	-																		
Students/Nacional/Javeriana	-	-							7	7	7	7								
Vitoria Ginja	F	WFP																		
Chiara Trozzo	F	WFP																		
Cundinamarca´s Department/Municipalities	-	-																		
Laura Berrocal	F	WFP																		
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<Project Team>																				
Kenji Morita	M	JICA Project Team				Attend	Attend	Attend	Attend	Attend			Attend	Attend	Attend	Attend	Attend	Attend		Attend
Kazunori Inoue	M	JICA Project Team																		
Masaki Todo	M	JICA Project Team												Attend	Attend					Attend
Masato Fujimoto	M	JICA Project Team	Attend																	
Akihiro Furuta	M	JICA Project Team		Attend	Attend	Attend	Attend	Attend												
Hirotada Hasegawa	M	JICA Project Team																		
Takeshi Katayama	M	JICA Project Team							Attend					Attend						Attend
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Hitoshi Baba	M	JICA								Attend	Attend	Attend	Attend	Attend						
Ginga Nakadai	F	JICA																		
Yasuyuki Shimizu	M	JICA								Attend	Attend	Attend	Attend							
Hiroshi Takebayashi	M	JICA								Attend	Attend	Attend	Attend							
Hidemitsu Sakurai	M	JICA Colombia																		
Satoshi Murosawa	M	JICA Colombia															Attend			
Yuki Kuraoka	F	JICA Colombia																		
Catalina Maria Bastidas Grijalba	F	JICA Colombia		Attend																
Masamichi Sunada	M	JICA Colombia											Attend							
Masami Ikuta	F	JICA Colombia																		
Mari Asano	F	JICA Colombia																		
Valeria Reinosa	F	JICA Colombia									Attend									
Diego Alejandro Martinez	M	JICA Colombia														Attend	Attend			
Jose Marie Sanchez	M	JICA																		
Yoshiharu Furuyama	M	JICA Senior Volunteer																		
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<Japanese Embassy>																				
Osamu Inagaki	M	Japanese embassy																		
Takatoshi Yamamoto	M	Japanese embassy																		
			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

List of Workshop

			Meeting	Meeting	WS	Meeting	WS	WS/Meeting	Meeting	WS	WS	WS	Meeting	5th JCC	Final Seminar
			Discussion on Guideline for River Plan formulation	VI Regional Platform for Risk Disaster	Roles and Responsabilities/Discussion on Guideline for IFMP-MC Draft	Discussion on IFMP MC	Roles and Responsabilities/Discussion on Guideline for IFMP-MC Draft	Finalización Roles y Responsabilidades Rio Negro/ Formulación Guía IFMP-SZ/Hoja de Monitoreo	Activities Agenda´s Review	Confirmation of final draft of IFMP in Rio Negro Basin	Finalization of IFMP in Rio Negro Basin/Finalization of Guidelines for IFMPs in Principal River and Sub-Zone	Finalization of IFMP in Rio Negro Basin/Finalization of Guidelines for IFMPs in Principal River and Sub-Zone	Review Presentations Final Seminar	Up date activities	Presentation Final Conclusions/IFMP-RP/IFMP-SZ/Guidelines
			9-Feb-18	12-Feb-18	14-Feb-18	20-Feb-18	23-Feb-18	1-Mar-18	29-May-18	31-May-18	7-Jun-18	14-Jun-18	26-Jun-18	28-Jun-18	28-Jun-18
"Colombian Side"			7	11	9	8	11	6	6	9	9	11	7	33	61
<Counterpart Agency>															
NAME	SEX	ENTITY	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance	Record of Attendance
Carlos Iván Marquez Perez	M	UNGRD													
Richard Vargas	M	UNGRD													
Diego Peña Lopez	M	UNGRD													
Lina Dorado	F	UNGRD		Attend										Attend	
Julio González Velandia	M	UNGRD													
Joana M. Perez	F	UNGRD		Attend	Attend		Attend	Attend	Attend	Attend	Attend	Attend	Attend	Attend	Attend
Gerardo Jaramillo	M	UNGRD													
Cristian Fernandez	M	UNGRD													
Antonio López Reales	M	UNGRD												Attend	Attend
Camila Chaparro	F	UNGRD													
Kulio Cesar	M	UNGRD													
Stefania Benavide Escobar	F	UNGRD													
Ivan H, Caicedo	M	UNGRD													
Claudia Cante	F	UNGRD													
Andrés Salazar	M	UNGRD													
Rafael Saenz Perez	M	UNGRD													
Margarita Arias	F	UNGRD													
Isabel C. Gonzalez	F	UNGRD													
Gabriel Garcia	M	UNGRD													
Marianella Botta Serrano	F	UNGRD													
Juan Camilo Olaya	M	UNGRD													
Lina Paola Martinez	F	UNGRD													
Luis Ignacio Muñoz	M	UNGRD		Attend											
Claudia Lorena Barajas	F	UNGRD													
Andres Sanabria	M	UNGRD													
Nidia Cristina Reyes	F	UNGRD													
MariaTeresa Martínez	F	UNGRD		Attend											
Mario Germán Trujillo	M	UNGRD													
Omar Franco Torres	M	IDEAM		Attend										Attend	
Omar Vargas Martinez	M	IDEAM		Attend										Attend	Attend
Christian Euscátegui	M	IDEAM		Attend											
Estefania Salas	F	IDEAM													
Diana Maria Quimbay Velencia	F	IDEAM												Attend	
Fabio Andrés Bernal Quiroga	M	IDEAM	Attend	Attend			Attend	Attend		Attend		Attend	Attend	Attend	Attend
Juan David Rondon	M	IDEAM													
Oscar Martínez	M	IDEAM													
Clara Lamo	F	IDEAM													
Catherine Fonseca	F	IDEAM		Attend										Attend	Attend
Wilson Becerra	M	IDEAM													
Natalia Soto	F	IDEAM													
Alberto Pardo Ojeda	M	IDEAM													
Guillermo Olaya Triana	M	IDEAM													
Nelson Obregon	M	IDEAM													
Ana Campille Pérez	F	IDEAM													
Freddy Garrido H.	M	IDEAM													
Henry A. Romero	M	IDEAM													
Hernando Wilches Suárez	M	IDEAM													
Nelsy Verdugo	F	IDEAM													
Maria Costanza Rosero	F	IDEAM													
Ivan Camilo Peña	M	IDEAM													
Enrique Rodríguez	M	IDEAM													
Adriana Maria Rojas	F	IDEAM													
Jorge Gonzalez	M	IDEAM													
Angela Paola Chia	F	IDEAM													
Minjung Kim	F	IDEAM													
Julian Arbelaez	M	IDEAM													
Juan Pablo Urrego	M	IDEAM													
Fabian Mauricio Caicedo	M	IDEAM													
Claudia Contreras	F	IDEAM													
Nestor Franco	M	CAR													
Carlos Manuel Montaño	M	CAR													
Cesar Clavijo Rios	M	CAR													
Heidy Milena Castillo	F	CAR													
Carolina Cárdenas	F	CAR													
Magda Suárez Ramírez	F	CAR													
Humberto Hernández Roa	M	CAR													
Hector H. Leguizamon	M	CAR													
John A. Sanchez	M	CAR													
Carlos Andrés Rodriguez	M	CAR													
Alexandra Forero	F	CAR													
Maria Cristina Reyes	F	CAR													
Juan Filiberto Cotrino G.	M	CAR													
Juan Carlos Loaiza	M	CAR													
Juan Camilo Pinzon	M	CAR													
Andres Mauricio Rodríguez	M	CAR													
Rafael Iván Robles López	M	CAR											Attend	Attend	Attend
Maryeny Caraballo	F	CAR			Attend				Attend	Attend	Attend	Attend		Attend	Attend
Andrés Camilo Rincón	M	CAR													
José Sebastián Cifuentes	M	CAR													
Raul Ernesto Celis	M	CAR													
Fernando Ospina	M	CAR													
Yuri Ulloa Sanchez	M	CAR													
Juan Camilo Acosta	M	CAR													
Miguel Alejandro Diaz	M	CAR													
Jenny Rico M.	F	CAR													
Oscar Santos	M	CAR			Attend	Attend	Attend	Attend	Attend	Attend	Attend	Attend			Attend
Carolina Pérez	F	CAR			Attend	Attend									
Diana Carolina Perez	F	CAR										Attend			
Ana Maria Escobar	F	CAR													Attend
Jaime Matiz Ovalle	M	Department of Cundinamarca					Attend		Attend	Attend	Attend	Attend	Attend	Attend	Attend
Onofre Sierra Gómez	M	Department of Cundinamarca													
Juan Manuel Acero	M	Department of Cundinamarca													
Maria Cristina Ruiz	F	Department of Cundinamarca												Attend	Attend
Alvaro Sanchez (Ing.)	M	Department of Cundinamarca													
Genmán Ribero	M	Department of Cundinamarca												Attend	
William Barreto R.	M	Department of Cundinamarca					Attend	Attend		Attend		Attend		Attend	Attend
Nancy Patricia Venegas Gualtero	F	Department of Cundinamarca													
Ana María Torres	F	Department of Cundinamarca													
Helmut Alexander Tequia	M	Department of Cundinamarca													Attend
Diana Robles	F	Department of Cundinamarca													
Jose Elvis Triviño	M	Department of Cundinamarca													
Jerónimo Gordillo N.	M	Department of Cundinamarca													
Lina Paola Mora Navarro	F	Department of Cundinamarca													
Ayza Trujillo	F	Department of Cundinamarca													
David Fernando Rodríguez	M	Department of Cundinamarca													
Antonio Alfonso Moreno	M	Department of Cundinamarca													
Andrés Mauricio Rodriguez	M	Department of Cundinamarca													
Jairo López Puentes	M	Department of Cundinamarca													
Campo Elias Vega	M	Department of Cundinamarca													
Christian Cruz	M	Department of Cundinamarca													
Jose Manote Rugio Olaya	M	Department of Cundinamarca													
Wilson Leonard Garcia F.	M	Department of Cundinamarca													
Magda Yamile Ruiz	F	Department of Cundinamarca												Attend	Attend
Diana Paola Garcia	F	Department of Cundinamarca												Attend	
Eduardo Contreras Ramirez	M	Department of Cundinamarca													
Carlos Manuel Montaño	M	Department of Cundinamarca													
Cesar Augusto Carrillo	M	Department of Cundinamarca												Attend	Attend
Julio Roberto Machado	M	Department of Cundinamarca													Attend
Jeffer Siatoba B	M	Department of Cundinamarca													Attend
Rubiela Sanchez	F	Department of Cundinamarca													Attend
Vladimir Boris Mora	M	Department of Cundinamarca													Attend
Ricardo Cifuentes	M	Department of Cundinamarca										Attend		Attend	Attend
Yexon Alexis Mojica	M	Department of Cundinamarca												Attend	Attend
Erika Elizabeth Sabogal	F	Department of Cundinamarca													
Luis Alfonso Escobar	M	MADS (C/P from Feb. 2016)													
Jairton Diez Diaz	M	MADS (C/P from Feb. 2016)												Attend	
Carolina González	F	MADS (C/P from Feb. 2016)													
Raimundo Tamayo	M	MADS (C/P from Feb. 2016)													
Mauricio Bayona	M	MADS (C/P from Feb. 2016)													
Yolanda Calderon	F	MADS (C/P from Feb. 2016)	Attend		Attend	Attend	Attend				Attend	Attend	Attend	Attend	Attend
Luz Francy Navarro	F	MADS (C/P from Feb. 2016)	Attend		Attend	Attend	Attend		Attend	Attend	Attend			Attend	Attend
Sergio Salazar	M	MADS (C/P from Feb. 2016)													
Diego Montes	M	MADS (C/P from Feb. 2016)												Attend	Attend
Orinana Blandon	F	MADS (C/P from Feb. 2016)													Attend
Linda Irene Gomez	F	MADS (C/P from Feb. 2016)													
			3	9	6	4	7	4	5	7	6	9	5	23	25
<Other Agency>															
Cesar Garay Bohórquez	M	CIRMAG (CORMAGDALENA)													
Diana Vargas Rodriguez	F	CORMAGDALENA	Attend			Attend	Attend							Attend	Attend
Carlos Andrés Quiza	M	CORMAGDALENA													
Vanessa Juliao	F	CORMAGDALENA													
Viviana Barrera	F	CORMAGDALENA													
Claudia Martinez	F	CORMAGDALENA													
Ana Maria Barreiro	F	CORMAGDALENA								Attend	Attend				
Nathaly Triumo	F	CIRMAG													
Jose Oliveros Acosta	M	CIRMAG													
Jorge Luis Sánchez Lozano	M	CIRMAG													
Aura Elena Becerra	F	CORPOBOYACA													
Maria Carolina Obando	F	CORPOBOYACA													
Félix Márquez	M	CORPOBOYACA													
Eduardo Bravo	M	UNIVERSIDAD NACIONAL													
Erasmo Rodriguez	M	UNIVERSIDAD NACIONAL													
Andrés Reyes	M	SERVICIO GEOLOGICO COLOMBIANO													
Claudia Avendaño	F	CDM SMITH													
Andrés Uribe Orozco	M	APC													
Liliana Sánchez	F	APC													
Catalina Jiménez	F	APC													
Santiago Molina Alvarez	M	APC												Attend	Attend
Juan Sandoval Plata	M	APC												Attend	Attend
Lina Maria Ibata	F	DNP													
Carolina Diaz	F	DNP													
Diego Rubio	M	DNP													
Luz Villoman	F	EMGESA													
Catalina Camacho	F	MIN-MINAS													
Jaime Martinez	M	Villeta Municipality													
Sergio Andres Murcia Salamarca	M	Villeta Municipality													
Deizy Anita	F	Villeta Municipality													
John Avila	M	Utica Municipality													
Mauricio Zarate	M	Utica Municipality													Attend
Municipalities in Rio Negro Basi	-	-													
Students/Nacional/Javeriana	-	-													
Vitoria Ginja	F	WFP													
Chiara Trozzo	F	WFP													
Cundinamarca´s Department/Municipalities	-	-													26
Laura Berrocal	F	WFP													
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Kenji Morita	M	JICA Project Team	Attend	Attend	Attend	Attend	Attend	Attend	Attend	Attend	Attend	Attend	Attend	Attend	Attend
Kazunori Inoue	M	JICA Project Team													
Masaki Todo	M	JICA Project Team	Attend		Attend	Attend	Attend				Attend	Attend	Attend	Attend	Attend
Masato Fujimoto	M	JICA Project Team													
Akihiro Furuta	M	JICA Project Team													
Hirotada Hasegawa	M	JICA Project Team													
Takeshi Katayama	M	JICA Project Team	Attend		Attend	Attend	Attend	Attend							
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Hitoshi Baba	M	JICA													
Ginga Nakadai	F	JICA													
Yasuyuki Shimizu	M	JICA													
Hiroshi Takebayashi	M	JICA													
Hidemitsu Sakurai	M	JICA Colombia													
Satoshi Murosawa	M	JICA Colombia												Attend	
Yuki Kuraoka	F	JICA Colombia													
Catalina Maria Bastidas Grijalba	F	JICA Colombia													
Masamichi Sunada	M	JICA Colombia												Attend	Attend
Masami Ikuta	F	JICA Colombia												Attend	Attend
Mari Asano	F	JICA Colombia												Attend	Attend
Valeria Reinosa	F	JICA Colombia													
Diego Alejandro Martínez	M	JICA Colombia		Attend											
Jose Marie Sanchez	M	JICA													
Yoshiharu Furuyama	M	JICA Senior Volunteer													
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<Japanese Embassy>															
Osamu Inagaki	M	Japanese embassy													
Takatoshi Yamamoto	M	Japanese embassy												Attend	Attend
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Appendix-3 Result of Baseline Survey

Result of the Baseline Survey

The parts in ***bold and italics*** are the analysis and conclusion of the expert team, and other parts are the description of the current situation in Colombia, including interviews with the relevant entities and reading of the published materials.

(1) Output 1: Capacity on flood risk assessment is improved and concept of integrated flood management planning and river basin management is introduced

Strengthening Flood Risk Assessment Capacity

Definition of Flood Risk

Risk is defined as the combination of the hazard that includes the probability of an event occurring and the vulnerability.[1] Therefore, in order to strengthen the capacity for risk assessment, it is necessary to strengthen the capacities for evaluating both hazards and the vulnerability.

Flood Hazard

In Colombia, "floods" are divided into "slow flood", in which the water level rises slowly, and the "flash flood", in which the water level is suddenly increased. Slow flood occurs in the middle and lower reaches of the Magdalena River, and flashflood occurs in high-slope rivers, such as the tributaries of the main rivers, accompanied by sediment transport.

Past Efforts in Colombia (Current Situation and Challenges)

Currently, IDEAM, the National University of Colombia (UNAL) and other universities, Colombian Geological Service (SGC), and CAR perform the hazard assessment.

IDEAM and UNAL conduct the hazard assessment for the slow flood from a national point of view. Flood area is evaluated by return period at the national level with the scale 1:100,000, based on satellite images, digital elevation data, and water level observation data.

Several entities perform the hazard assessment for flashflood where the water level suddenly rises since the basins where these floods occur are sub-basins (basin of a tributary of a main river) and are frequently associated with sediment disasters. ***However, it is a complex flood phenomenon with sediments, and there are not enough hydrographic data. Therefore, there are few examples of hazard assessment that includes probability assessment.***

The entities that develop threat maps are CAR as part of the elaboration of Basin Ordination and Management Plans (POMCA hereinafter), IDEAM and UNAL, both of which elaborate hazard maps that include the probability assessment (scale 1: 5,000 approximately) in 10 regional cities.

[1] Ministry of Environment and Sustainable Development, Protocol for the Incorporation of Risk Management in River Basin Ordination and Management Plans, November 2014

One of the characteristics of the hazard maps in Colombia is that the flood hazard area is presented based on the geomorphological assessment. For example, POMCA for the Rio Negro basin developed by CAR includes flood hazard area map at 1: 50,000 scale. This hazard area is determined based on fluvial terraces, micro topography, and old channels from the geomorphological point of view and the record of past floods. ***However, this type of geomorphological quantitative assessment can not indicate the range of variation of meteorological-hydrological phenomena or provide a detailed analysis of hazards with approximately 1:5,000 scale, in which municipalities are interested.***

In Colombia, the policy is to combine flood risk assessment based on the flood record and the geomorphological point of view, the hydrological methodology (to evaluate of the discharge of the river from rainfall and evaluate the flood phenomenon) based on the flood record and geomorphology. This policy is consistent with the tendency that the evaluation of flood risk at an urban spatial level in the municipalities in Colombia has become mandatory under the legal requirement to incorporate the flood risk in POMCA to reflect the flood risk in the land use plan. ***Therefore, it is necessary to strengthen the capacity to evaluate flood risks with a higher resolution with a hydraulic hydrological method.***

Modeling activities for flood risk assessment (including hydraulic hydrological modeling activities for forecasts and alerts) carried out in Colombia are based on projects. Even within IDEAM, software from Europe (Netherlands and Denmark), the United States, and Japan are being used. IDEAM's activities are focused on the slow floods mentioned above, in which the water level increases slowly. The hydraulic modeling project targeting the Mojana area, a major flood zone in the Magdalena Baja region, is ongoing with technical support from the Netherlands. ***The management of tributary basins that are included in the model of the Magdalena River's middle basin, which will be mentioned later (Output 2), is not so precise due to the lack of hydrological data. It is recognized that it is important for IDEAM to improve the accuracy of the model in the tributary basins.***

Conditions of the Rio Negro Pilot Basin

The pilot basin of Rio Negro is one of the tributaries on the right bank of the Magdalena River's the middle section. The basin area is approximately 4,500 km^2, and the length of the main course of Rio Negro is 187 km. It is a steep and high river, and its slope is between 1/30 upstream and 1/700 downstream. Of the 300 hydrographic subzones in Colombia for which POMCA must be developed, 120 have a basin area between 1,000 and 3,000 km^2, the most common basin area range for hydrographic subzones. Therefore, the Rio Negro basin area is close to the average.

The municipalities of Utica and Villeta are the cities that face flood problems in the Rio Negro basin. The municipality of Utica is located at the point where the slope changes, where the Quebrada Negra, Quebrada Terama and Rio Negro meet; the watershed area upstream reaches 2,082 km^2. However, the disaster that has affected the municipality of Utica for more than the last

50 years is a flood disaster with sediments from Quebrada Negra (basin area of 70 m^2). The most recent occurred on April 18, 2011. ***<u>This flood is characterized by the fact that the flooding effect near the urban center is increased by the sediment runoff from the hillside upstream that flows down the riverbed. It is necessary to evaluate the risks taking into account the sediments in the channel.</u>***

In the municipality of Villeta, the left bank of the Villeta river in the urban center suffered erosion, and the flood water reached areas near the hospital.

SGC and CAR carry out the flood risk assessment of the Quebrada Negra (a request was made to CAR to share the materials and has not been answered). SGC performs the flood risk assessment taking into account the sediment characteristics in the Quebrada Negra, from the position of the national geological research center.

Effort in Flood Risk Assessment

As an effort to assess the risk of flood in Colombia, the Ministry of Environment and Sustainable Development promotes the incorporation of disaster risk analysis (landslides, floods (slow flood), flash floods, forest fires) in the formulation of POMCA. The formulation of POMCA by the CAR is regulated by decree 1640 (Ministry of Environment and Sustainable Development), and decree 1807 (Ministry of Housing) stipulates that the results of zoning based on the results of the disaster risk analysis must be reflected in the land use plan (POT). The Ministry of Environment and Sustainable Development published technical guidelines for the formulation of POMCA in 2014, among which are the risk management policy and the implementation process in POMCA. In addition, there are also internal documents that describe more detailed procedures (Protocol). However, at the national level (396 hydrographic subzones), POMCAs that have incorporated risk management have not yet been published, and many are in the reviewing process. CAR, the implementing entity that updates POMCA, states that it is in the process of reviewing POMCA of three subzones within the jurisdiction, two of which (Rio Bogota, Rio Alto Suarez) are based on the Fund, and their updates have been outsourced to the private sector consultancy; the plan is to finalize the update in December 2016. With respect to the other sub-area (Rio Magdalena / Seco), POMCA is being formulated under the direct administration of CAR. ***<u>As mentioned above, the efforts to assess flood risks in Colombia are made through the incorporating risk management in the existing POMCA (POMCA review), implemented from the point of view of the ordination and management of the water resources and the environment of the water source and the river basin.</u>***

The current challenge to incorporate risk management in POMCA is the method to incorporate vulnerability. There are problems related to the management of items that are difficult to quantify, such as regional characteristics, and social, cultural and environmental conditions. In addition, given that the scale of maps available for risk management is small, efforts are also being made to ensure a scale of 1: 25,000 for the formulation of POMCA, including the results of zoning.

<u>One of the conclusions of the baseline study is the following: the Ministry of Environment and</u>

Sustainable Development has incorporated risk management into POMCA from the point of view of the management and ordination of water rources and basin environments. The point of view of flood management based on structural/nonstructural measures on the river is not its focus. This is also evident in CAR's opinion that structural/non-structural measures are the responsibility of the municipalities. It is necessary to continue the discussions in the future for the relationship between the quantification of flood risk (projected number of people affected, the projected amount of damages, etc.), the planning of measures based on the result of the risk assessment (≈ river plan) and POMCA.

The Ministry of Environment and Sustainable Development and CAR are looking forward to the contributions of the expert team on the POMCA risk management method. Regarding risk assessment from the point of view of management and ordination of water sources and basins (POMCA risk management) and risk management from the point of view of flood management and damage reduction, which the project plans to provide, the first step would be to clarify the difference and ideas in common between C/P and the expert team. It is necessary to continue the dialogue to achieve mutual understanding with C/P.

In addition, UNGRD has shown interest in the integral management of disaster prevention and the establishment of objectives for the quantitative reduction of damages based on the Sendai Framework policy adopted at the Third UN World Conference on Disaster Reduction. The estimation of direct and indirect damages caused by floods is considered an effective approach in terms of flood risk management in Colombia. It is necessary to continue discussing the contents of the flood risk assessment appropriate for Colombia with UNGRD, providing inputs on Japanese examples of damage estimates.

Introduction of the Integrated Flood Risk Management Plan (IFMP) and Concept of Basin Management

Integrated flood risk management refers to the formulation of a plan for a combination of structural and non-structural measures based on the hazard and risk assessment for flood in the basin from the point of view of the whole basin, clarification of the role sharing among the relevant entities, and the implementation of this plan.

In the baseline study conducted between July and August 2015, interviews and the field study were conducted with CAR and the Department, which are related to the Rio Negro basin. The current situation of "hazard and risk assessments related to the basin" corresponds to the aforementioned.

The common elements shown in IC/R are well known as the menu for integral flood risk management. However, the plan of each river basin is different according to the natural social characteristics of the basins and rivers.

The majority of the Rio Negro basin is a fast and inclined river; small settlements are located in a dispersedly on the slopes of deep valleys, and the urban areas along the river include the municipalities of Utica and Villeta, etc. In the municipality of Utica, the flood disaster at the point of confluence of the rivers with sediment runoff has been a problem for 50 years, and measures such as the dredging in the riverbed, the protection of the banks, and the bypass channel have been proposed by research centers of the central government, the municipalities and CAR. After the flood disaster in April 2011, in the municipality of Utica, dykes have been built with sand bags in the main channel of Rio Negro, sediment dredging has been carried out in the central part of the river bed, and they have built dykes with sediments dredged in the Quebrada Negra. ***This plan and design were carried out by the Department of Cundinamarca and CAR. Although some effectiveness is expected, the foundations of the plan from the point of view of river engineering, the quantitative evaluation of effectiveness, and the role sharing among these entities are not clear.***

On the other hand, the introduction of non-structural measures such as the installation of water level sensors upstream is being advanced by the initiative of the municipality. ***In this sense, a certain degree of understanding of the need for integral measures for the reduction of flood risk is observed.***

In the case of the municipality of Utica, it is also well known that upstream sediment runoff aggravates flood disasters, and the municipality's land-use planning scheme clearly mentions the measures that combine sediment runoff control structures and channel shortcuts.

The challenge is to analyze the local problems from a basin-wide point of view, analyze the river longitudinally and understand these local flood problems from a river engineering point of view, under the current situation in which these problems in Utica are treated as strictly local problems along with the municipality upstream of Quebradanegra.

(2) Output 2: Capacity on flood forecasting, warning and information dissemination to relevant organizations is improved (mainly IDEAM and UNGRD)

Meteorological-Hydrological Monitoring Network

IDEAM updates and installs the meteorological and hydrological stations. Since the completion of the JICA study in 2013, 6 meteorological stations, 56 rainfall stations and 23 hydrological observation stations have been installed. IDEAM plans to install the weather radar (band C) with the maintenance fund in 2016.

Use of Meteorological- Hydrological Data

IDEAM seeks to use satellite rainfall data to compensate for the shortage of rainfall stations. ***However, the analysis of the difference between the observation value on the ground and the satellite value is not conducted in an extensive manner.***

IDEAM is developing a hydraulic-hydrological model for flood forecasting and warning as one of the uses of hydrological and meteorological data.

- Model for the middle Magdalena River basin (including the Rio Negro basin)

  It includes 8 basins of the tributaries in the middle section of the Magdalena River (200km stretch from Pto. Salgar to Barranquilla). HEC-HMS is used for the tributary basin and MIKE11 for the channel. IDEAM explained that the observation data are included in the channel.

- Model for the upper Cauca river basin

  CVC (Local Regional Autonomous Corporation) is developing this with the Danish software called HVB.

- Model of the upper Bogota river basin

  A rainfall runoff model developed with HEC-HMS. A joint work between CAR and IDEAM

These models are incorporated in a Dutch integral platform system called FEWS (Flood Early Warning System). FEWS uses the HYDRA3 system to visualize IDEAM's real-time observation data.

Flood Early Warning

IDEAM issues flood warnings and alerts based on the accumulated rainfall in large areas at the regional level on its website and transmits them to different entities.

Regarding the forecast and alert in individual rivers, IDEAM defines water levels as alert level (red), warning level (orange) and precaution level (yellow), and transmits information to citizens when the River level is projected to approach these levels. As a basic rule, the alert level is determined as the level of the water that causes damage to the houses, etc. at the point where the level station is installed. However, the projected flood area upstream and downstream the level station has not been well understood. In addition, although IDEAM has a plan to install more level stations in real time, ***it is still necessary to increase the technical knowledge to select an effective point for the installation and improve the topographic survey as well as the dicharge observation.***

Additionally, the Rio Negro basin, a basin representative of a tributary in the right bank, is treated as a hydrological model (runoff from the hillsides) in the flood model of the middle basin of the Magdalena River that IDEAM is building. ***However, it is a fairly simple model due to the lack of rainfall data in the short period, so it is not possible to predict the water level with this model.***

Communication of the Information

In IDEAM's meteorological hydrological monitoring, the data sent from the automatic system of the stations in real time and two daily calls from the observer in the dams and the water level observation stations at the national level are received.

It is necessary to improve these IDEAM water level alerts and their accuracy in communicating this information to local municipalities in the flood warning area for evacuation purposes, etc.

In the baseline study, cases of existing municipal system were confirmed. For example, in the municipality of Villeta in the upper Ro Negro basin, local firefighters initiate the response when the water level reaches 2m higher than the normal level of the river, which is defined as the alert level. Likewise, in Utica, the municipality upstream communicates with the municipality downstream as part of the safety measures. In addition, the firefighters of the municipality monitor the 4 censors installed by the municipality to respond to the flood. It was confirmed that a flood response system at the municipal level has been successfully constructed.

(3) Output 3: Roles and responsibility of the central and local government for flood risk reduction are elucidated and enhanced (mainly UNGRD and IDEAM)

Current Risk Management

It is understood that the documents that are the basis of flood risk management are POT at the municipal level and POMCA at the basin level. The Ministry of Environment and Sustainable Development developed the guidelines for the incorporation of risk at the end of 2013 and the Protocol for the incorporation of risk management in POMCA in November 2014.

The National Water Policy of 2010 stipulates that it is the responsibility of the Ministry of the Environment to study the strategic policy for macro basins (there are 5 including Magdalena-Cauca). The strategy must include risk management.

With the 1991 Constitution, decentralization progressed, and the responsibilities of the municipalities increased. As a result, the responsibilities of risk assessment and measures to mitigate floods are mainly of the municipalities. ***Therefore, a mechanism to coordinate measures in the river plan is considered necessary in case the measures involve several municipalities upstream and downstream of the river (for example, the relationship between the water source locations and the project areas).***

In addition, based on C/P's views on the flood risk management, it was confirmed that improvement in the residents' quality of life is expected with the formulation of the flood risk management plan and that discussions on the role sharing related to flood risk management, because it is currently unclear.

Disaster Risk Assessment

In recent years, UNGD and departments have expanded areas of effort from the post-disaster response to the preparation and acquisition of knowledge. Within these efforts, the entity responsible for the hazard assessment for landslide and seismic activities is SGC, and for floods they are IDEAM and UNGRD.

Regarding the risk assessment, the knowledge related to the vulnerability assessment methodology and zoning concepts are considered necessary for the formulation of POMCA and POT.

Based on the law 1523, in order to incorporate the flood risk in POT, the departments and CAR have jointly begun the development of risk maps. Since local cultural elements greatly influence flood risk management, basin committees are created and information is exchanged among stakeholders for the formulation of POMCA.

Land Use Regulation

In the municipalities that suffered the flash flood in May of this year (2015), great damages were inflicted because of the lack of lead time to issue the alert, due to the fact that the water level increased rapidly, despite the fact that the information about the flood and sediment disasters had previously been shared. In these places, the time between obtaining information and the evaluation is extremely short, and the land use regulation would be an appropriate measure. However, the implementation of land use regulation is extremely difficult in existing urban centers.

(4) Output 4: Capacity of flood management planning is enhanced through formulation of integrated flood management plan (IFMP) in the pilot river basin

It was clarified that the river administration in the elaboration of the river plan, study of measures, economic evaluation and role sharing based on the river engineering have not been carried out in a medium basin such as the Rio Negro basin.

The items related to the guidelines of future activities within the results of the study of each Output mentioned above are presented in the following page.

Result of Baseline Survey (Summary)

Based on the results of the baseline survey, the following table organizes the items related to the direction of future activities by Output, categorizing them as "items, facts", "analysis", "challenges" and "method/guidelines for future training".

#	Items, Facts	Analysis/Observation	Challenges	Method/guidelines for future training
Output 1: Capacity on flood risk assessment is improved and concept of integrated flood management planning and river basin management is introduced				
	A. Strengthen the flood risk assessment capacity with a resolution			
1	One of the characteristics of the hazard maps in Colombia is that the flood hazard area is presented based on the geomorphological assessment	This type of geomorphological quantitative assessment cannot indicate the range of variation of meteorological-hydrological phenomena or provide a detailed analysis of hazards with approximately 1:5,000 scale, in which municipalities are interested	It is necessary to assess flood risks with a higher resolution on a more detailed scale map based on a hydraulic hydrological method.	Carry out trainings on flood risk assessment methods based on flood hazards calculated with a hydrological-hydraulic methodology through the work of the river plan formulation.
2	IDEAM's activities are focused on the slow floods mentioned above, in which the water level increases slowly.	The management of tributary basins that are included in the model of the Magdalena River's middle basin is not so precise due to the lack of hydrological data.	It is recognized that it is important for IDEAM to improve the accuracy of the model in the tributary basins.	Carry out trainings that improve the accuracy of the model at tributary level through the work of the formulation of the river plan.
3	Flood problems in the municipality of Utica in the Rio Negro basin are flood disasters that include sediments.	This flood is characterized by the fact that the flooding effect near the urban center is increased by the sediment runoff from the hillside	It is necessary to evaluate the risks taking into account the sediments in the channel.	Conduct trainings on flood hazard assessment methods that take into account sediments through the work of formulating the river plan.

#	Items, Facts	Analysis/Observation	Challenges	Method/guidelines for future training
		upstream that flows down the riverbed.		
	B. Effort in Flood Risk Assessment			
4	Risk is defined as the combination of the hazard that includes the probability of an event occurring and the vulnerability in Colombia. Currently there are few POMCAs in which risk management is incorporated, and most are in the review process.	The current challenge to incorporate risk management in POMCA is the method to incorporate vulnerability. There are problems related to the management of items that are difficult to quantify, such as regional characteristics, and social, cultural and environmental conditions. The point of view of flood management based on structural/nonstructural measures on the river is not its focus.	It is necessary to continue the discussions in the future for the relationship between the quantification of flood risk (projected number of people affected, the projected amount of damages, etc.), the planning of measures based on the result of the risk assessment (≈ river plan) and POMCA.	Conduct trainings in which the vulnerability assessment methodology in which appropriate methods of incorporation are studied and taught (discussed). The methods of incorporating risk management from the point of view of flood management are studied and taught. Regarding risk assessment from the point of view of management and ordination of water sources and basins (POMCA risk management), and risk management from the point of view of flood management and harm reduction, which the project plans to provide, the first step would be to clarify the difference and points in common between C/P and the expert team. It is necessary to

#	Items, Facts	Analysis/Observation	Challenges	Method/guidelines for future training
				continue the dialogue to achieve mutual understanding with C/P.
5	UNGRD has shown interest in the integral management of disaster prevention and the establishment of objectives for the quantitative reduction of damages based on the Sendai Framework policy adopted at the Third UN World Conference on Disaster Reduction.	The estimation of direct and indirect damages caused by floods is considered an effective approach in terms of flood risk management in Colombia.	It is necessary to continue discussing the contents of the flood risk assessment appropriate for Colombia with UNGRD, providing inputs on Japanese examples of damage estimates.	It is necessary to continue discussing the contents of the appropriate flood risk assessment for Colombia, providing inputs on Japanese examples of damage estimates.
	C. Introduction of the Integrated Flood Risk Management Plan (IFMP) and Concept of Basin Management			
6	In the municipality of Utica, dykes have been built with sand bags in the main channel of Rio Negro, sediment dredging has been carried out in the central part of the river bed, and they have built dykes with sediments dredged in the Quebrada Negra.	This plan and design were carried out by the Department of Cundinamarca and CAR. Although some effectiveness is expected, the foundations of the plan from the point of view of river engineering, the quantitative evaluation of effectiveness, and the role sharing among these entities are not clear.	It is necessary to formulate and evaluate the plan from the point of view of river engineering.	Present the methodologies to formulate and evaluate the plan from the point of view of river engineering through the work of formulating the river plan.
7	The introduction of non-structural measures such as the installation of water level sensors upstream is being	A certain degree of understanding of the need for integral measures for the reduction of flood risk is	It is necessary for the participants to achieve a deeper understanding of the integral measures in a	Carry out trainings on the integral measures through the work of the formulation of the river plan.

#	Items, Facts	Analysis/Observation	Challenges	Method/guidelines for future training
	advanced by the initiative of the municipality.	observed.	systematic manner.	
8	In the case of the municipality of Utica, it is also well known that upstream sediment runoff aggravates flood disasters, and the municipality's land-use planning scheme clearly mentions the measures that combine sediment runoff control structures and channel shortcuts.	Currently, these problems in Utica are treated as strictly local problems along with the municipality upstream of Quebradanegra.	It is necessary to analyze local problems from a basin-wide point of view, analyze the river longitudinally and understand these local flood problems from a river engineering point of view.	Conduct training on the methodology of the analysis of the whole basin and longitudinal analysis through the work of the formulation of the river plan.
Output 2: Capacity on flood forecasting, warning and information dissemination to relevant organizations is improved (mainly IDEAM and UNGRD)				
9	It is recognized that it is important for IDEAM to improve the accuracy of the model in the tributary basins.	IDEAM seeks to use satellite rainfall data to compensate for the shortage of rainfall stations.	It is necessary to establish a rainfall assessment method by analyzing the difference between the observation value on the ground and the satellite value.	Conduct trainings to analyze the difference between the observation value on the ground and the satellite value and understand its trend.
10	Regarding the forecast and alert in individual rivers, IDEAM defines water levels as alert level (red), warning level (orange) and precaution level (yellow), and	As a basic rule, the alert level is determined as the level of the water that causes damage to the houses, etc. at the point where the level station is installed. However, the	It is necessary to understand the water level that causes damage and its horizontal expansion. These water level alerts and their accuracy need to be improved.	Carry out trainings on the methods of understanding and analyzing the water level that causes damage and its horizontal expansion through the selection of a pilot area for analysis.

#	Items, Facts	Analysis/Observation	Challenges	Method/guidelines for future training
	transmits information to citizens when the River level is projected to approach these levels.	projected flood area upstream and downstream the level station has not been well understood		
11	Rio Negro basin, a basin representative of a tributary in the right bank, is treated as a hydrological model (runoff from the hillsides) in the flood model of the middle basin of the Magdalena River that IDEAM is building.	It is a fairly simple model due to the lack of precipitation data in the short period, so it is not possible to predict the water level with this model.	It is necessary to forecast the water level of the river at the level of the Rio Negro basin in order to respond to local needs.	Carry out trainings where the methodology to forecast the water level of the river at the level of the Río Negro basin is studied through the work of formulating the river plan.
12	Cases of existing municipal system were confirmed.	There are few cases in which the system is established.	It is necessary to systematically classify the systems that are functioning properly to replicate it.	Analyze and classify systems that are functioning properly.
Output 3: Roles and responsibility of the central and local government for flood risk reduction are elucidated and enhanced (mainly UNGRD and IDEAM)				
13	With the 1991 Constitution, decentralization progressed, and the responsibilities of the municipalities increased. As a result, the responsibilities of risk assessment and measures to mitigate floods are mainly of the municipalities.	A mechanism to coordinate measures in the river plan is considered necessary in case the measures involve several municipalities upstream and downstream of the river (for example, the relationship between the water source locations and the	It is necessary to regulate the role sharing among relevant entities to coordinate the measures of the plan.	Clarify the role sharing through the work of formulating the river plan. Create opportunities to build a common understanding among Colombian entities, through the exchange of opinions in the workshops.

#	Items, Facts	Analysis/Observation	Challenges	Method/guidelines for future training
		project areas).		
Output 4: Capacity of flood management planning is enhanced through formulation of integrated flood management plan (IFMP) in the pilot river basin				
14	Different entities have relevant information necessary for the formulation of IFMP.	Apparently, there is a large volume of information; however, several entities possess different parts of it, and it is not common to share the information among the relevant entities.	It is necessary to find out which entity owns what type of information concretely and collect the information.	Start with the preparation for the formulation of the plan, organizing the information held by each entity in an information matrix, collecting the information and preparing for sharing it in the future.
15	River administration in the elaboration of the river plan, study of measures, economic evaluation and role sharing based on the river engineering have not been carried out in a medium basin such as the Rio Negro basin.	Plans are currently being formulated at the local level. There are places that require the formulation and evaluation of the plan from the point of view of IFMP.	It is necessary to facilitate the formulation of the plan and evaluation from the point of view of the basin and river engineering.	Introduce the methodology for the formulation of the plan and evaluation from the point of view of river engineering. The first step is to achieve mutual recognition and understanding of the challenges related to river management with the Colombian C/P. Define target areas of the study and formulate a plan that contains the goal of river/basin management and river/basin management methods (structural and non-structural measures).

Appendix-4 Output 2, Recommendations on Flood Early Warning

Recommendations on flood forecasting and warning

JICA Expert Team

For improvement of flood forecasting and warning in Colombia, the following activities are recommended to conduct based on the actual situation confirmed in the Project.

The following activities are recommended for Hydrographic Subzone which has similar river basin area with Rio Negro basin of 4,572 km^2.

- IDEAM should establish some local meteorological observatories targeting flood forecasting and warning for the Hydrological Subzone.
- While an automatic water level gauging station is recently installed more, water level is basically observed manually/visually. In order to issue warning at proper timing, an automatic water level gauging station should be installed more taking into account the range of river section in charge. If an automatic water level gauging station cannot be installed sufficiently, the frequency of visual water level observation should be increased during rise in water level before flood happened.
- In order to enhance collaboration on early warning between upstream and downstream municipalities which are not always provided proper flood warning by Departmental level is effective. As one of the activities in the Project, Department of Cundinamarca had experience of holding workshop on February 17th of 2017 with participation of eleven municipalities in Rio Negro basin at Guaduas municipality to enhance the collaboration between municipalities in the basin.
- Flood hazard map with a scale of 1:10,000 needs to be prepared for formulation of evacuation plan. If the inundation analysis model cannot be prepared, inundation assumed area can be estimated by referring the past inundation damaged records.
- In order to provide effective warning information for the receivers, the necessary actions to be taken by municipal officers and residents should be clarified corresponding to each danger water level (Yellow, Orange and Red). Regarding the clarification of actions to be taken corresponding to each warning, the guideline targeting municipal level is expected to be formulated mainly by UNGRD.
- In order to secure enough lead time for proper actions before disaster happened, the required time for warning dissemination and evacuation completion in each municipality should be confirmed in the normal time for warning issuance at proper timing. As one of the activities in the Project, the case study was conducted at Cordoba in Rio Negro basin.

- In order to validate effectiveness of warning, the contents and timing of warning are expected to be improved through collecting feedbacks from the receivers such as municipalities and residents after the event of each disaster.

Also, the Project did not cover local unexpected disasters such as debris flow happened in Mocoa municipality in April 2017, but the following activities are recommended to conduct for such disasters.

- Heavy rainfall warning is currently issued on a daily basis by IDEAM, but it should be on an hourly basis in order to respond to local unexpected disasters.
- Damage potential zone of debris flow should be estimated in the normal time since the risk assessment is not relatively considered compared to the one for flood inundation.

The following activities are recommended to conduct for Río Principal such as Magdalena river.

- In case of slow flooding, while interval time from rise in water level to flood happened is relatively enough, inundation duration after flood happened tends to continue for a long time. Therefore, the relevant organizations need to consider advance activities such as preparation of emergency goods corresponding to the inundation duration.
- National or Departmental level should support municipal level to proceed collaboration on early warning and comprehensive evacuation between municipalities since the scale of flood damages tends to expand over the municipal boundary.

Appendix-5 Output 3, Recommendations on Role Sharing

Recommendations on the role sharing related to flood risk management among local governments and the central government

In this project, 12 workshops were held between October 2015 and March 2018, where the representatives of the entities related to flood risk management in Colombia participated to repeatedly discuss the role sharing related to flood risk management among the central government and local governments in Colombia. This document details the recommendations of the expert team on the responsibilities that each entity must assume, taking into account the discussions and agreements reached in the workshops, capacities (technical, human resources, financial) of each entity related to flood risk management, as well as the opinions of the team of experts.

Table 1 Points on responsibilities and roles of the central government and local governments related to flood risk management agreed in the workshops

	Items to implement				Central Governmanet				Regional Government			
					UNGRD	MADS	IDEAM	CARMAC	CORMAGDALENA	Departament	CAR	Municipality
Principal River	Recognition of problems	Understand flood damage situations		Where did the flood occur? The magnitude of the damage	Support during large scale flood		information providing			Support during mid scale flood		○
Principal River	Recognition of problems	Understand flood damage situations		The cause of the flood?			○		Support	Support	Support	Support
Principal River	Recognition of problems	Comprehensive assessment and organization of problems			○	○	Support (only for hazard)	○	Support	Support	Support	Support
Principal River	Study measures	Determine the goal of flood risk management - Determine target area and design scale Where will these measures be implemented? - Determine design flood discharge and inundation area - Study of cost benefit ratio			○	Support	○	Support	Support			
Principal River	Implement measures	Structural measure (Levee development)		Study and design	○		information providing		Support	Support	Support	Support
Principal River	Implement measures	Structural measure (Levee development)		Works	Support		information providing		Support	Support	○	Support
Principal River	Implement measures	Structural measure (Levee development)		Maintenancee and administration / Monitoring	Support		information providing		Support	○	○	○
Principal River	Implement measures	Non-structural measure (Land use regulation in floodplains)		Policy and guideline		○						
Principal River	Implement measures	Non-structural measure (Land use regulation in floodplains)		Study and planning / Regulation / Monitoring							○ Land use management	
Subzone	Recognition of problems	Understand flood damage situations		Where did the flood occur? The magnitude of the damage	Support during large scale flood		information providing			Support during mid scale flood		○
Subzone	Recognition of problems	Understand flood damage situations		The cause of the flood?			○				○	○
Subzone	Recognition of problems	Comprehensive assessment and organization of problems			Support					Support	○	Support
Subzone	Study measures	Determine the goal of flood risk management - Determine target area and design scale Where will these measures be implemented? - Determine design flood discharge and inundation area - Study of cost benefit ratio				○	information providing				○	○
Subzone	Implement measures	Structural measure (flood prevention structure)		Study and design			information providing				○	
Subzone	Implement measures	Structural measure (flood prevention structure)		Works			information providing			○	○	Support
Subzone	Implement measures	Structural measure (flood prevention structure)		Maintenance and administration / Monitoring			information providing			○	○	○
Subzone	Implement measures	Structural measure (Dredging in the confluence with the tributary)		Study			information providing				○	
Subzone	Implement measures	Structural measure (Dredging in the confluence with the tributary)		Works (dredging etc)	Support					○	○	Support
Subzone	Implement measures	Structural measure (Dredging in the confluence with the tributary)		Maintenance and administration						○	○	○
Subzone	Implement measures	Land use regulation	Disaster Risk Reduction Map (DRR Map)	Collect information and identify flood areas			○				○	○
Subzone	Implement measures	Land use regulation	Disaster Risk Reduction Map (DRR Map)	Runoff and flood analysis			Support				○	
Subzone	Implement measures	Land use regulation	Disaster Risk Reduction Map (DRR Map)	Creation and distribution of DRR Map			○				○	○
Subzone	Implement measures	Land use regulation	Land use regulation in floodplains (Conservation of wetland)	Policy and guideline		○						
Subzone	Implement measures	Land use regulation	Land use regulation in floodplains (Conservation of wetland)	Study and planning			information providing				○	○
Subzone	Implement measures	Land use regulation	Land use regulation in floodplains (Conservation of wetland)	Regulation / Monitoring							○	○
Subzone	Implement measures	Flood forecast and warning	Improvement of the flood forecast and warning system	Observation oof precipitation and water level			○			○	○	
Subzone	Implement measures	Flood forecast and warning	Improvement of the flood forecast and warning system	Water level forecast			○			○	○	
Subzone	Implement measures	Flood forecast and warning	Improvement of the flood forecast and warning system	Organization of the system (communication of information)	○		○			○	○	○
Subzone	Implement measures	Flood forecast and warning	Raise awareness among residents	Preparation of brochures and carrying out orientations						○		○
Subzone	Implement measures	Improvement of the flood response			○					○		○

Table 2 Recommendations on responsibilities and roles for each entity related to flood risk management

Entity	Items agreed upon in workshops	Recommendations on future activities
National Unit for Disaster Risk Management (UNGRD)	Support the municipalities in collaboration with the department in understanding the damage situation, etc. in large floods. Lead the comprehensive evaluation of the task in principal rivers, and support the process in hydrographic subzones. Lead studies on measures in principal rivers and support the dredging of sediments, etc. in hydrographic subzones.	Formulate IFMP-RP at an early stage in cooperation with MADS, IDEAM and CARMAC through a comprehensive assessment of the problems of principal rivers and the study of measures. Ideally, lead the response to floods in cooperation with entities related from a comprehensive point of view in large floods.
Ministry of Environment and Sustainable Development (MADS)	Comprehensively assess flood risk management problems and support in the study of measures for principal rivers. Lead the study of measures in hydrographic subzones. Manage the floodplains as a non-structural measure regardless of whether it is in principal rivers or hydrographic subzones.	Ideally, participate actively in the formulation IFMP-RP and IFMP-SZ. It is convenient to take advantage of being an entity capable of studying the entire basin from an environmental perspective, especially in relation to water retention in the basin and the sediment runoff control.
Institute of Hydrology, Meteorology and Environmental Studies (IDEAM)	Lead the identification of the causes of the floods and the study of the measures such as the definition of the planned discharge in the principal rivers. Lead the development of the DRR map and the improvement of flood forecast and warning. Provide hydrological and meteorological information at each stage of problem recognition, study of measures and implementation of measures.	Ideally, contribute to the management of flood risk effectively using the information analysis technology that the entity has. It is necessary to consider the elaboration of the DRR map and the improvement of the flood forecast and warning system in the application to principal rivers.
Regional Environmental Council of the Macro-basin (CARMAC)	Study the flood risk management in CARMAC taking advantage of the existing framework that includes entities related to the planning of principal rivers. Conduct a comprehensive assessment of the problems and support in the study of the measures in flood risk management of principal rivers.	Ideally, use this committee to formulate IFMP-RP. There are few opportunities in which entities related to flood risk management meet in one place, and it is ideal for a committee equivalent to CARMAC to fulfill this role in other principal rivers other than the Magdalena River.
CORMAGDALENA	Support the main responsible entities in each of the three stages which are the recognition of problems, the study of the measures and implementation of the measures in the Magdalena River. Given that there is currently no legal provision for the entity to actively institute	Currently the entity has a proven track record in the formulation of the basin management plan and installation of river structures, and has the ability to lead the river management. Therefore, it is ideal for the entity to consider the possibility of legal amendments that would strengthen its authority, and

Entity	Items agreed upon in workshops	Recommendations on future activities
	flood control, the role of the entity is limited.	actively participate in each of the three stages of recognition of problems, study of the measures and implementation of the measures.
Departments	Support in medium flood damage and the integral evaluation of tasks. Support the study, design, construction and implementation of structural measures in principal rivers, and lead their administration and maintenance and monitoring. Lead the implementation of structural and non-structural measures in hydrographic subzones.	It is ideal to strengthen collaboration between municipalities and CAR in order to facilitate the response immediately after a disaster and the implementation of structural measures. Ideally, lead the implementation of structural and non-structural measures together with CAR, especially in hydrographic subzones.
Regional Autonomous Corporation (CAR)	Support the study of the cause of floods, comprehensive assessment of tasks, and regulation of land use in floodplains in principal rivers. Lead the recognition of problems, the study of the measures, and implementation of the measures in each stage of the process in hydrographic subzones.	Ideally, lead the formulation of IFMP-SZ in hydrographic sub-zones and the implementation of flood risk management based on this, taking advantage of past experiences in formulating POMCAs and implementing river works.
Municipalities	Lead the evaluation of the damage situation. Lead the administration and maintenance of structural measures and support the recognition of tasks and the implementation of structural measures in principal rivers. Lead the study of measures and the administration and maintenance of structures, as well as the implementation of non-structural measures, and support the implementation of structural measures in hydrographic subzones.	Given the lack of human resources and capacities related to flood risk management in the current situation, it is ideal to create awareness about flood risk management, developing human resources and strengthening flood response systems with the support from departments and UNGRD.

The entities related to flood risk management in Colombia are the following nine organizations. The recommendations for each entity are as follows.

(1) National Unit for Disaster Risk Management (UNGRD)

UNGRD is the administrative entity of the central government that represents Colombia in disaster risk management. In terms of flood risk management, it is considered to be an entity capable of studying measures take the balance in all national basins into consideration, taking the importance of each region into account. In the workshops of this project, participants agreed that with regard to flood risk management, the entity should "support the municipalities in collaboration with the department in the understanding of the situation of damage, etc. in large floods, lead the comprehensive evaluation of the task in principal rivers, and support the process in hydrographic subzones, lead studies on measures in principal rivers and support the dredging of sediments, etc. In the future, in addition to these responsibilities as a minimum, IFMP-RP must be formulated at an early stage in cooperation with MADS, IDEAM and CARMAC through a comprehensive assessment of the problems of principal rivers and the study of measurements. Ideally, the entity should lead the response to floods in cooperation with related entities from a comprehensive point of view in large floods.

(2) Ministry of Environment and Sustainable Development (MADS)

MADS is an administrative entity of the central government, which is capable of administering a wide area beyond the boundaries of administrative divisions. It is also an entity related to land use, which is an important element of flood control in basins. In addition, it is the most appropriate entity to lead basin management, including the management of floodplains, conservation of the water retention function of the basin, and measures against disasters related to sediments, etc. Currently, the institution is responsible for developing the basin's environmental strategy. In the workshops of this project, participants agreed that with regard to flood risk management, the entity must "comprehensively assess the flood risk management problems and support the study of measures for principal rivers, and lead the study of measurements in hydrographic subzones. Likewise, it must administer the floodplains as a non-structural measure, regardless of whether it is in the principal rivers or hydrographic subzones. "From now on, in addition to these responsibilities at least, it should ideally participate actively in the formulation IFMP-RP and IFMP-SZ. It is convenient for the entity to take advantage of being an entity capable of studying the entire basin from an environmental perspective, especially with regard to the water retention in the basin and sediment runoff control.

(3) Institute of Hydrology, Meteorology and Environmental Studies (IDEAM)

IDEAM is the administrative entity of the central government that manages hydrological and meteorological information in Colombia, and has already implemented the DRR map and the flood forecast and warning system. In the workshops of this project, it was agreed that in terms of flood risk management, the entity should "lead the identification of the causes of floods and the study of measures such as the definition of the planned discharge in principal rivers, lead the elaboration of the DRR map and the improvement of the forecast and the flood warning. It must also provide hydrological and meteorological information at each of the three stage, the problem recognition, study of the measures and implementation of the measures." Henceforth, in addition to these responsibilities as a minimum, it ideally should contribute to flood risk management effectively using the information analysis technology that the entity has. It is necessary to consider the elaboration of the DRR map and the improvement of the flood forecast and warning system in the application to principal rivers.

(4) Regional Environmental Council of the Macro-basin (CARMAC)

CARMAC is a regional environmental council of the macro-basin, composed of MADS, related ministries, CAR and the departments. In this committee, the plan etc. is currently being studied for the Magdalena river basin. Given this current situation, in the workshops of this project, participants agreed that in relation to flood risk management, the committee should "study flood risk management, taking advantage of the existing framework that includes entities related to planning principal rivers. With regard to flood risk management of principal rivers, it must carry out a comprehensive assessment of the problems and support the study of the measures. In the Magdalena River basin, this committee is already functioning, so it must be used to formulate IFMP-RP in the future. There are few opportunities in which entities related to flood risk management meet in one place, and it is ideal for a committee equivalent to CARMAC to fulfill this role in other principal rivers other than the Magdalena River.

(5) CORMAGDALENA

CORMAGDALENA is the entity currently responsible for the formulation of the basin management plan, and its main function is navigation etc. However, the entity has a proven track record of installing river structures on the Magdalena River, in accordance with the provisions of the Constitution. Therefore, the entity is considered to have the capacity to lead the river management initiative to counteract the floods. Given that there is currently no legal provision for the entity to actively institute flood control, in the workshops of this project, participants agreed that with regard to flood risk management, the entity should support the main responsible entities in each of the three stages, the recognition of problems, the study of measures and implementation of the measures in the Magdalena River. Henceforce, in addition to these responsibilities as a minimum, it is ideal for the entity to consider the possibility of legal amendments that would strengthen its authority, participate actively in each of the threes stage of recognition of problems, study of the measures and implementation of the measures.

(6) Departments

The departments, along with the municipalities, are considered to be entities that manage the flood risk, stay in contact with the residents of the flood damage area and place of implementation of the flood control measures. In the department of Cundinamarca, there is a public entity (ICCU) that manages the equipment and implements the local restoration works immediately after the flood. In the workshops of this project, participants agreed that with regard to flood risk management, the entity should "support in the medium flood damage and comprehensive assessment of tasks, support the study, design, construction and implementation of structural measures in principal rivers, and lead their management and maintenance and monitoring. Likewise, the entity must lead the implementation of structural and non-structural measures in hydrographic subzones. Henceforth, in addition to these responsibilities as a minimum, it is essential for the entity to strengthen collaboration between the municipalities and CAR in order to facilitate the response immediately after a disaster and the implementation of structural measures. Ideally, the entity should lead the implementation of structural and non-structural measures with CAR, especially in hydrographic subzones.

(7) Regional Autonomous Corporation (CAR)

CAR is the entity that formulates POMCA, which is the upper plan of IFMP-SZ, and it is currently implementing river projects on its own initiative. For this reason, it is considered to be an appropriate entity to lead the management of flood risk, especially in hydrographic subzones. In the workshops of this project, participants agreed that with regard to flood risk management, the entity should "support the study of the cause of floods, the comprehensive evaluation of tasks, and the regulation of land use in the floodplains in principal rivers. In hydrographic subzones, it should lead the recognition of problems, the study of the measures, and the implementation of the measures in each stage of the process. Henceforth, in addition to these responsibilities as a minimum, ideally the entity should lead the formulation of IFMP- SZ in hydrographic subzones and the implementation of flood risk management based on it, taking advantage of past experiences in formulating POMCAs and implementing river works.

(8) Municipalities

The municipalities are responsible for understanding the damage situation at the time of the occurrence of the flood and the responses immediately after the disaster according to the provisions of the law. Since it is the organization most familiar with the area of flood generation, it is expected to be the first line of an activity in the response to the people affected. In the workshops of this project, participants agreed that in relation to flood risk management, the entity should "lead the assessment of the damage situation, lead the administration and maintenance of structural measures, and support the recognition of tasks and the implementation of structural measures in principal rivers. Likewise, the entity should lead the study of the measures and the administration and maintenance of the structures, and the implementation of non-structural measures and support the implementation of structural measures in hydrographic subzones. Henceforth, in addition to these responsibilities as a minimum, it is ideal to raise awareness about flood risk management, developing human resources and strengthening flood response systems with the support of departments and UNGRD, given the lack of human resources and management skills related to the flood risk in the current situation.

Appendix-6 IFMP-RP (provisional plan) for Magdalena River

Japan International Cooperation Agency (JICA)
National Unit for Disaster Risk Management (UNGRD)
Institute of Hydrology, Meteorology and Environmental Studies (IDEAM)
Autonomous Regional Corporation of Cundinamarca (CAR)
Department of Cundinamarca
Ministry of Environment and Sustainable Development (MADS)

Project for Strengthening Flood Risk Management Capacity in the Republic of Colombia

IFMP-RP for Magdalena River

May 2017

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1. The Purpose of the Elaboration of the IFMP-RP for Magdalena River and its Content

1.1 The Purpose of the Elaboration of the IFMP-RP and its Methodology

In this project, the IFMP-RP for the Magdalena River will be formulated in order to clarify the position of Rio Negro within the whole basin of the Magdalena River as well as the conditions of the confluence point of the both rivers as part of the formulation of the IFMP-SZ for Río Negro.

CORMAGDALENA has made several plans. First, they elaborated a document about the future vision called POMIN in 2002. The next plan, PMC, specifies quality objectives through indicators such as floods and banks stability. The last plan is PMA. The main approach in these plans is the recovery of navigability, and other components of a river plan are not visible.

Since the flood related elaboration in the existing PMA may be insufficient, the additional elaboration to the existing plan will be considered as results of the project. For example, the Project will elaborate additional materials such as texts on the comprehension and analysis of the flood phenomena as part of the project activities, and regard those additions as results of the project, which is this IFMP-RP.

1.2 Profile of the Magdalena River (taken from the Master Plan of Magdalena River)

Known as the largest river in Colombia, the Magdalena River has a main stream of 1,613km with a 3,685m difference in elevation, crosses 11 Departments from south to north and converges in the Caribbean Sea when passing through the city of Barranquilla as well as the Bay Of Cartagena via the Canal del Dique. Its tributaries including Rio Negro, which is the Project target area, spread over 8 departments and Bogota D.C.

The Basin has an area of 266,500 km^2, which is 23% of Colombian territory. The water resources are abundant with an average annual runoff of 234.7 billion m^3. The Magdalena River Basin is the most influential area politically, culturally and economically in Colombia, with 77% population located and 85 % GDP of the country produced in the area. The management and development of the basin have great strategic importance for the economic development, social progress, and environmental protection of Colombia.

CORMAGDALENA manages the Magdalena River, mandated by the Constitution.

The main areas of its administration are recovery of navigability, soil management and conservation, hydropower generation and distribution, as well as sustainable use or protection of the environment.

Although there are some materials on navigation, the environment and the hydroelectric generation of the Magdalena River, a holistic or systematic plan had never been developed. The Magdalena River Master Plan (M/P hereinafter), elaborated in December 2013, is the first of its kind. As it was mentioned previously, the POMIN and PMC also are documents with comprehensive approaches toward the Magdalena River, and MADS is currently elaborating a strategic plan for its macro-basin.

1.3 Efforts in This Project

After the confirmation of the contents of the M/P, surveys and observation of certain points of the river (although limited), the following items regarding the Magdalena River's floods and measures to protect against them were clarified.

1) The flood mechanism of the Magdalena River is extremely different from the one in Japan.

2) There is no concept of formulating a river plan using the basic high water discharge and estimated high water discharge.

3) CORMAGDALENA, an entity mandated under the Constitution to be in charge of the Magdalena River, has developed the Magdalena River Master Plan without enough studies on flood control measures because flood control is out of the scope of the main functions of the entity. The official PMA was elaborated with the available official information, and the analysis on the protection measures for the main riparian municipalities was carried out by the international and national groups of experts. The lack of information for the correct flood management in Colombia has been identified.

Taking the above into account, the project operated on the basis of learning about the real situation of the Magdalena River and respecting the current concepts of flood damage reduction in Colombia in order to *elaborate materials to complement the insufficient contents based on the M/P*. Regarding the insufficient contents, the study was carried out following the steps to elaborate the river plan in Japan.

(1) Organization of Flood-Related Contents in the Master Plan

Flood-related contents in the M/P were organized.

The structure of the Magdalena River Master Plan (December 2013)

1. Summary of the Basin
2. Current Situation and Main Challenges of Management, Development, and Conservation of the Basin
3. Important Points on Administration, Economic, Social Development, and Basin Conservation
4. Summary of the Plan
5. Navigation Plan
6. Hydroelectric Generation Plan
7. Environmental Protection Plan
8. Other Plans
9. Comprehensive Basin Management Plan
10. Environmental Impact Assessment (EIA)
11. Observation for the Execution and its Impact Analysis
12. Proposal towards the Future

In the current situation of use and administration of the Magdalena River, CORMAGDALENA is focusing on navigation, hydroelectric generation, and environmental protection, and several pages of the M/P are dedicated to these contents.

As for measures against floods, they are treated as a part of the other plans. There is no mention of the basic high water discharge or estimated high water discharge, although there are contents on peak discharge and annual total discharge in the upstream, midstream, and downstream of the river.

There is no process of calculating the basic high water discharge and estimated high water discharge through the runoff analysis. In order to carry out these calculations, the digital topographic model is required, but it is not available due to expensive processing costs.

※Flood Runoff Content in 2010-2011 (M/P)

In recent years, the Magdalena river basin has often suffered from flood damage, and the most serious situation occurred in 2010 and 2011.

Due to flooding in these two years, approximately 3,000,000 people lost their home, 570,000 homes were destroyed, 813 schools and 15 health centers were affected, and the economic loss exceeded 8.6 billion USD, according to statistics.

Floods in the Magdalena River basin are caused by storms. The average annual maximum discharge and periodic floods increase gradually especially in the midstream where the increase is relatively large.

Magdalena River basin has two flood seasons (April-June, October-December) corresponding to two rainy seasons per year. Between April and June, there are floods in the upstream and midstream, and between October and December, there are more floods in the downstream. The peak discharge and the annual maximum discharge in the upstream, midstream and downstream are shown in the graph and table below.

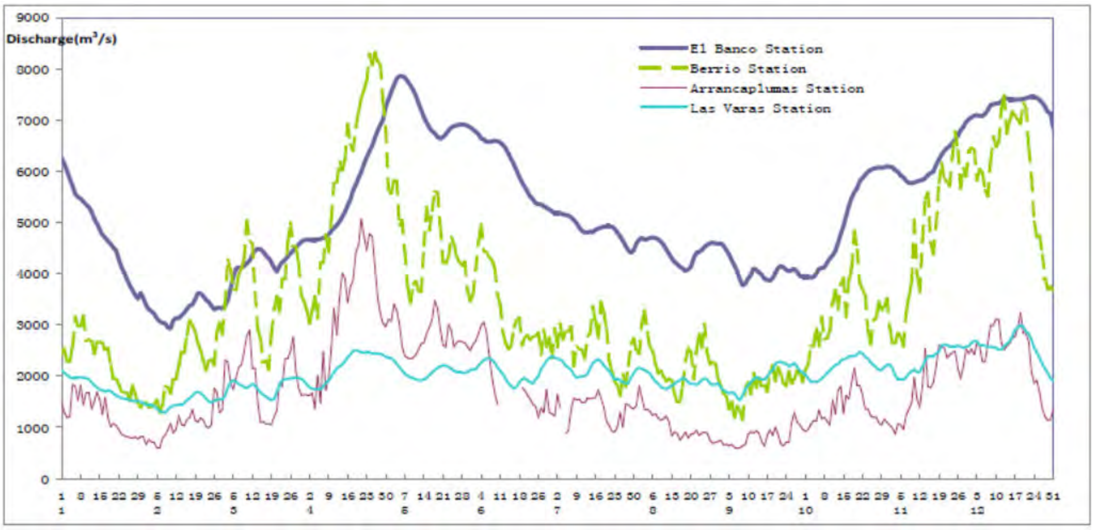


Figure 1.3.1 Annual Discharge Variation

Table 1.3.1 Peak Discharge and Annual Total Discharge in Upstream, Midstream and Downstream Basin

Reaches	Catchment Area of Controlling Station		Year-to-Year Average Annual Flood Peak Discharge		Maximum Year-to-Year Average Monthly Flood Volume	
	km^2	%	Discharge (m^3/s)	Percentage (%)	Flood volume (billion m^3)	Percentage (%)
Upper reaches	54,359	21.1	3,579	30.4	4.45	16.5
Middle reaches	139,657	54.2	6,340	53.8	14.95	55.4
Lower reaches	257,438	100	11,780	100	27.0	100
Cauca River	59,013	22.9	4,076	34.6	8.49	31.4

(2) Concept of the River Administrator in Colombia

The following text is part of the presentation prepared by the Ministry of the Environment of Colombia. The concept of riverside area (Ronda Hidrica) is shown as below.

Decree 2811 of 1974, Article 83 D Except for rights acquired by individuals, the following areas are inalienable and imprescriptible goods of the State: d) a strip parallel to the line of maximum tides or to the permanent channel of rivers and lakes, up to thirty-meters wide.

The Ronda Hidrica was defined in this manner, and is understood as "normal width of the river + 30m", where activities such as urban development and construction are regulated. This concept is the basis of river management related to floods.

It is assumed that the following factors could influence the creation of the Ronda Hidrica concept.

- There are no dikes around rivers.
- When a flood occurs, the river expands horizontally.

  ... The Colombian rivers are managed horizontally, while the Japanese rivers are managed vertically due to the existence of the dikes
- The objective of the conservation of bordering areas of the river is the conservation of the environment of the riverbank. (Flood prevention is not the main objective)

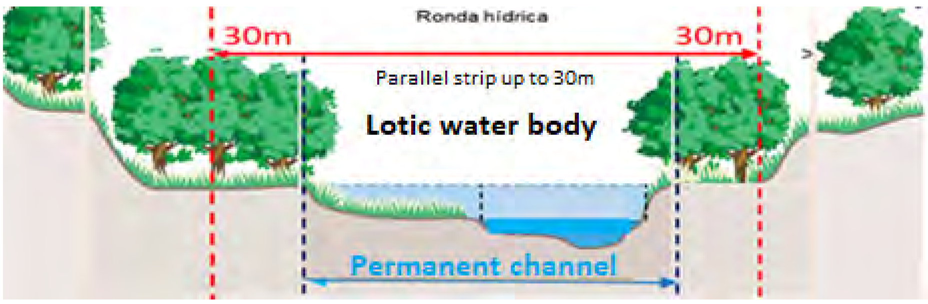


Figure 1.3.2 Ronda Hidrica

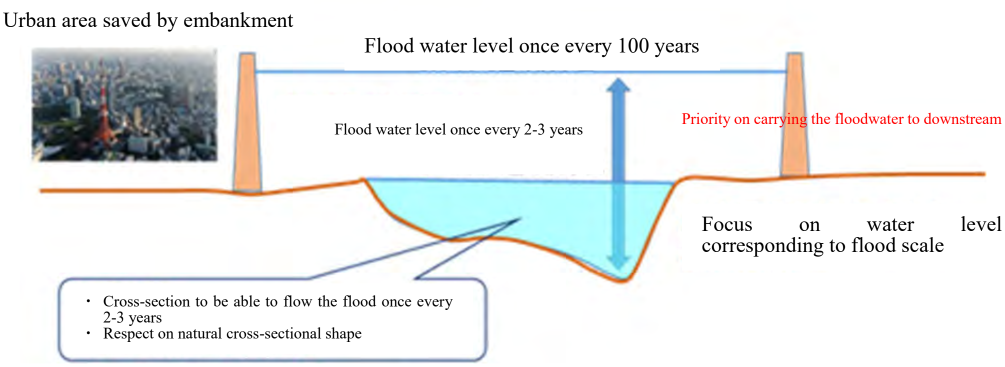


Figure 1.3.3 River Management in Japan (River Area)

It should be mentioned that in cases of flood such as the ones in 2011, where the normal width of the river (the permanent channel: 2-3km) increased up to 20-30km due to the width of flood, the definition of the Ronda, "30m from the edge of the flood", is virtually irrelevant.

Currently, the Ministry of the Environment is reviewing the regulation of the Ronda to include the point of view on flood control (this will be elaborated later). Taking the point of view described above into account, the Ronda concept was redefined as “the area to be protected and conserved” and “a strip parallel to the maximum tide or permanent riverbed of rivers and lakes up to 30m in width” (Article 206 Law 1450, 2011) in the 2011. Currently, MADS is working toward the adoption of some technical criteria such as the morphodynamics, the most frequent flood levels and the riparian vegetation.

(3) Study Schedule in This Project

In elaborating the IFMP-RP for Magdalena River as a result of this project, it would be difficult to apply the Japanese methodology directly to Colombia for the reasons described above, and it was decided to carry out the study according to the following organization chart.

- Understanding flood damage and characteristics in the Magdalena River
- Understanding the characteristics of the target river (analysis of the flood phenomenon, understanding the real use situation)
- Study of measures to reduce flood damage in the Magdalena River
- Water level at the confluence with Rio Negro

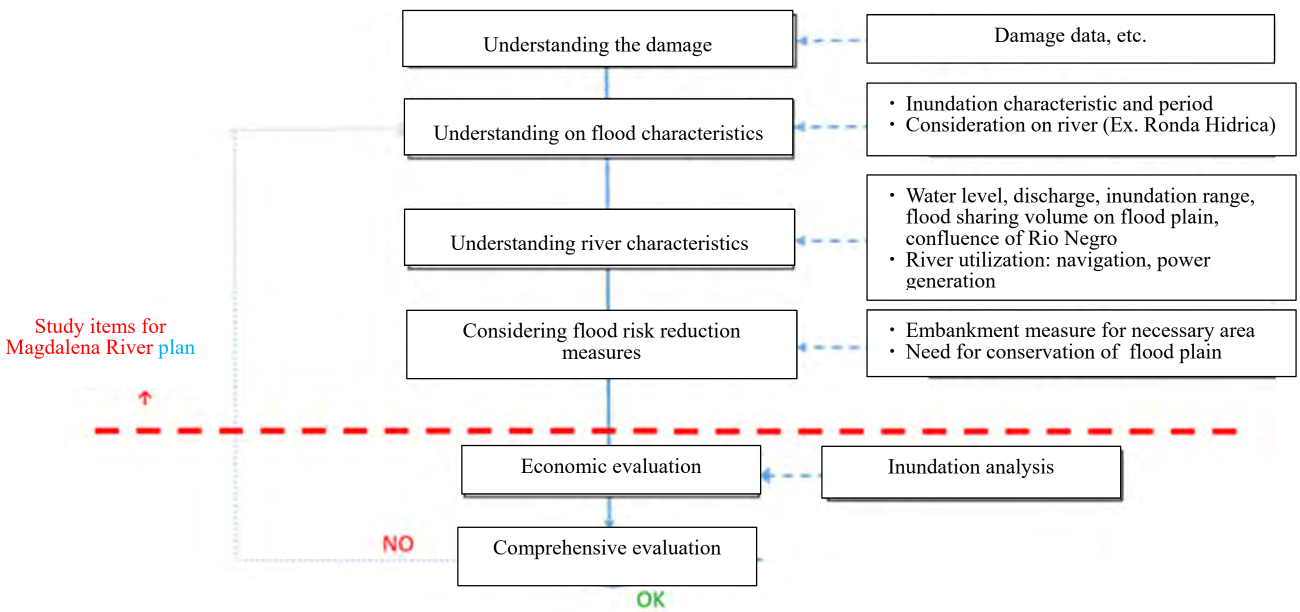


Figure 1.3.4 Study Flow Chart

2. Flood Damages

2.1 Causes of Flood (Master Plan)

Due to the La Niña phenomenon, the Magdalena River basin has been affected by intense rains continuously in recent years. According to statistics, 28 of the 32 departments across the country were affected by the floods in September 2010. In 2011, Colombia experienced the longest rainy season since 1974.

(1) Causes of Flood the Midstream and Downstream Basins

The most direct causes of flooding in midstream and downstream basins are the extraordinary climate caused by the La Niña phenomenon and the natural condition created by the confluence of 4 main tributaries, the Sogamoso River, Cesar River, Cauca River, and San Jorge River. The basin area of each of those 4 tributaries exceeds 10,000km^2, and the floods in this area are caused by the fact that there are the confluence points of the 4 tributaries in the section between Barrancabermeja and El Banco, which is only 260km long.

From the topographic point of view, the main channel widens quite far downstream of Puerto Salgar. The lands bordering the natural dikes are extremely flat before Barrancabermeja. Downstream of El Banco the alluvial plain of the Caribbean region is located, with relatively smooth topography, which is suitable for flood drainage. The existing flood control system in the Magdalena River basin is deficient and unable to store and discharge floods. In addition, flood storage capacity and detention in the basin has also been weakened by the invasion of lakes, swamps and wetlands by human activity.

The midstream and downstream basin of the Magdalena River are key areas for flood control. There are 24 towns and villages along the middle section with a population of 830,000 and cultivated land area of 1,364 km^2, representing 13.7% and 20.2% of the total population and the total cultivated area respectively, according to the Plan. The river network is developed in the downstream of Barrancabermeja, but most of the area belongs to the floodplains with no flood control facilities.

Also, there are 57 cities and municipalities in the downstream basin, with a population of 3,920,000 and a cultivated area of 2,033 km^2, equivalent of 64.6% of the total population and 30.1% of the total cultivated area in whole basin respectively.

According to the analysis of past data, the flood level fluctuates gradually along with the bank level in the midstream and downstream where they are affected by flooding. There has been no catastrophic flooding in some areas with low dikes (generally less than 2m). For example, in the flood of 2011, the major causes of death were secondary disasters such as avalanches and landslides, among others.

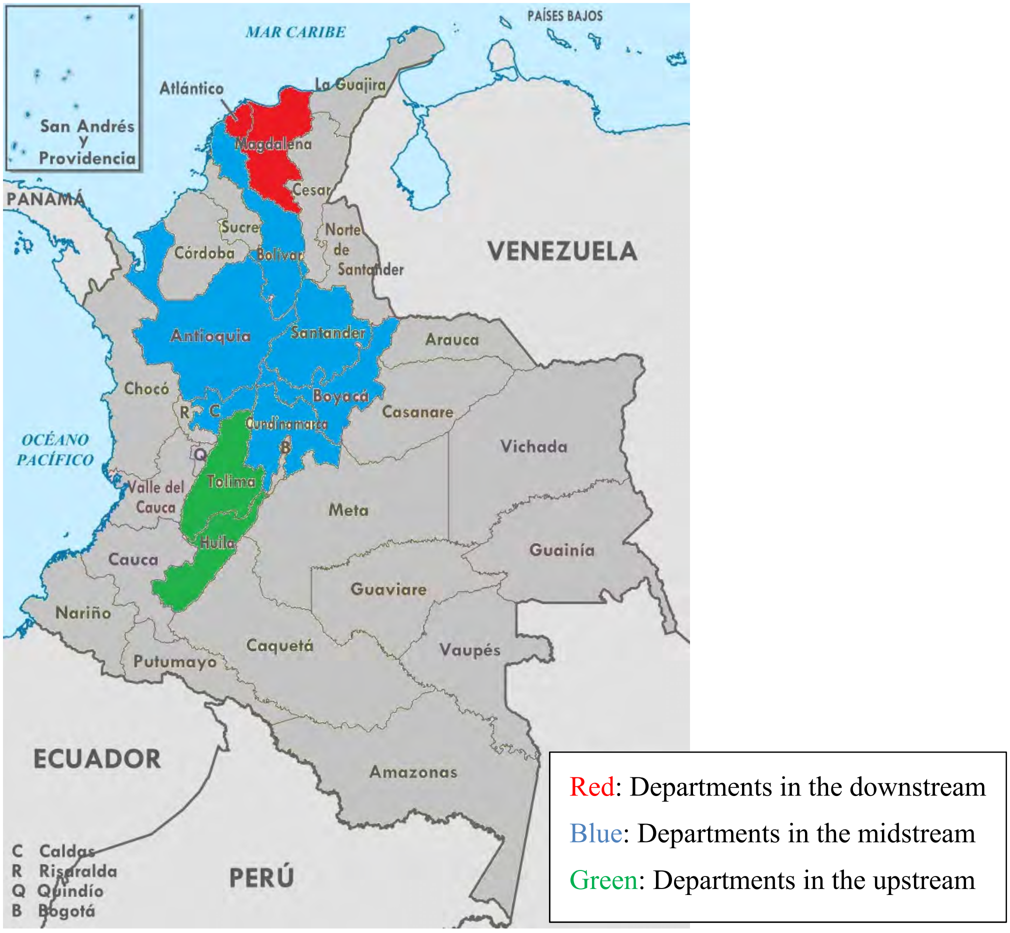


Figure 2.1.1 Location of the Departments in the Upstream, Midstream and Downstream

2.2 Flood Damages in 2010-2011 (Outcome of Project for Strengthening Flood Risk Management Capacity in the Republic of Colombia)

As there are no data related to flood damage between the years 2010-2011 in the M/P, information on the situations of flood damage was organized according to the existing materials prepared by the Economic Commission for Latin America and the Caribbean.

Based on these results in the table below, it can be observed that the greatest damages occurred in the midstream departments.

- The number of affected people was 155,044 in upstream departments, 1,534,346 people in midstream departments, and 538,642 people in the downstream departments. The number of affected households was 42,884 in upstream departments, 269,048 in midstream departments, and 142,857 in downstream departments.
- The number of affected houses was 21,781 in upstream departments, 178,134 in midstream departments, and 101,318 in downstream departments.

Table 2.2.1 Flood Damages in 2010-2011

	Damage recorded per Department						
	Department	Affected population		Hogares afectados		Viviendas afectadas	
		Number	%	Number	%	Number	%
Upstream Departments	Huila	33,475	6.2%	8,487	1.9%	5,142	1.7%
	Tolima	121,569	22.6%	34,397	7.6%	16,639	5.5%
Subtotal		155,044	7.0%	42,884	9.4%	21,781	7.2%
Midstream Departments	Antioquia	176,874	7.9%	45,657	10.0%	29,168	9.7%
	Bolivar	405,604	18.2%	112,119	24.6%	80,170	26.6%
	Boyacá	66,697	3.0%	19,307	4.2%	12,456	4.1%
	Caldas	40,247	1.8%	11,377	2.5%	7,136	2.4%
	Cesar	689,422	30.9%	37,239	8.2%	23,508	7.8%
	Cundinamarca	57,649	2.6%	16,281	3.6%	10,781	3.6%
	Santander	97,853	4.4%	27,428	6.0%	14,915	5.0%
Subtotal		1,534,346	68.9%	269,408	59.2%	178,134	59.1%
Downstream Departments	Atlántico	188,599	8.5%	49,085	10.8%	41,998	13.9%
	Magdalena	350,043	15.7%	93,772	20.6%	59,389	19.7%
Subtotal	Total	538,642	24.2%	142,857	31.4%	101,387	33.6%
Total	Total	2,228,032	100.0%	455,149	100.0%	301,302	100.0%

<u>Damages by Industrial Sector</u>

- The damages in agricultural sector were 50,117,000,000 pesos in upstream departments, 23,007,000,000 pesos in midstream departments, and 46,498,000,000 pesos in downstream departments.
- The damages to infrastructure were 20,809,000,000 pesos in upstream departments, 7,346,000,000 pesos in midstream departments, and 4,887,000,000 pesos in downstream departments.
- The social damages were 70,926,000,000 pesos in upstream departments, 483,735,000,000 pesos in midstream departments, and 81,232,000,000 pesos in downstream departments.

Table 2.2.2 Damages in Each Industrial Sector

	Damage per Department (million pesos)						
	Department	Agricultural damage	Damage to infrastructure	Damage to mining/ tourism	Social damage	Total	Percentage (%)
Upstream Departments	Huila	24,984	6,487			31,471	1.5
	Tolima	25,133	14,322			39,455	1.9
Subtotal	Sub total	50,117	20,809			70,926	3.4
Midstream Departments	Antioquia	46,969	40,579		549	88,097	4.2
	Bolivar	59,033	9,651		2,404	71,088	3.4
	Boyacá	37,393	11,479			48,872	2.4
	Caldas	10,176	18,932			29,108	1.4
	Cesar	17,903	11,810	1,469	119	31,301	1.5
	Cundinamarca	46,433	63,754	2,939	12	113,138	5.5
	Santander	57,844	41,235	2,938	114	102,131	4.9
Subtotal	Sub total	275,751	197,440	7,346	3,198	483,735	23.3
Downstream Departments	Atlántico	5,957	31,174	882	4,241	42,254	2.0
	Magdalena	17,050	15,324	3,996	2,608	38,978	1.9
Subtotal	Sub total	23,007	46,498	4,878	6,849	81,232	3.9
Total	Total	348,875	264,747	12,224	10,047	635,893	31

Source: http://www.cepal.org/publicaciones/xml/0/47330/olainvernalcolombia2010-2011.pdf

3. Understanding the Real Flood Situation

3.1 Confirmation of the Actual Situation of Floods and Damages in 2010-2011 (Outcome of this Project through Workshops)

Since there is not enough mention of specific flood damages in the M/P, the Project tried to understand the actual situation through the workshops.

Regarding to flood damage in 2010 and 2011, IDEAM has developed a flood map as shown below.

- Normal flood area (purple),
- Flood area in 2010-2011 (blue).

As understanding flood damage and sharing this information among relevant entities is an important step, discussion was held among C/Ps about "type of flood damage", "damage situation", and "cause of flood", and these were integrated in the map below.

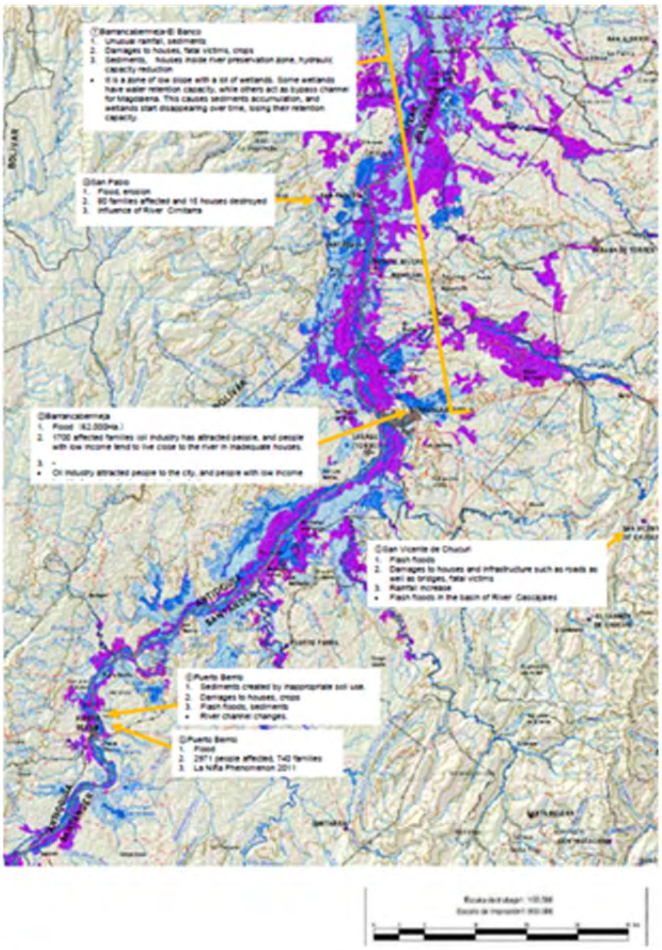


Figure 3.1.1 Workshop in May 2016 (Left), Flood area and flood damages in 2010-2011 (Right)

Table 3.1.1 Flood Damages in Magdalena River mentioned in the Workshop (by City)

①Type of flood damage ②Damage situation ③Cause of flood

Name of the city /municipality	Flood Damages
1: Puerto Salgar	① Flood ② 200 flooded houses in the urban area(inappropriate houses structure) ③ Flood increase
2: Puerto Salgar-Puerto Triunfo (valley zone)	① Inundation ② Damages to crops, cattle, peasant houses , fatal victims ③ Rainfall increase
3: Puerto Boyacá (urban zone)	① Flood ②Damages to houses, approx. 2000 affected people (1000 families) in 9 neighborhoods (riverbank) ③ -
4: Puerto Nare (urban zone)	① Flash floods, flood ② Damages to houses ③ Rainfall increase, sediment on the riverbed
5: San Vicente de Chucuri	① Flash floods ② Damages to houses and roads, fatal victims ③ Rainfall increase
6: Puerto Berrío	① Sediments produced by bad land use ② Damages to houses and crops ③ Rainfall increase
7: Barrancabermeja-El Banco	① Unusual rainfall, sediments ② Damages to houses and crops, fatal victims. ③ Sediments, houses inside ronda, reduction of the hydraulic capacity It is a zone of low slope with many wetlands. Some wetlands have water retention capacity However, there are cases in which there have been created channels from upstream until downstream for irrigation. This causes sediments accumulation, and wetlands start disappearing over time, losing their retention capacity.
8: Ricaurte (Cundinamarca)	① Urban flood ② Approx. 20 houses ③ High water level in upstream. Islands show up easily because riverbed course changes frequently. As it is so flat, a little water level increase raises flood area meaningfully.
9: Honda	① Urban flood ② More than 20 houses damaged ③ High water levels upstream. High valuation of lands close to Betania dam made damages to have a high money cost. Guali River is very steep and produces a high amount of sediments that accumulate in Magdalena River.
10: Puerto Boyacá	① Urban flood ② 100 houses damaged ③ High water levels
11: Puerto Berrío	① Flood ② 2971 victims, 740 families ③ La Niña phenomenon 2011
12: Puerto Berrío	① Flood (62.000Ha.) ② 1700 families injured. Damages to oil palm crops. ③ Oil industry has attracted people, and people with low income tend to live close to the river in inadequate houses
13: San Pablo	① Flood, erosion ② 80 families injured and15 houses destroyed ③ Influence of Cimitarra River
14: Puerto Mosquito	① Flood ② - ③ Damage of dike in 2008

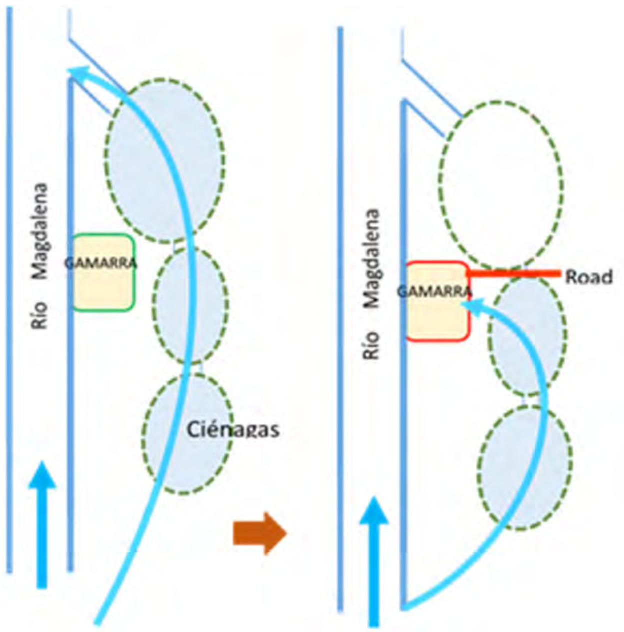
15: Gamarra	① Big flash floods in Magdalena tributaries ② 100% urban area, partial rural area ③ There is peripheral dike without enough drainage. Peripherical dikes to the urban area. And wetlands are the bypass channel to Magdalena river, but the road construction cuts the flood flow but this channel and its direction change affected Gamarra.
16: La Gloria	① Overflow ② - ③ Overflow of the closed wetland at the confluence of Magdalena River and its tributary
17: Tamalameque	① Dikes overflow（200h??） ② Oil palms crops, transportation dock ③ Overflow and erosion Construction of roads that split up Magdalena river and one wetland with water retention capacity
18: El Banco (Magdalena)	① Flood ② 50 fatal victims,15 missing, 1800 victims ③ Overflow of Zapatosa wetland, La Niña phenomenon, 2010-2011
19: Mompox	① Flood ② 30 fatal victims, 12 missing ③ La Niña Phenomenon, 2010-2011 Formerly, Magdalena crossed close to Mompox, but riverbed has changed. (Mompox is UNESCO Heritage)
20: Achí	① Flood ② 3 fatal victims, 18 missing ③ Overflow of Cauca and San Jorge rivers , dike broken
21: Pinillos	① Flood ② 20 fatal victims, 8 missing ③ - Agriculture important land. There are several dikes. Flood can last 2 years
22: Magangué	① Flood by overflow of Magdalena River ② 50 fatal victims, 15 missing ③ La Niña Phenomenon, 2010-2011
23: El Plato (Nuevo Sitio)	① Dike broken over the Magdalena River ② 15 fatal victims, 18 missing, 20,000 victims ③ Flood

3.2 Characteristic Damages (Outcome of this Project)

In the workshop, Mr. Cesar Garay of CIRMAG (CORMAGDALENA research center) introduced the characteristic pattern of flooding on the Magdalena River. Since there are almost no dikes there, the flooding area expands to the wetlands during catastrophic floods. As there were cases where roads were built in these wetlands, the flood channel were modified, causing floods where they did not exist before. In addition to the road construction, the level of intervention in the marshes is high, causing sedimentation, alteration, pollution, cut off, or drying. They affect their capacity of regulating flood, as well as people living along the riverbanks.

Example 1: Gamarra

- There were wetlands parallel to the Magdalena River
- During the flood, these wetlands have flood retention capacity, controlling the increase of water level. In other words, these wetlands worked as retention reservoirs.
- A road was constructed cutting off the connection between these wetlands.
- As a result, the flood that had to be stored in the wetland accumulated and began to flow into the urban areas.



- A ring dike is currently used to prevent flood damage.

Example 2: El Banco-Tamalameque

- Cutting the water flow by road construction
- Changing the flood area
- Between El Banco-Tamalameque Retention

  Area (wetlands) is 30,000-50,000ha

- A large amount of suspended sediment enters the wetlands along with the floodwater. These wetlands

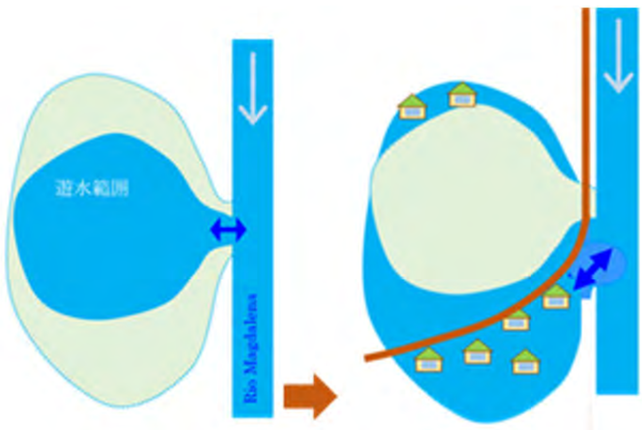


Figure 3.2.1 Conceptual Drawing before/after Road Construction

do not have a much depth. Therefore, retention areas may be weakened by accumulation of sediment and loss of retentive capacity, causing movement in the retention area.

【Conclusion】“It is necessary to understand the area of flood including the wetlands for the study of the phenomenon of flood”.

4. Features of the Target River

4.1 Analysis of Flood Phenomenon (Result of this project)

(1) Objective of the water level and flood area calculation

One of the purposes of this work is to recreate and assess the flood phenomenon based on methodology used in Japan. To do this, it is more realistic to "consider the entire flood area as part of the river" in the case of the Magdalena River, as explained above.

When performing the hydraulic analysis of the area adjacent to the river, the data of the channel and the height of floodplains are necessary; however, regarding to the Magdalena River, topographic and bathymetrical surveys have only been carried out in limited sections.

It is worth mentioning that although satellite image topographic data exist, it is necessary to combine and adjust the data of topographic surveys and height. Taking these conditions into account, the C/P technician (IDEAM) prepared the data set for the floodplain and river course according to the height data obtained by satellite image, and performed the non-uniform flow calculation.

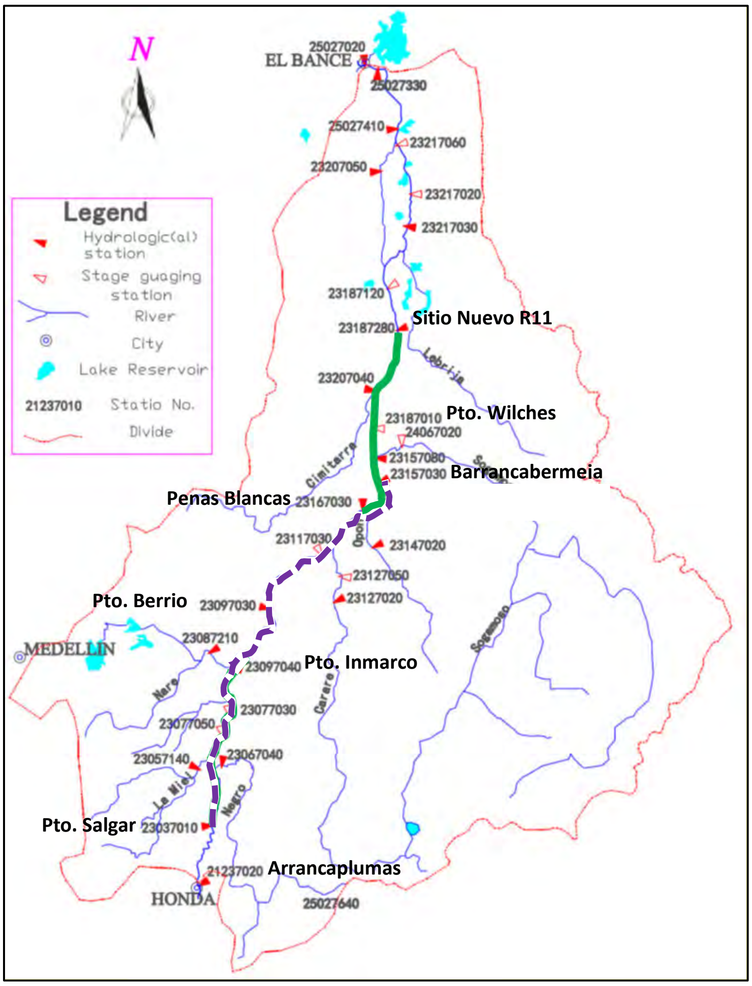


Figure 4.1.1 Target Area for the Non-Uniform Flow Calculation

◆Purpose of the Study and Target Sections

- Section 1: Peñas Blancas (upstream) ～Barrancabermeja ～Pto. Wilches ～Sitio Nuevo R11 (downstream)
- Section 2: Pto. Salgar (upstream) ～ Pto. Inmarco ～ Pto Berrio ～ Barrancabermeja (downstream)

Remark: the analysis was started in Puerto Salgar since bathymetry survey is available from this point onward.

The Section 1 is called “the midstream section” in this project. In the 2010-2011 flood, the flood width exceeded the normal width of the channel and expanded into large areas. Although the objective was to “recreate flood area = area of the Magdalena River occupied by flood", the limitations in the topographic digital elevation model for reproducing surrounding areas of the main channel of the river did not allow for satisfactory modeling.

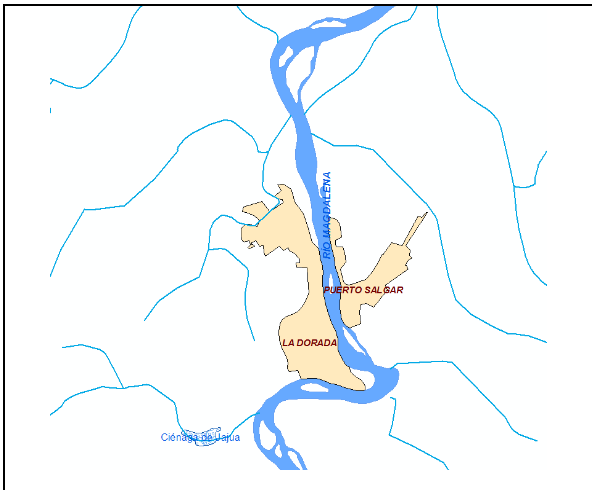
Section 2 includes Río Negro, which is the pilot river for this project. The objective will be "to reflect the flood water level and discharge along the main river into the river plan along the tributaries" following to the Japanese methodology to elaborate the river plan.

-Setting Identified Control Points

For the flood analysis, it is convenient to identify some control points that will allow for the establishment of certain features of the river in specific locations, such as narrowing of the section caused by topographical factors or by human settlements. These control points will be described as follows.

<u>Puerto Salgar</u>

The existence of Salgar station allows for the definition of this point as a given control point for certain water levels. It could cause harm to urban areas or overflows in upstream locations.

	
Normal Condition	Flood Condition(2010-2011)

Puerto Boyacá – Puerto Perales

The section between these two settlements has high slope areas that make it a control section to estimate the water for river transportation and to define flood areas in the upstream.

Normal Condition

Flood Condition(2010-2011)

La Sierra

At La Sierra, the main channel narrows. Even though Puerto Inmarco station does not have a long register that allows for the provision of information during La Niña 2010-2011, it is an interesting control point due to the narrowing of the riverbed section.

Normal Condition

Overflow Condition (2010-2011).

Puerto Berrío

From the flood condition analysis in the section, some control points could be identified. They work as a control section either due to their river bank configuration (ring dikes, high natural zones) or due to geological conditions that make them stable and narrow sections.

Among them is the adjacent area to the urban area of Puerto Berrio. There were damages in some urban areas, including Puerto Olaya located on the right bank of the river in this section. This site is suitable for a reference point because the discharge that can be transported by the river channel can be identified in this section adjacent to urban areas. In addition, volumes above this discharge will cause overflow in upstream areas or sections with less capacity or with natural regulating / storage areas available on both sides of the river.

Normal Condition

Overflow Condition (2010-2011).

The flood discharge along the analysis section is summarized as below.

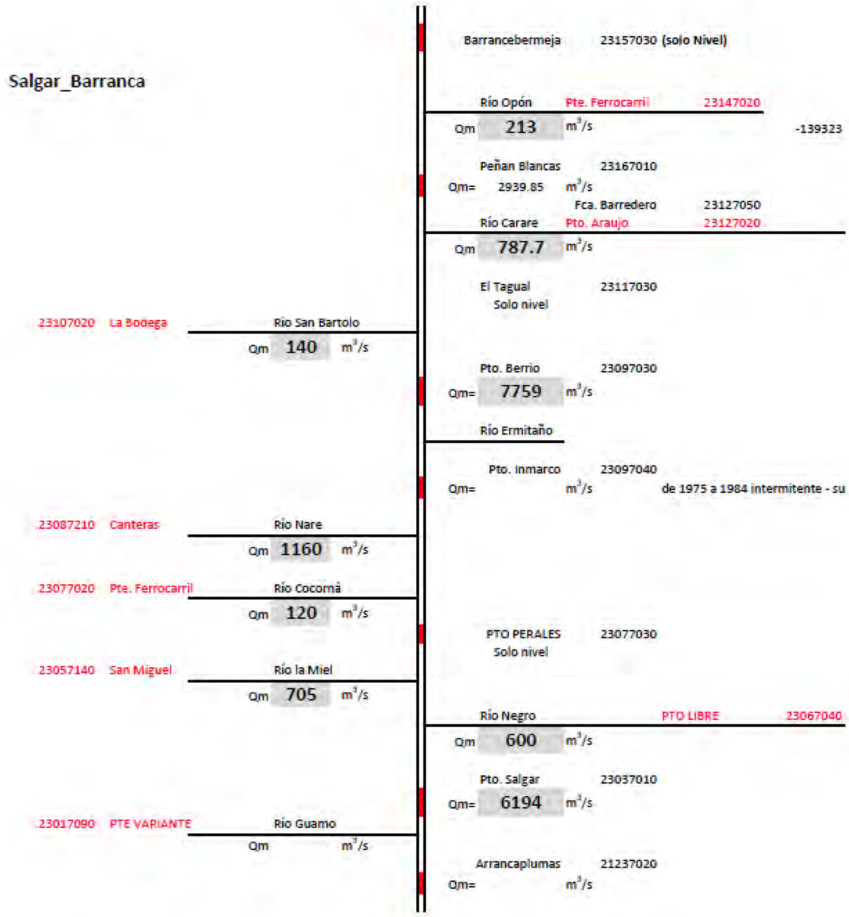


Figure 4.1.2 Magdalena River between Puerto Salgar and Barrancabermeja; the values introduced correspond to the estimated ones for April 23rd, 2011

◆ Items for the Calculation

To analyze the flood of 2010-2011, calculations of the following items were made:

① Maximum flood water level

② Flood area

③ Maximum water level at the point of confluence with Río Negro

(2) Observation data

The maximum flood level in the section Puerto Salgar- Barrancabermeja was observed around April 2011; however, eight stations mentioned below had recorded maximum levels.

The followings were analyzed based on these water level and flood discharge data.

Table 4.1.1 Observation Points that Recorded the Maximum Water Level in April 2011

No. of observation point	Name of observation point
23187280	Sitio Nuevo R11
23187010	Pto. Wilches
23157030	Barrancabermeja
23167010	Penas Blancas
23097030	Pto. Berrio
23097040	Pto. Inmarco
23037010	Pto. Salgar
21237020	Arrancaplumas

	21237020	23037010	23097040	23097030	23167010	23157030	23187010	23187280
	Arrancaplumas	Pto. Salgar	Pto. Inmarco	Pto. Berrio	Peñas Blancas	Barranceber meja	Pto. Wilches	Sitio Nuevo R 11
2011/4/20	199.38	172.31	130.88	110.2	99.1	75.65	66.26	52.88
2011/4/21	200.11	172.85	131.17	110.29	99.18	75.67	66.28	52.85
2011/4/22	199.63	172.69	131.3	110.35	99.21	75.73	66.26	52.84
2011/4/23	199.23	172.17	131.25	110.41	99.32	75.76	66.24	52.83
2011/4/24	199.71	172.5	131.12	110.35	99.39	75.81	66.26	52.84
2011/4/25	199.63	172.64	130.87	110.28	99.41	75.84	66.24	52.86
2011/4/26	198.73	172.17	130.77	110.36	99.45	75.85	66.26	52.89
2011/4/27	197.76	171.74	130.51	110.3	99.39	75.77	66.24	52.85

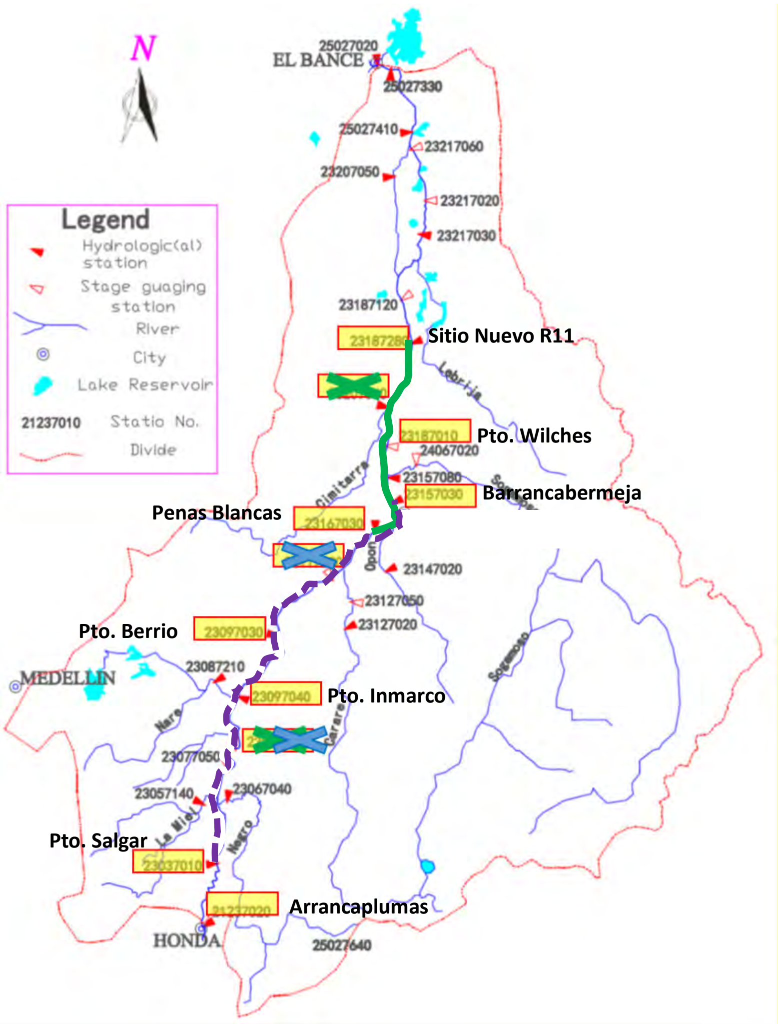


Figure 4.1.3 Observation Points with the Maximum Water Level in April 2011

(3) Cross-section

a. Cross-section

Each cross-section and the maximum water level (observed) in the flood of 2011 are shown.

The analysis of only the observed level shows that the maximum water level flowed within the cross-section of the main channel for the sections with IDEAM stations.

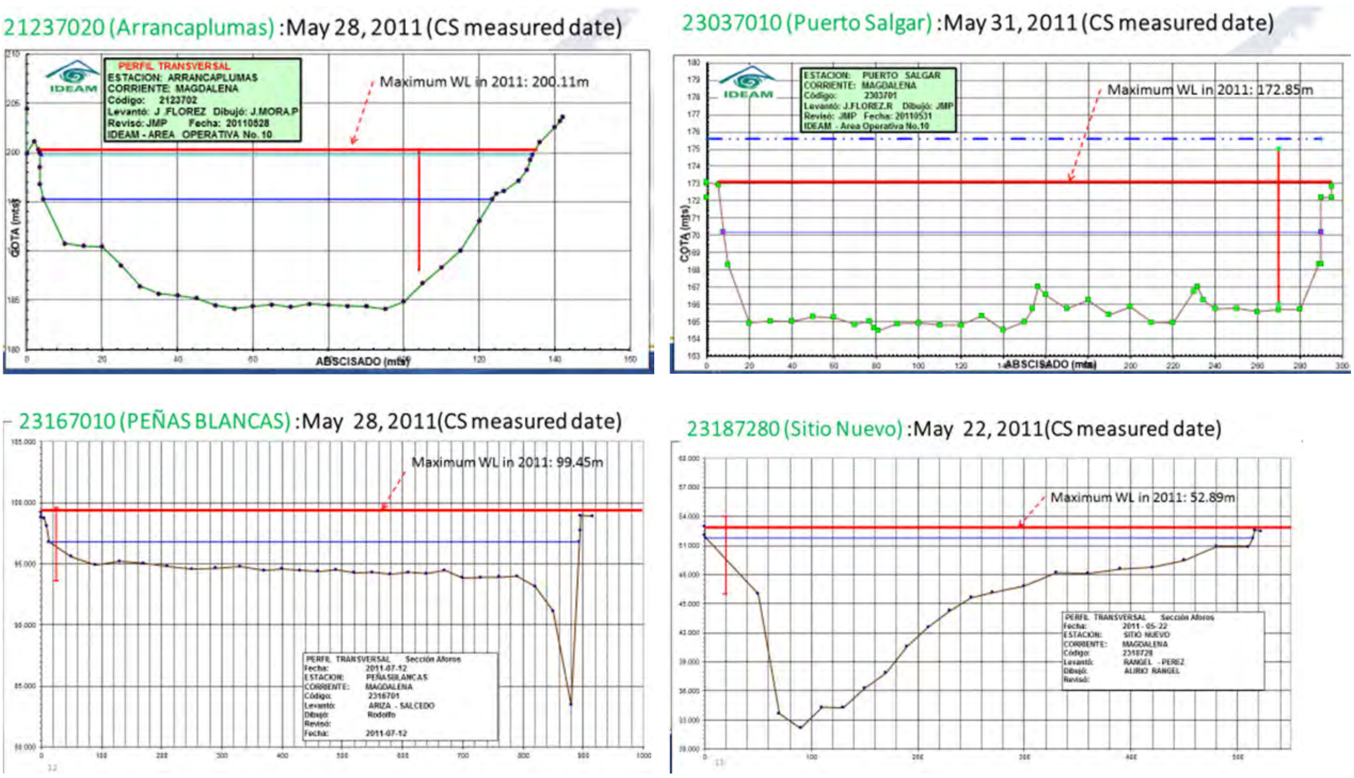


Figure 4.1.4 Cross−Sections Obtained by Topographical Survey and Maximum Flood Depth in 2011 (red line)

With the aim of evaluating the flow capacity of the river in 2010-2011 floods, it was decided to assess the river hydraulic capacity including its flood plain. For such purpose, the digital elevation model available in Colombia with 30 meters resolution and the bathymetries surveyed by IDEAM at Salgar-El Banco section in different periods of time were used. Although the 30m model accuracy is not the best, the exercise was carried out in order to try to establish banks along the river with better details as well as to set the river's approximate flow capacity in its main channel in this manner.

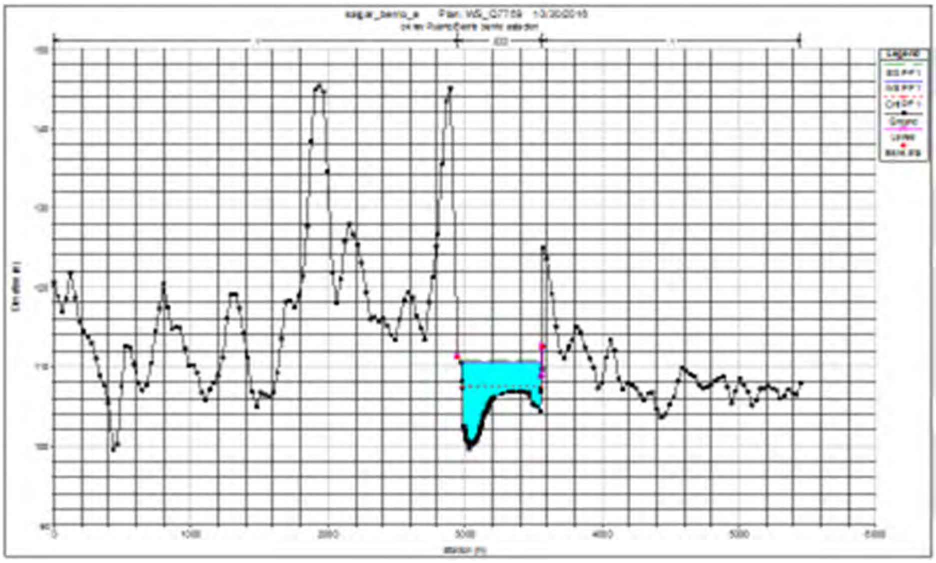
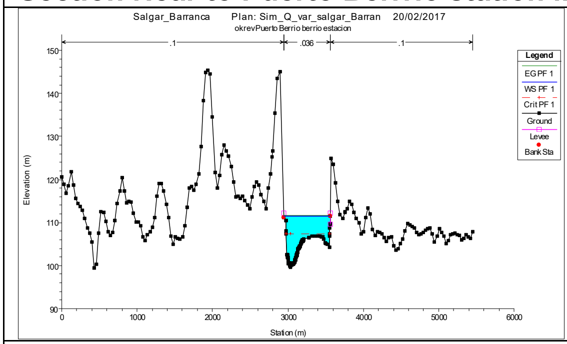


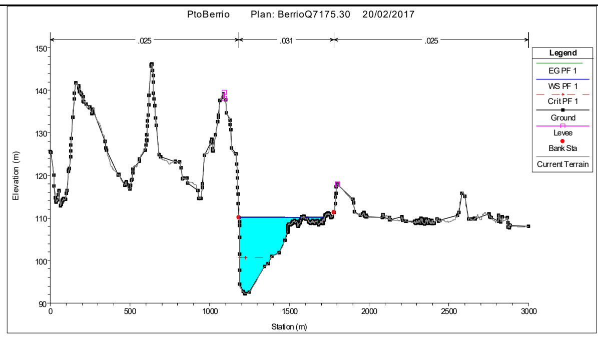
Figure 4.1.5 Example of Data Combination of Floodplains Obtained from Satellite Images and Channel Data.

Considering that more accurate sections could be obtained particularly for Puerto Berrio through LIDAR surveys in some river points carried out by MADS, the comparison among the sections obtained is presented. This will allow for the general observation of the degree of concordance between the sections.

Section Near to Puerto Berrrio station in Puerto Berrio



DEM – Bathymetry



Lidar-Bathymetry- MADS

Figure 4.1.6 Comparison of the Composed Section obtained with DEM and Bathymetry and Section obtained with Lidar and Bathymetry carried out by MADS

b. Data Revision H-Q

In the flood of 2010-2011, there was a flood mark that surpassed previous floods. The maximum value of the H-Q curve is often a line extrapolated from existing flood data, and applicability needs to be verified. In the section described below, the applicability of the H-Q curve was checked for the measured section of Puerto Berrio. In this section, the observation of discharge in the flood of 2011 was carried out. As a result of the verification, it was confirmed that the observed flood values (water level and flood discharge) in the measured section of Puerto Berrio coincide with the H-Q curve in general. Therefore, it was determined that the maximum observed level at the station and the existing H-Q curve will be used for the calculation of the maximum discharge.

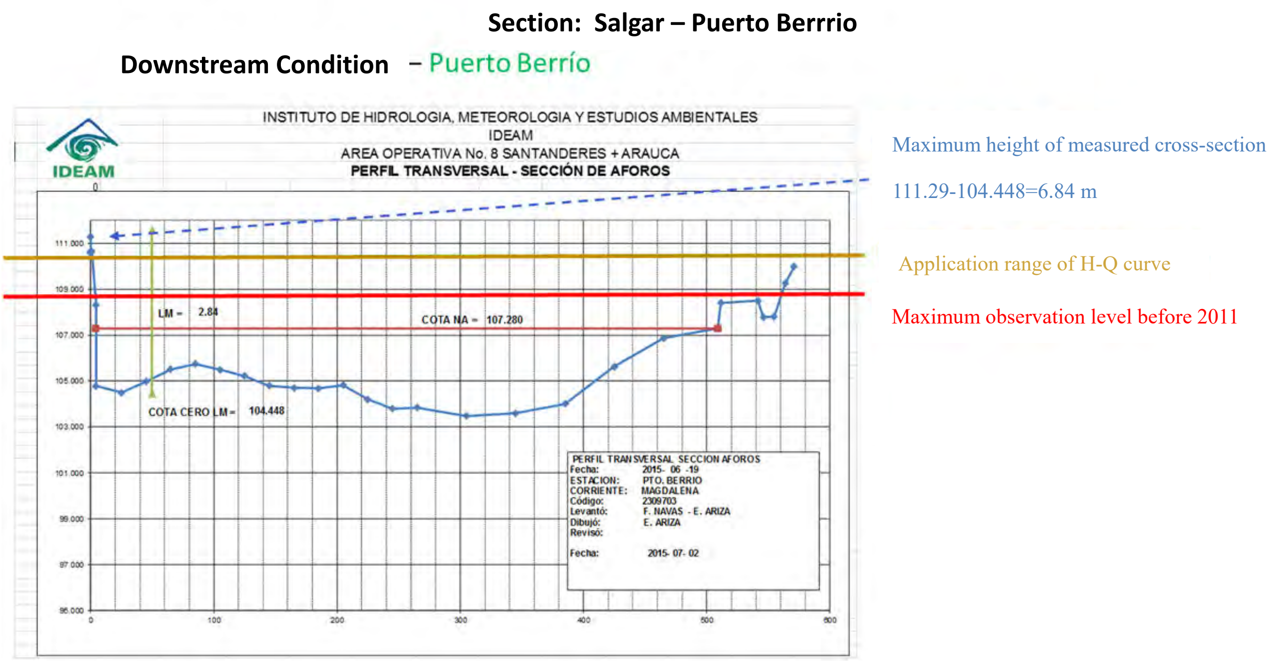


Figure 4.1.7 Cross-Section in AFOROS and Application Range of the H-Q curve

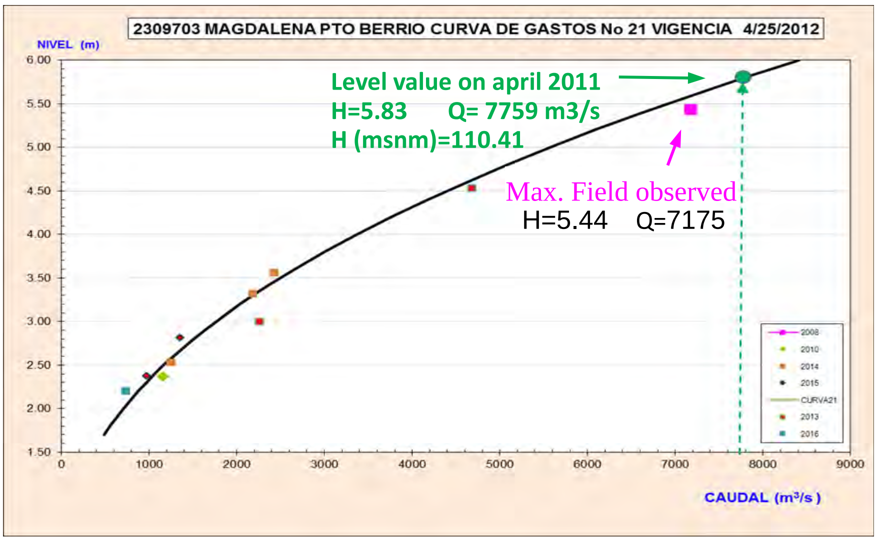


Figure 4.1.8 Existing H-Q curve

In the floods of 2010-2011, there are cross-sections emerged from the cross-section of the normal channel (main channel). In case of calculating the flow capacity of areas including the main channel and floodplains, the applicability of the existing H-Q curve must be checked again. Hereinafter, it is planned to use the conveyance methodology used in the US Army Corps of Engineers to verify it.

(4) Boundary Conditions of Water Level and Discharge Values for the Simulation

Using the cross-section verification methodology described above, it was possible to verify the applicability of existing H-Q data. Based on these results, the "water level at the starting point" and "planned discharge" were set to be used in the non-uniform discharge calculation.

① Water level at the starting point was defined as follows:

Boundary condition of the water level for the downstream section of the model was defined by the water level in the Barrancabermeja station, which corresponds to 75.76 msnm.

	Distance(m)	Level	Place
Water level section 2-1	246,921.5	172.17	Puerto Salgar Stn.
Water level section 2-2	144,695.3	131.25	Puerto Inmarco Stn.
Water level section 2-3	100,948.3	110.41	Puerto Berrio Stn.
Water level section 2-4	14.87	75.76	Barrancabermeja

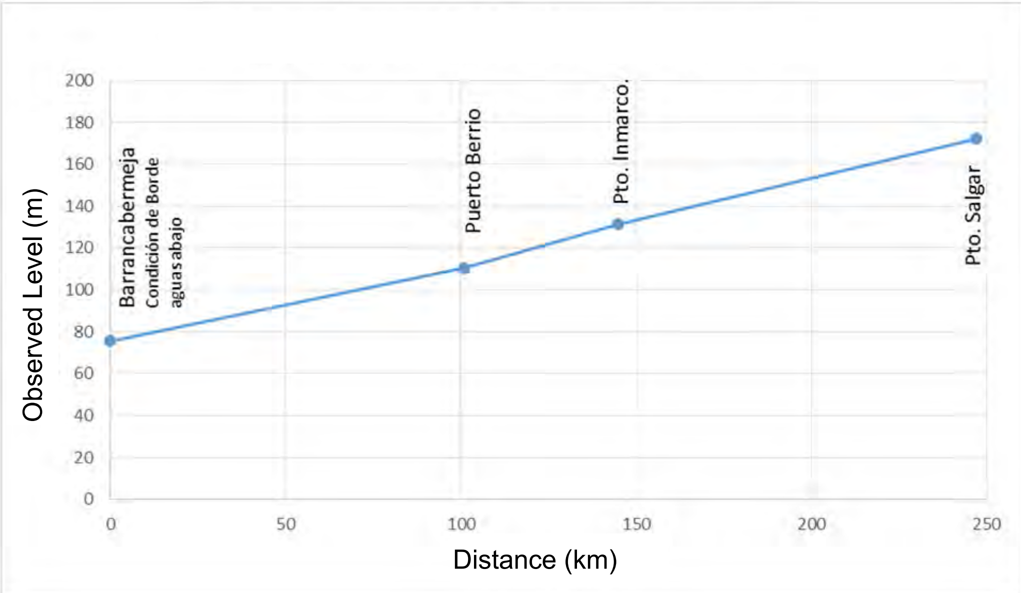


Figure 4.1.9 Water Level at Starting Points

② Discharge was defined as follows:

Section	Distance (m)	Discharge (m^3/s)	Place
2-1	248,052	6,194.0	Puerto Salgar Station
2-2	209,227	7,499.0	Confluence with La Miel and Negro Rivers
2-3	167,384	7,619.0	Confluence with Cocorná River
2-4	144,695	7,759.0	Confluence with Nare River

Regarding the table above, discharge in the main channel increases from Puerto Salgar station up to Barrancabermeja, based on points of confluence of main tributaries. In the case of the confluences with La Miel and Río Negro Rivers, just one point to increase the discharge is set in the model due to their proximity.

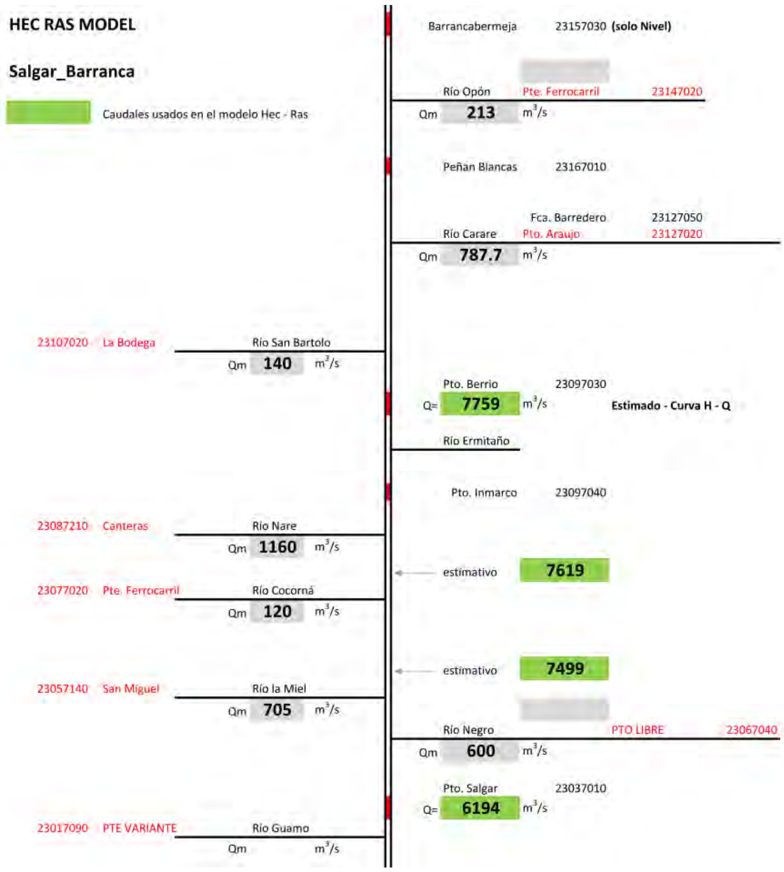


Figure 4.1.10 Simulated Discharge in the Magdalena River between Puerto Salgar and Barrancabermeja

(5) Result of Calculation

a. <u>Water Level</u>

The results of water level calculation in the sections defined are as follows.

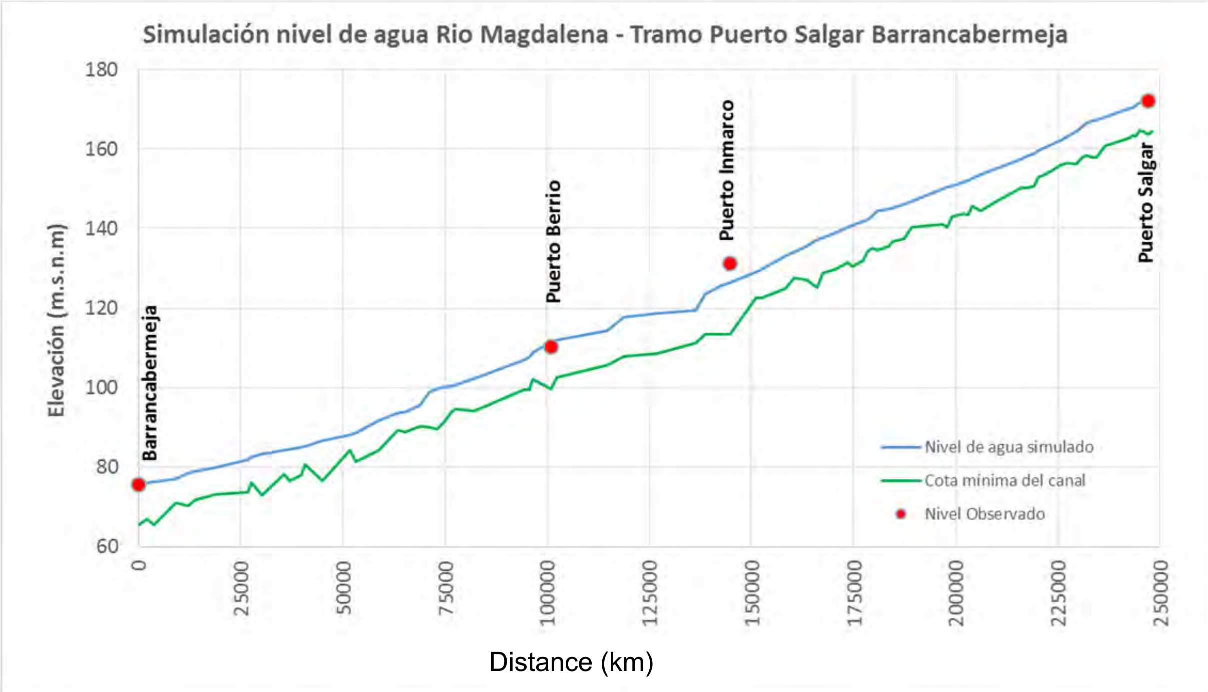


Figure 4.1.11 Result of the Water Level Simulation in the Section Puerto Salgar-Barrancabermeja for the data from April 23rd, 2011

From the results obtained through the boundary condition of the water level defined in Barrancabermeja, the following can be observed:

- In spite of the revisions, a considerable difference persists between the simulated water level and the observed data in Puerto Inmarco. This leads one to suppose that there is some inconsistency in the datum level and the real height. Possibly, it corresponds to a benchmark point that is not certified by IGAC. This is consistent with the fact that the bathymetrical section is deeper in this specific site.

  A second possibility, which is difficult to verify with the available information, would be that river slope may reduce drastically in this section, generating an increase in the water level that may correspond to the observed level. However, the interval of available sections does not allow for the verification of this hypothesis.

- Simulated water levels in Puerto Salgar and Puerto Berrio coincide with the data observed in the existing stations in these two sites. This allows for an inference that the result of the simulation is satisfactory in general.

b. Flood Area

The results were as follows:

- Sitio Nuevo: 17.2km width (the maximum for this section).
- Puerto Wilches: 5.0km width.
- Barrancabermeja: 6.6km width

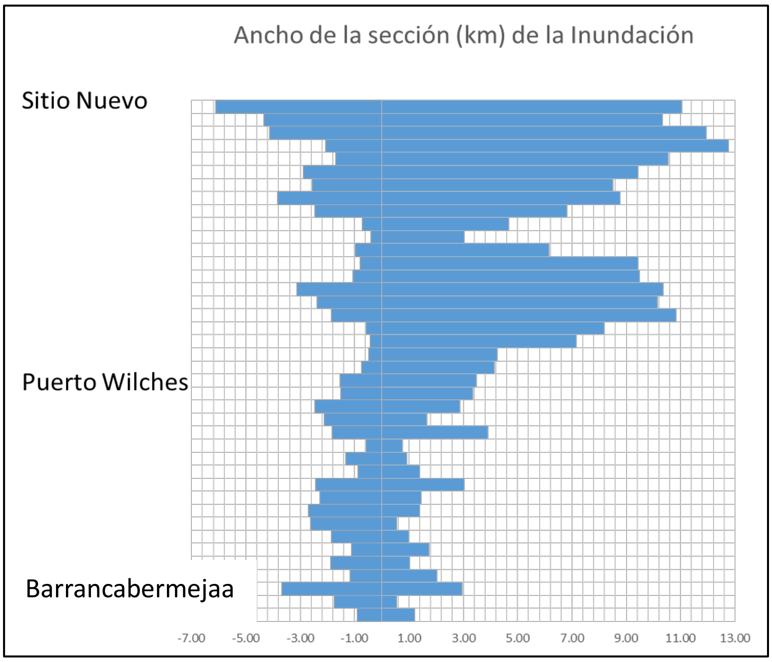


Figure 4.1.12 Inundation Range

Since the normal width of Magdalena River is from 2-3km, it was observed that the flood occurred within the 15km of flood plains in this section.

There is a need to study the flooding of the Magdalena River including flood plains.

It is important to understand the orogeny and geomorphology of the Magdalena river basin since the upstream is channeled by the central and east mountain ranges. Consolidated rock formations restrict it; however, closer to its mouth, the flood plains become wider. Horizontal floodplain can reach kilometers of width in the Caribbean plain.

c. <u>Maximum water Level at the Confluence Point with Rio Negro</u>

For the modelling, there were two sections taken into account: downstream section (209,227.8) and another in the upstream section of the Magdalena River, specifically upstream of the confluence with Rio Negro (216,016.0). From this available information, it was established that the confluence is in the 211,520.1 section. The simulated water level corresponds to 155.64 meters above sea level in this section.

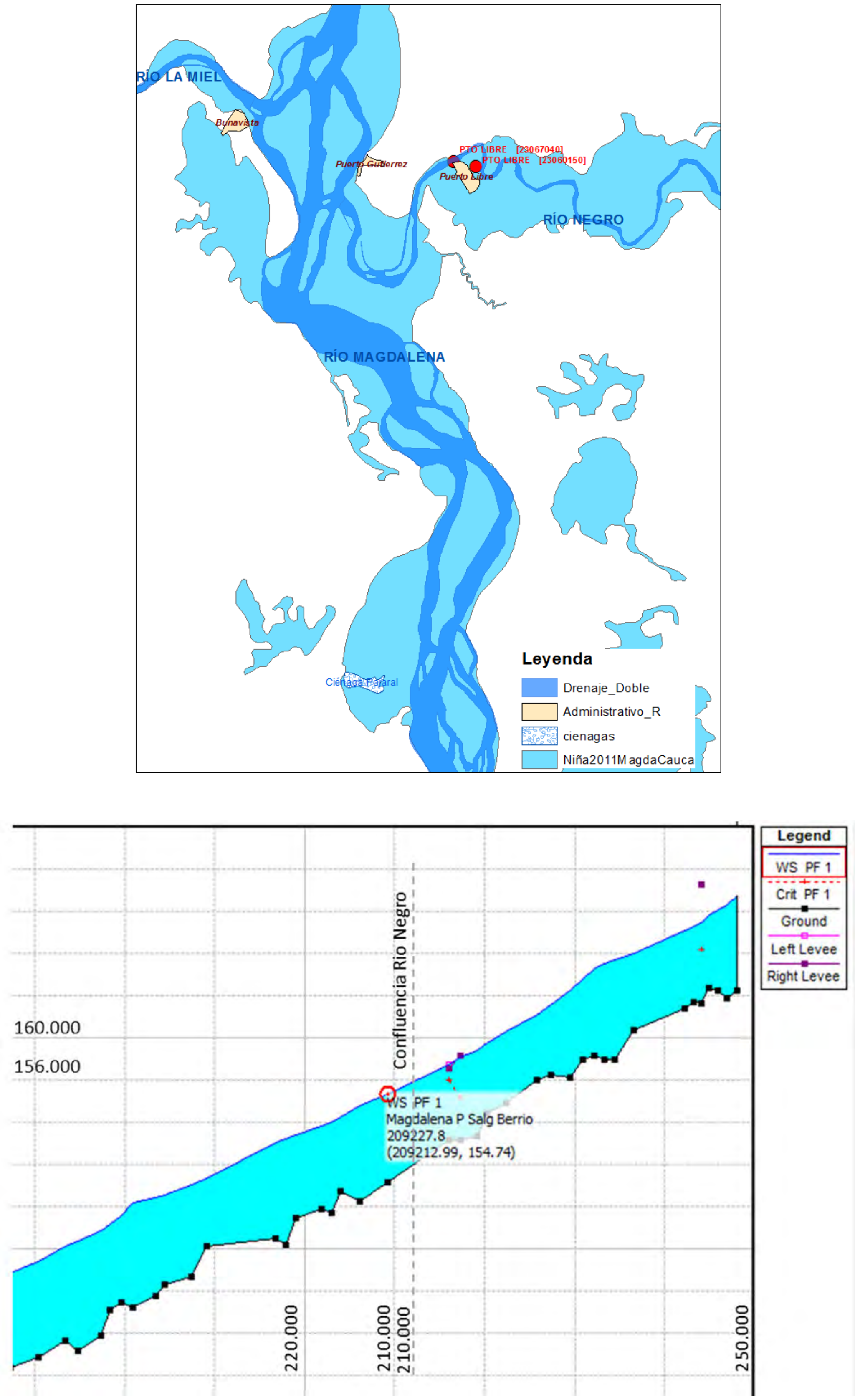


Figure 4.1.13 Confluence of Río Negro to Magdalena River and Flood Coverage 2010-2011

As an element for verification, the maximum water level reached by the flood at the confluence between Rio Negro and the Magdalena River (155.64) was compared to the data from Puerto Libre station along Rio Negro, located 6km upstream of the confluence (meandering section). The water level on April 23rd, 2011 in this station was 155.86 meters above sea level.

Table 4.1.2 Detailed Analysis Data

River Sta	Point of interest	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Discharge Area	Q Left	Q Channel	Q Right	Q Total	Conv. Chnl	Top W Chnl	Top W Left	Top W Right	Top Width
		(m)	(m)	(m)	(m)	(m/m)	(m2)	(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m)	(m)	(m)	(m)
248052		164.45	173.52		173.93	0.001502	2931.32		5556.45	637.55	6194	143383.9	393.74		637.69	1031.42
246921.5	Est. Pto Salgar	163.8	172.61		172.79	0.000653	5130.66	2.81	4926.81	1264.38	6194	192779.7	460.39	151.47	1195.15	1807.02
245901.8		164.52	172.09		172.22	0.000477	6392.14	257.58	4855.93	1080.49	6194	222296.1	556	1041.11	990.17	2587.28
244960.9		164.72	171.65		171.76	0.000479	6425.73	239.31	4891.62	1063.07	6194	223427.1	656.66	491.94	1134.52	2283.13
244139.5		163.3	170.98	168.41	171.21	0.000934	3541.81		5735.13	458.87	6194	187620.8	612.15		582.28	1194.44
243274		163.36	170.51		170.58	0.00058	6957.37		4083	2110.99	6194	169471.5	910.26		1582.76	2493.02
242282.5		162.85	170.13		170.2	0.000284	6537.24	10.39	5659.99	523.62	6194	335936.8	1043.42	164.79	937	2145.21
236593		160.77	168.04		168.11	0.000496	6165.94	784.86	5409.14		6194	242876.6	1526.97	706.81		2233.78
234482.3		158	167.39		167.46	0.000209	5849.38		6141.18	52.82	6194	424887.4	1088.26		1084.51	2172.77
233279.8		158	167.03		167.13	0.000375	5058.29		6097.01	96.98	6194	314828.2	1060.24		1201.91	2262.16
232167.6		158.3	166.53		166.69	0.000391	3497.38		6194		6194	313122.4	598.51			598.51
230971.7		158	165.61		165.85	0.001578	2896.8		6179.58	14.42	6194	155562.8	1010.59		211.95	1222.54
229550.8		156.29	164.51		164.61	0.000515	5649.04	0	5560.77	633.22	6194	244998.4	984.51	1.64	1468.44	2454.59
227303.2		156.49	163.14		163.29	0.000698	4508.58	13.21	5744.86	435.93	6194	217503.1	848.52	119.35	1383.23	2351.1
225840.6		156.02	162.26		162.36	0.000563	5511.96	82.43	5802.98	308.59	6194	244600.1	1285.45	403.78	1051.31	2740.54
222356.7		153.85	160.6		160.64	0.000422	10836.64	672.02	4205.38	1316.6	6194	204731.8	1451.55	1529.45	3074.11	6055.11
220268.5		152.84	159.58		159.69	0.000528	4729.88	6.02	6038.91	149.07	6194	262791.8	1138.75	162.87	633.49	1935.12
219156.5		150.72	158.77		158.93	0.000856	4751.39	55.91	5704.52	433.57	6194	195024.8	905.44	322	1401.56	2629
217249.8		150.31	158.15	154.31	158.2	0.000204	8237.87	1043.28	5056.75	93.97	6194	353771.5	973.15	997.65	243.89	2214.69
216016		150.31	157.53	155.97	157.69	0.00108	4071.07	132.33	5529.15	532.52	6194	168208.3	985.51	530.65	204.27	1720.43
209227.8	Confluencia Rio La Miel	146.36	154.74		154.8	0.000247	7553.19	13.58	7242.72	242.69	7499	460561.3	1479.9	193.28	762.53	2435.7
206080.4		144.52	153.55		153.73	0.000488	4091.06		7495.3	3.7	7499	339263.9	779.46		47.11	826.56
204077.2		145.54	152.53		152.66	0.000566	4801.17	121.81	7377.19		7499	310095	1137.07	176.45		1313.51
203031.6		143.43	152.04		152.14	0.000433	8467.49	138.41	5902.37	1458.22	7499	283762	846.54	487.14	1861.28	3194.96

River Sta	Point of interest	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Discharge Area	Q Left	Q Channel	Q Right	Q Total	Conv. Chnl	Top W Chnl	Top W Left	Top W Right	Top Width
		(m)	(m)	(m)	(m)	(m/m)	(m2)	(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m)	(m)	(m)	(m)
201886.2		143.8	151.68		151.73	0.000264	10602.82	692.49	5434.09	1372.42	7499	334675.3	1363.02	1056.09	739	3158.1
199033.9		142.94	150.79		150.88	0.000339	8681.89		6224.41	1274.59	7499	338292.3	873.92		2291.05	3164.97
197918	Puerto Triunfo (a. arriba)	140.42	150.47		150.54	0.000281	7182.86		6819.08	679.92	7499	407149.7	1204.27		602.24	1806.51
196829.2	Puerto Triunfo	141.06	150.07		150.18	0.000382	5078.71	20.65	7478.35		7499	382803.1	1078.82	78.85		1157.67
189193.4		140.33	146.75		146.85	0.0005	7052.22		6366.13	1132.87	7499	284680	1031.13		1351.29	2382.42
187413.8		137.38	146.1		146.16	0.000285	7084.29		7305.46	193.54	7499	432609.2	1589.81		624.74	2214.54
184509.7		136.69	145.15		145.21	0.000373	9192.76	692.75	6286.59	519.67	7499	325440.7	1638.9	1231.13	729.51	3599.54
183516.7		135.58	144.94		144.99	0.000145	7760.99		7499		7499	622657.9	1579.18			1579.18
180940.1		134.52	144.37		144.45	0.000311	5830.85		7499		7499	424946.8	1365.44			1365.44
179714.4	Puerto Boyacá (a. arriba)	135	143.15		143.66	0.001669	2860.99	383.13	7115.87		7499	174165.4	453.17	445.73		898.91
178395.9	Est. Puerto Boyacá	134.28	142.35		142.52	0.000455	4328.83		7478.81	20.19	7499	350476.5	801.88		220.56	1022.44
177346.7	Puerto Boyacá (abajo)	131.86	141.79		142	0.000523	4187.56		7309.17	189.83	7499	319589.8	595.78		461.05	1056.83
174822.8		130.38	140.79		140.88	0.000357	6457.84	176.19	7281.27	41.54	7499	385325.3	1372.32	467.7	279.84	2119.85
173473.1		131.33	140.3		140.41	0.000348	6008.62	193.51	7305.49		7499	391864.8	1098.4	863.72		1962.12
170463.8		129.77	138.81		139	0.000643	4049.77		7447.02	51.98	7499	293637.8	813.85		349.23	1163.08
167384		128.79	137.71		137.76	0.000263	10763.69		5774.5	1844.49	7619	356333.9	1187.49		2223.18	3410.67
165967.9		125.15	137.13		137.28	0.000458	6470.18	205.91	6741.06	672.04	7619	315025	647.7	401.07	1490.13	2538.91
163410.5		127.19	135.56		135.83	0.000711	3350.53		7619		7619	285835.2	619.85			619.85
160384		127.51	134.03		134.09	0.000433	8544.71	550.55	6327.38	741.07	7619	304242.1	1570.03	767.22	796.39	3133.64
158330.8		124.95	133.1		133.18	0.000432	7648.78	676.18	6872.79	70.03	7619	330631.5	1549.04	1222.83	163.3	2935.18
152418.7		122.41	129.82		129.92	0.000737	8091.44	723.32	5609.51	1286.17	7619	206623	1115.87	695.57	1746.36	3557.81
150994.6		122.45	128.98		129.06	0.000526	10533.42	1888.79	4747.55	982.67	7619	207092.6	817.36	2109.1	1721.44	4647.9
144695.3	Est. Puerto Inmarco	113.4	126.41		126.56	0.000299	6629.03	16.37	6776.86	965.77	7759	391613.8	483.87	58.7	1124	1666.57
142676.9	la Sierra (abajo)	113.4	125.72		125.88	0.000375	6534.53	1062.99	6586.46	109.55	7759	340035.5	472.77	955.2	382.63	1810.6
138660.3		113.4	123.39	120.49	123.7	0.000859	3758.7	514.92	7244.08		7759	247218.5	508.1	343.87		851.97

River Sta	Point of interest	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Discharge Area	Q Left	Q Channel	Q Right	Q Total	Conv. Chnl	Top W Chnl	Top W Left	Top W Right	Top Width
		(m)	(m)	(m)	(m)	(m/m)	(m2)	(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m)	(m)	(m)	(m)
136269		111.22	119.41		120.27	0.002707	1901.94		7754.79	4.21	7759	149050.3	389.01		50.91	439.91
126913.7		108.64	118.59	111.19	118.62	0.000048	11266.5		7585.82	173.18	7759	1093905	1209.92		745.14	1955.06
118801.4		107.92	117.61	113.89	117.72	0.000463	7062.31	1080.24	6678.76		7759	310551.6	944.42	1350.26		2294.68
114833.6		105.74	114.43	111.99	114.76	0.001338	3027.51		7759		7759	212089.6	751.27			751.27
102455.2		102.47	111.9	107.25	111.92	0.000089	21494.04	1844.22	3819.78	2095	7759	405634.7	635.67	3261.76	1806.48	5703.9
100948.3	Est. Puerto Berrio	99.58	111.44	107.45	111.65	0.000453	3860.27	0.01	7759		7759	364680.3	608.59	0.56		609.15
96566.02		102.18	108.72		108.91	0.000932	4764.76	550.93	7207.77	0.3	7759	236057.1	1010.81	851.86	54.59	1917.27
95703.85		99.47	107.52		107.84	0.001626	3139.78		7738.21	20.79	7759	191931.2	908.47		92.47	1000.93
94132.48		99.52	106.83		106.86	0.000281	14973.72	1351.56	2541.77	3865.67	7759	151598	984.1	1494.97	1816.48	4295.55
82321.88		94.21	102.22		102.29	0.000549	9828.29	1886.97	4993.8	878.24	7759	213148.9	994.81	1884.71	896.38	3775.9
77559.26		94.58	100.53		100.57	0.000256	14259.11	232.1	3141.41	4385.48	7759	196433.6	488.1	173.64	3344.25	4006
76656.59		93.9	100.4		100.41	0.00012	20895.97	0.88	2274.38	5483.73	7759	207434	784.39	32.94	4145.5	4962.83
74660.76		91.28	100.03		100.06	0.000316	13673.46	32.32	4001.67	3725.02	7759	225194.8	1562.22	166.8	3173.71	4902.72
73056.73		89.51	99.56		99.6	0.000276	12951.36	76.83	3811.17	3871.01	7759	229511.3	871.63	490.28	2273.85	3635.75
71299.06		90.01	99.01		99.04	0.000407	10467.56	2642.59	4609.18	507.23	7759	228597.7	1785.92	1336.13	268.03	3390.08
68985.45		90.18	95.54	95.54	96.33	0.014071	2222.89	1105.12	6653.89		7759	56094.1	1110.51	442.02		1552.53
65504.13		88.76	93.84		93.84	0.000055	31080.18	1875.92	353.62	5529.45	7759	47747.7	885.7	2472.14	3194.37	6552.21
63640.95		89.26	93.65		93.66	0.000176	18996.15	5844.6	1120.5	793.9	7759	84473.3	1219.72	2584.69	1036.37	4840.77
58777.04		84.16	91.75		91.96	0.001018	5400.76		6124.37	1634.64	7759	191968	679.99		997.67	1677.65
53295.85		81.32	88.7		88.73	0.000378	15202.82	3771.27	1652.31	2335.43	7759	85018.1	264.56	1681.12	3218.12	5163.8
51746.7		84.33	88.18		88.19	0.000377	14774.53	5667.92	696.12	1394.96	7759	35870.3	555.25	1956.66	1817.48	4329.39
45114.8		76.63	86.66		86.67	0.000176	18971.46	5777.94	1488.91	492.15	7759	112103.4	698.66	3111.94	842.06	4652.65
40893.24		80.58	85.32		85.35	0.000795	11950.68	4803.53	1979.04	976.44	7759	70203.5	855.86	3314.86	901.86	5072.58
39936.88		78.06	84.99		85.01	0.000214	18661.88	5563.91	1622.17	572.92	7759	110829.6	574.42	3852.47	1267.3	5694.18
37093.16		76.47	84.4		84.42	0.000202	17881.19	4500.11	2172.08	1086.82	7759	152856.4	697.51	2750.51	1625.8	5073.82
35776.28		78.15	84.16		84.17	0.000162	24182.82	4927.17	1164.66	1667.18	7759	91613.9	720.63	4889.07	1847.06	7456.75

River Sta	Point of interest	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Discharge Area	Q Left	Q Channel	Q Right	Q Total	Conv. Chnl	Top W Chnl	Top W Left	Top W Right	Top Width
		(m)	(m)	(m)	(m)	(m/m)	(m2)	(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m)	(m)	(m)	(m)
30207.61		73.03	83.17		83.19	0.000179	18028.32	4060.63	2373.19	1325.18	7759	177336.9	680.74	2639.58	1870.07	5190.38
27775.99		76.15	82.6		82.64	0.000337	12769.75	1492.73	4363.04	1903.23	7759	237600.5	921.65	1487.48	2253.53	4662.66
26819.1		73.77	81.92		82.09	0.000901	6306.76	764.77	5458.2	1536.03	7759	181836.9	636.91	415.29	1027.94	2080.14
18991.23		73.08	79.99		80	0.000141	17549.08	355.98	3966.95	3436.07	7759	334569.8	1276.16	342.71	3876.57	5495.44
13933.59		71.63	79.04		79.07	0.000259	14655.5	41.91	3833.09	3883.99	7759	238241.7	1069.42	233.61	3700.78	5003.81
12189.53		70.33	78.5		78.53	0.000378	15008.92	3171.81	3178.87	1408.33	7759	163564	1289.82	1976.39	4398.03	7664.24
9329.346		71.07	77.14		77.17	0.000647	12662.9	3404.2	3114.16	1240.64	7759	122436.7	1103.81	2718.2	2066.63	5888.64
3829.445		65.39	76.34		76.34	0.000072	26402.16	1939.83	3478.67	2340.5	7759	410454.6	1980.57	2383.13	3256.44	7620.15
2088.404		67.02	76.03		76.08	0.000568	10002.74	1462.59	5794.8	501.61	7759	243190	2182.94	2057.03	622.45	4862.41
14.87	Cerca a Barrancabermeja	65.39	75.76	68.66	75.77	0.000063	27240.48	1406.65	2384.09	3968.26	7759	300723.5	1971.65	2310.99	2297.99	6580.63

Based on the analysis results from the hydraulic model, the conclusion is the following. In the section between Puerto Salgar and the confluence with Río La Miel River, there are sections on the left bank that assume 4% to 11% of the total discharge, although it is not constant and occurs only in some sections. On the right bank, 2% to 20% of the total discharge is concentrated; the discharge transportation is more constant than on the left bank.

Between the the Magdalena River-Rio La Miel confluence and Puerto Triunfo, the flood plain on the left bank transports an average value of 2% of the total discharge, while on the right bank there is an average value of 11%.

Between Puerto Triunfo and Puerto Boyacá, the flood plain on the left side transports 9% in one section while the flood plain on the right side transports 8% on average. It is clarified that in some sections the discharge is concentrated in the main channel.

In the section Puerto Boyacá-Puerto Inmarco (La Sierra), the left channel transports 7% of the total discharge on average, while in the right channel transports 10% of the total discharge.

In the section between Puerto Berrio and Barranca, the left margin transports 37% on average (in a range from 7% to 72% in the reaches defined between the different sections); its right margin transports 29% on average (in a range from 6% to 71% in the reaches defined between the different sections).

The proportion of the discharge the flood plain increased observably downstream of Puerto Berrio as seen in the map elaborated by IDEAM and IGAC through the interpretation of flood extension.

The next figure intends to summarize the flow capacity of Magdalena River channel between Puerto Salgar and Barrancabermeja and its flood zone.

The blue line represents the main channel's flow capacity (without the flood plain), and in it the capacity of the main channel is observed to increase downstream of Río La Miel up to the confluence of Río Nare over 4,000 m^3/s. However, change in the river's cross-section causes the capacity to decrease downstream up to Barrancabermeja. Supposing that the water does not flow outside the main channel section, which is not necessarily true since it is not easy to establish connectivity with lateral areas that are lower than the river bed according to the digital model. However, this assumption will be used for this section for the purpose of exercise.

The red line represents the maximum discharge during La Niña phenomenon in 2011, adopting discharges registered in some stations on the Magdalena River and its main tributaries as described at the beginning of this chapter.

The orange line represents the proportion of the discharge that flows through the main channel in the simulation carried out by the model constructed with the composed sections.

The following can be concluded from the results despite the uncertainty generated by the inaccuracy of the available sections.

The main channel of Magdalena River between Puerto Salgar s well as the confluence with Río Negro can transport nearly 1,260 m^3/s without interacting with surrounding low areas. The river, however, can transport between 4,000 and 6,000 m^3/s in this section if close flooding zones and bodies of water are included.

The Magdalena River between Río Negro as well as the confluence of Río Nare can transport almost 4,000 m^3/s in its main channel; most of the section can transport a little more, except for some sections that have less capacity and that allow a connection with low surrounding zones. In this section, the river can transport between 4,000 and 7,400 m^3/s, flooding low surrounding area that belong to its flood plain.

Finally, the section between the confluence of Río Nare and Barrancabermeja becomes wider and presents less capacity in the main channel, which is highly changeable upon observing the River configuration in this section Even though it was supposed that the discharge concentrates in the main channel for this exercise, a capacity of 3,400 m^3/s is obtained assuming that there is not any connection with the surrounding low zones in the cross-sections. The simulation carried out with the flood plain shows points with capacities lower than 1,000 m^3/s exist, although the capacity of the main channel can exceed 2,000 m^3/s in general, with the exception of some sections. The simulation result indicates that flooding zones around the main channel can allow for the transportation of up to 7,700 m^3/s, considering possible damages to productive areas that are within the flooding areas.

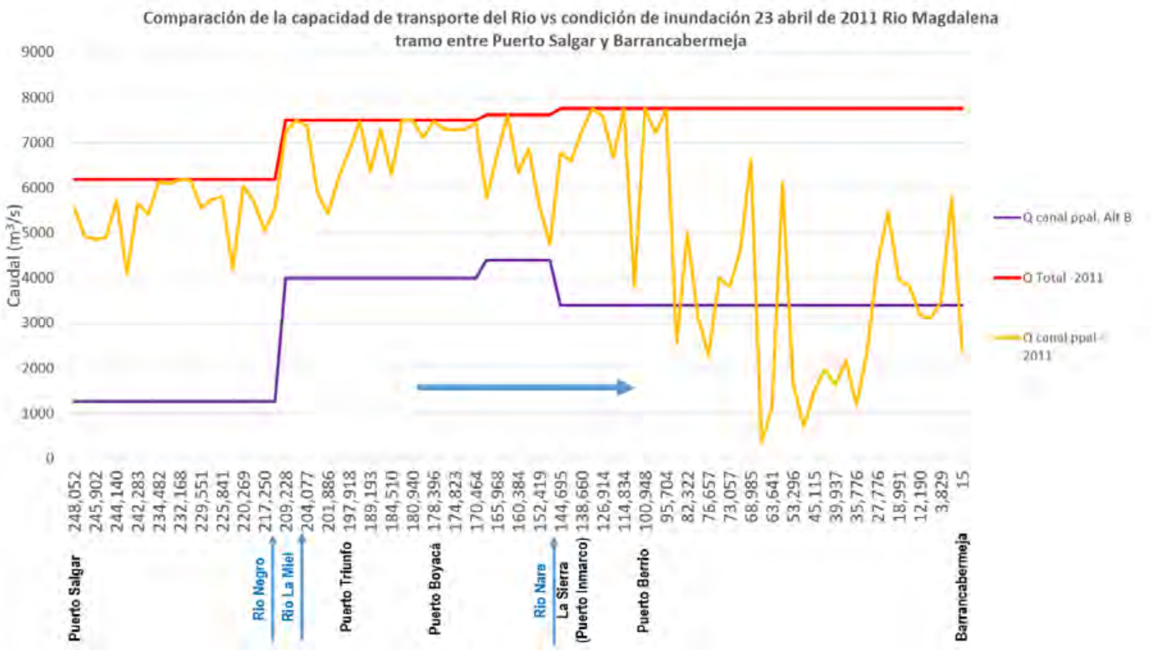


Figure 4.1.14 Comparison of the Flow Capacity of the Main Channel and Discharges during the 2011 Flood (April 23rd)

(6) Future and Current Challenges

- The results in the section of Puerto Salgar- Barrancabermeja are acceptable considering that the composed sections were constructed using a 30m elevation model, but inputs with better accuracy would allow for improved results.
- It is necessary to verify the zero gage data in Puerto Inmarco, although they can currently be linked to Marga Sirgas. For the simulated period, the data referenced to the zero gage do not correspond to the simulation or the bathymetry.
- It was possible to obtain an assessment of the discharge conditions (applicability of the H-Q curve: verification with K conveyance) that shows the heterogeneous transport capacity of the main channel in the analyzed section, therefore the permanent interaction with the flooding zones even for the mean discharges.
- Even though the results are acceptable, the estimation of the proportion of the flood that flows through the floodplains in zones where the elevation model is currently not so accurate and can be improved, if elevation models or information that is more accurate is obtained.
- It is necessary to define the flood areas that interact with the river frequently more accurately, even for intermediate conditions of the river in certain months.
- Creating more complex representations should be considered as an option in order to understand the modification of the outline of the river, since the changes in the river are valuable when trying to represent the transport capacity of the main channel.

4.2 Use and management of Magdalena River (Outcome of this project)

(1) Magdalena River Management

Under the Constitution, CORMAGDALENA manages the Magdalena River.

The main approaches in this administration are "navigation", "port activity", "land management and conservation", "energy generation and distribution" and "sustainable use and preservation of the environment".

http://dc02eja.cormagdalena.gov.co/index.php?idcategoria=50

Article 5 of the Law 161 of 1994 stipulates that CORMAGDALENA has functions of "preparing, adopting, coordinating, and promoting the execution of a general plan for the development of its objectives in accordance with the National Development Plan".

CORMAGDALENA should promote the execution, execute, directly or in association with other public and private entities, projects of land adaptation, drainage and flood control, operate and administer such projects or grant them and delegate their administration and operation to other public or private entities", and here, we see an aspect of the entity as a river administrator. Specifically, it should advise on the activities that influence the hydrological condition of the basin carried out by all public and private entities, articulate them and coordinate them.

(2) Navigation

① History of Navigation

The history of navigation on the Magdalena River is ancient, and in pre-Columbian times the indigenous population used the canoe to navigate midstream and downstream. Between 1500 and 1820 (the colonial period), the indigenous people, Spaniards and Creoles practiced navigation in the upstream, midstream and downstream sections, with a cargo capacity of 15-20 tons as a result of improvements on the boats.

Between the 1870 and 1960, national and international entrepreneurs navigated the upstream, midstream and downstream sections by steamships, with an increase in the carrying capacity. Between 1948 and 1991, navigation to transport hydrocarbons prospered, and the load capacity increased approximately up to 1,500,000 tons; however, road construction advanced, and navigation was limited to the midstream and downstream sections.

Currently, the navigable channel of the Magdalena River is 1300km (from Neiva to the Atlantic Ocean). This can be divided into three sections: upstream, midstream and downstream section. The 631km-long downstream section from Barrancabermeja to Barranquilla has the largest volume of navigation, and its depth is 2.1m throughout the year (with 90% reliability). The average stretch of 256km from Puerto Salgar to Barrancabermeja has a depth of 1.35m (with 90% reliability, 1.8m in rainy season), and seasonal navigation is possible. A dredging work is currently underway, and the depth will be 2.1m after the completion of the work. In the 413km-long upstream section from Neiva to Puerto Salgar has a depth of less than 0.9m, and only passenger ships and small boats can advance.

Currently in Colombia, the roads occupy 73% of the means of transportation, the railroad occupies 26%, and the navigation occupies only 1%. In 2014, the Magdalena River had the transport capacity of 530,000,000 tons per year.

http://www.eltiempo.com/contenido-comercial/especiales-comerciales/navegabilidad-del-rio-magdalena/16298598

② Work Plan to Ensure Navigability

Dredging is planned to ensure the navigability of the Magdalena River in the 886km-long section between Puerto Salgar and Cartagena-Barranquilla. The target area of the work and the planned depth are divided into 4 sections as shown (the image below).

In order to achieve these objectives, necessary dredging works will be carried out as follows:

- Cartagena ~ Calamar K90 (Including Canal del Dique): dredging of 1,200,000m^3 (approximate budget- 12,000,000,000 pesos)
- Barranquilla ~ Calamar K90: dredging of 450,000 m^3 (approximate budget- 12,700,000,000 pesos)
- Calamar ~ Barrancabermeja: dredging of 20,000,000,000 m^3 (approximate budget- 45,000,000,000 pesos)
- Barrancabermeja ~ Puerto Salgar: dredging of 1,550,000 m^3 (approximate budget - 10,000,000,000 pesos).

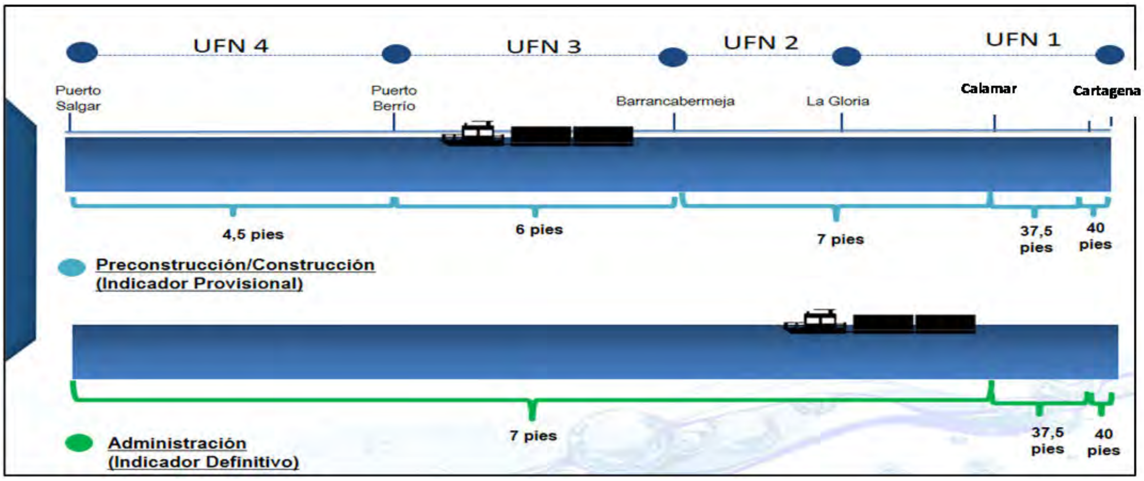


Figure 4.2.1 Dredging Plan for the Navigability of the Magdalena River

③ Relationship between the Flood Countermeasures and Navigation Plan

To maintain the depth obtained by dredging, it is necessary to prevent the accumulation of sediments on a daily basis. This is achieved by defining a narrow navigable channel within the main channel, so that the water flow normally concentrates in the main channel, increasing its capacity to remove the sediments.

CORMAGDALENA plans to construct ”horizontal dikes” as shown in the figure below as a structural measure for this purpose.

Looking at the presentation materials, this structure is similar to the one that exists in Shingen Tsutsumi of the Kamanashi River. However, this appears to be low, and the upper edge remains above the surface of water under normal conditions. The horizontal dikes have a discontinuous structure, which could disperse the flood energy by allowing the water to flood through the slit between dikes. In addition, it could prevent the floodwater from flowing to downstream in one sitting and has an effect of allowing the water to flow gradually.

It seems they have not yet been installed; however, it will be necessary to study the impact of these structures on the downstream in the future, when the study of measures against flooding advances.

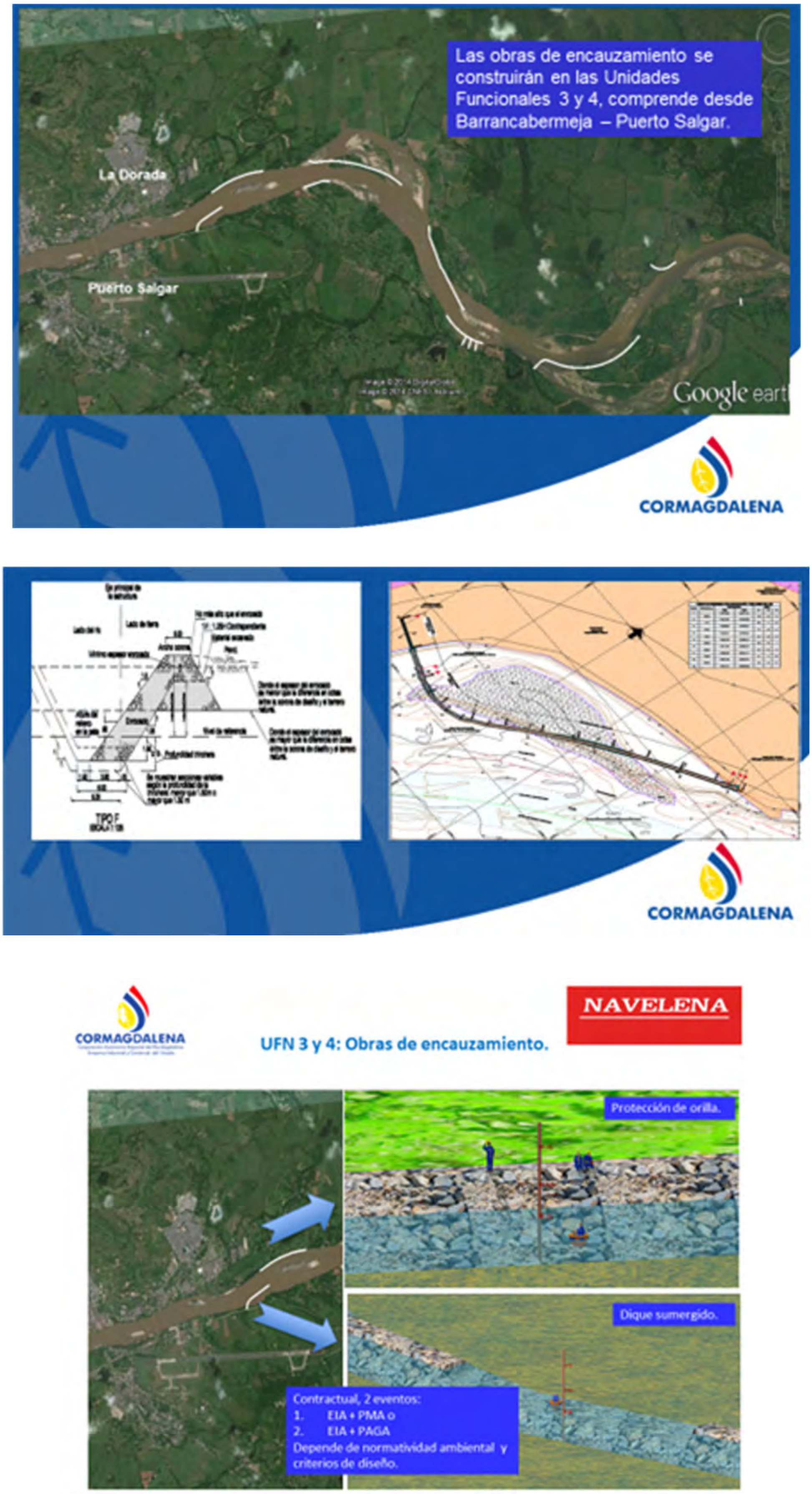


Figure 4.2.2 Conceptual drawing of horizontal dikes

(3) Hydropower generation (Master Plan)

The hydroelectric generation plants on the Magdalena River are currently located in Betania and El Quimbo (Department of Huila). Betania has an area of 7,400ha, a total capacity of $1{,}970 \times 10^6 m^3$, and a usable capacity of $1{,}042 \times 10^6 m^3$.

https://es.wikipedia.org/wiki/R%C3%ADo_Magdalena#Navegaci.C3.B3n

El Quimbo has an area of 8,250ha and total capacity of $1{,}824 \times 10^6 m^3$.

https://en.wikipedia.org/wiki/El_Quimbo_Dam

※The M/P does not mention the effects of hydropower plants construction on flood control. The power plants constructed are not multipurpose, and their main objective is to create energy even though Betania currently has great-scale agriculture activities.

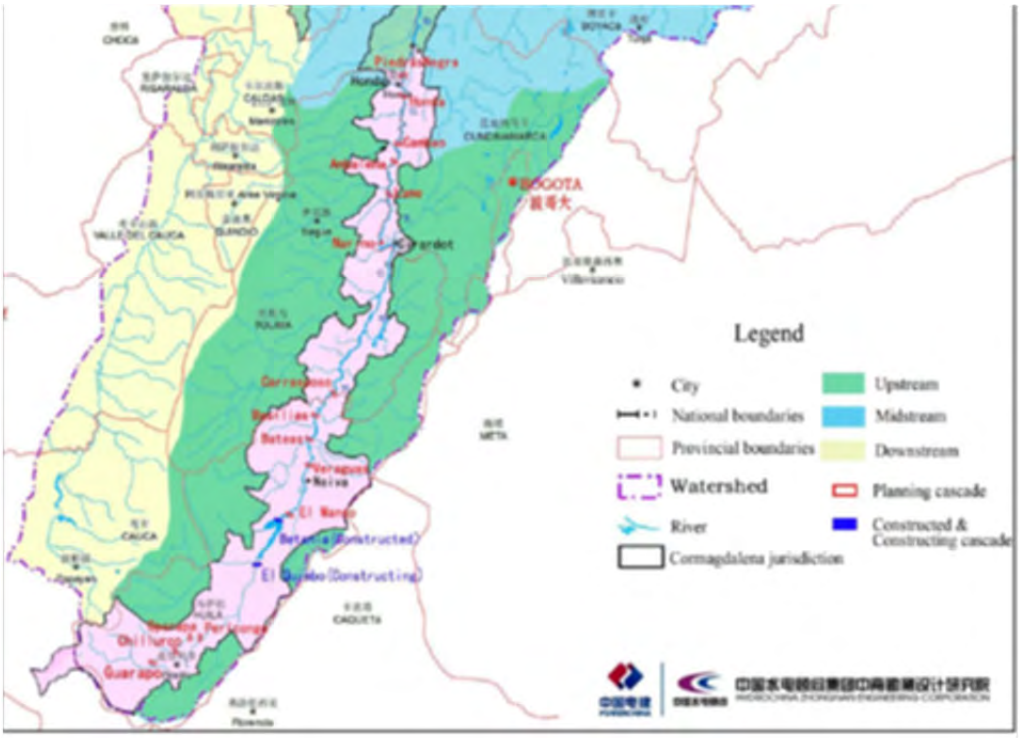


Figure 4.2.3 Geographic Positions of Dam Site of Cascade Plan Options

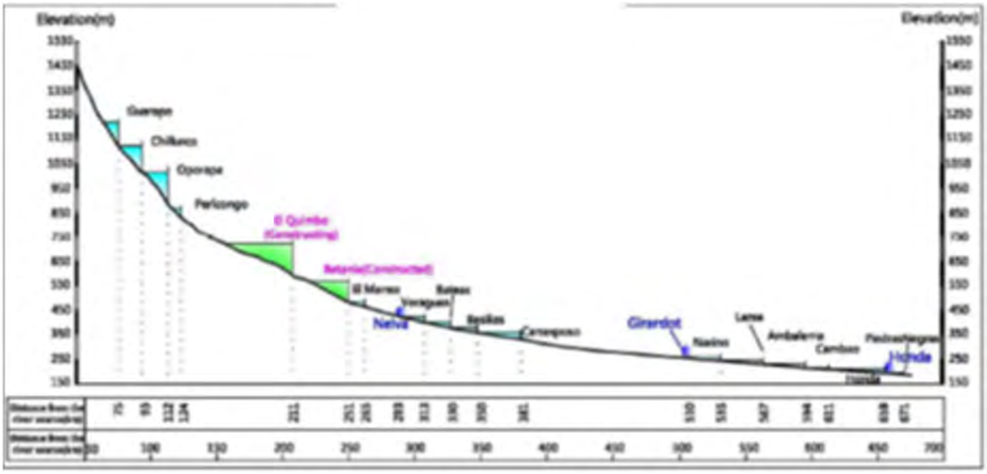


Figure 4.2.4 Longitudinal Section of Planned Cascades on the Main Stream of the Magdalena River

5. Study on Countermeasure Works for Flood Damages Reduction

5.1 Countermeasures introduced in the Master Plan (Master Plan)

In the M/P, the following general description of flood damage mitigation measures can be found, mainly referring to structural countermeasures.

(1) Flood Control with Dams

There is a mention of the dam plan developed by Holland in the 1970s. At that time, there was a plan to build a set of dams that included Betania, Holanda, Palmalarga, Sogamoso, and Caucamedio.

The catchment area was equivalent of 45% of the total area of the Magdalena River, and the total capacity of 48,000,000,000m³ was projected. The main objective was hydroelectric generation; however, in case of considering the use of this set of dams for flood control, it would be 19,000,000,000m^3, and for floods of the return period (W) = 1/4～1/20, the calculation indicates it would reduce 4% of the total flood volume and 5% of the peak flood discharge.

The M/ P mentions the need for a detailed study on the capacity of flood control by dams.

(2) Flood Retention with Swamps and Wetlands

The swamps and wetlands around the Magdalena River as well as the dams retain the flood slow the runoff to the main channel and reduce the discharge, contributing to the reduction of flood damage.

Approximately 68% of Colombian natural wetlands are located in the Magdalena River basin. These swamps and wetlands serve as a natural buffer between the developed areas and the river.

As swamps and wetlands in the Magdalena River basin play a more important role than existing artificial dams in terms of flood retention. Their natural conservation is one of the feasible measures both from the environmental and economic points of view.

※ Among flood mitigation measures included in the M/P, flood retention with swamps and wetlands is a feasible and effective option. For this, a conservation measure that includes these swamps and wetlands is indispensable. Although there is no specific mention in the M/ P, concrete discussions were carried out with the C/Ps, including the Ministry of the Environment and other relevant entities such as CIRMAG in this project. CORMAGDALENA has formulated a Restauration Plan for the wetlands and swamps, which includes their importance as a regulation mechanism among other criteria. The execution of this plan is carried out with local and environmental authorities.

⇒ Refer to Ronda on the next page.

(3) Dikes

Protection against floods with dikes is the most direct countermeasure, with which the target city can be protected directly against flooding. Therefore, dikes are considered to be an effective and viable measure. Especially in the downstream basin where the number of residents exceeds 900,000, it is inevitable to depend on the direct protection offered by dikes and the retention of flood with swamps and wetlands for the reduction of flood damages.

By the end of 2004, 125 dikes were built along the Magdalena River
.... Due to the lack of the IFMP-RP, it is assumed that these dikes are structures installed according to the local criterion at each point.

In the M/ P, 17 locations below are described as proposed locations for the construction of new dikes. Their objective is "flood prevention and damage reduction in urban areas" as well as leisure and recreation. Therefore, the Plan proposes to "use several types of dikes".

※ In this project, countermeasures with flood-dikes are considered to be effective and feasible as an option for "local protection". It should be mentioned that most of these locations proposed in the M/ P coincide with the places that suffered flood damage identified in the workshop in this project.

Table 5.1.1 Suggested Areas for Dike Construction【M/P】

S/N	City/Town	Project Overview	Investment (billion peso)
1	Pinillos	1. Build a new 1281m-long dike with local materials. 2. Build 7 spur dikes with local materials so as to control the deposit situation along the banks.	0.723
2	Magangue	1. Barrio Samarkanda District: build a new1435m-long dike with imported materials and protect the slopes with cobbles; build two pumping stations; build an 80m-long plain concrete flood wall and a 70m-long reinforced concrete wall for revetment. 2. Flood dike in the southern part: build a 620m-long reinforced concrete flood wall and use imported materials to reinforce the existing slopes from K1+360 to K1+980. Use soft cobbles to pave a 620m-long slope protection zone. 3. Chorro District: use 300 m³ of gravel to pave aslope protection zone.	8.458
3	Puerto Wilches	1. Guayabo Town: build a 300m-long concrete slope protection works along the river bank and build a 3600m-long flood control dike between Guayabo Town and the drainage channel. Build cofferdams for the existing drainage channel to enable geotextile to be used to build a new 300m-long dike for the overflow channel. 2. Carpintero Town: build a new 3,323m-long flood-control dike with local materials.3. Downtown of Puerto Wilches: add reinforced concrete wallboards to the existing flood walls and heighten some parts of the walls along the reaches. Build a 595m-long ordinary concrete flood wall. 3. Bucarelia: use imported materials to reinforce the 8640m-long flood control dike at the south side between the quarry and the causeway; build a new 122m-long flood control dike.	7.740

4	Calamar	1. Barranca Vieja: reinforce and rebuild the existing dikes and heighten them to 10.25 m, totally 1800m-long. Build new umping stations. 2. Downtown of Sleep: build a new 280m-long flood wall with a height of 1.5 m to 1.8 m. Reinforce and rebuild the existing dikes and heighten them to 9.55 m, totally 240m-long. 3. Brisas District: Build a 700m-long ordinary concrete flood wall with a height of 1.5 m to 1.8 m. Reinforce and rebuild the existing dikes and heighten them to 9.8 m, totally 380m-long.	2.540
5	Río Viejo	1. Victoria drainage channel: build a 130m-long flood dike for the rainage channel with imported materials. This dike will be connected with the existing flood dike. Reinforce the existing facilities and lay short-stalk straw on the surface. The length of reinforcement works is 270 m. 2. Flood dike for the ferry dock from Victoria to Rio Viejo: build a 400m-long flood dike with imported materials.	7.055
6	La Gloria	1. River banks in downtown: build a 915m-long ordinary concrete flood wall as per the designed elevation. Reinforce the 72m-long flood walls and heighten the existing facilities to the new design elevation. 2. Palomar river banks: extend the existing drainage channels with imported materials, totally 1750m-long. Heighten them to the new design elevation and lay short-stalk straw on their surfaces. 3. Marquetalia river banks: extend the existing discharge channels with local materials, totally 726.9m-long. Heighten them to the new design elevation and lay short-stalk straw on their surfaces.	3.132
7	Regidor	1. Downtown of Regidor: build a 220m-long erosion control structure, build a new 700m-long flood dike with imported materials and build a 200m-long approach dike at the electric gate. 2. Flood dikes in areas between Regidor and Victoria: build flood dikes with imported materials, totally 2,300 m long.	3.602
8	Guamal	1. Puerto Rangel: reinforce the existing flood dikes, totally 2,800m-long. 2. Flood control works in the residential area of uerto Rangel : set timber piles and pave gravel on the 428m-long channel slopes	2.850
9	El Banco	1. Cerrito Town: reinforce the 75m-long shear wall and the existing 760 m-long reinforced concrete wall. Use local materials to build a 460m-long new flood dike. 2. Mata de Cana: reinforce the 800m-long flood dike with screened imported materials and build a new 1,100m-long flood dike with local materials.	2.291
10	Plato	1. Waterway between the sluice and Camargo: build a new 107.7m-long ordinary concrete flood wall and reinforce the flood walls on the slopes. Chalupas Port: build a new 130m-long flood dike with imported materials. Reinforce the flood dike of the Chalupas Port to achieve a crest width of 7 m and a length of 118 m. In addition, build rigid pavement, platforms and stairs on the reinforced flood dikes and build pumping trenches and electric pump stations in the reinforced structures. 2. River channel from Camargo to the police station: build a new 100m-long flood dike with imported materials and build a 94m-long protective belt with timber piles. 3. The river channel between the police station and the original ECP	4.605

		station: reinforce the 1316.44m-long flood dike with imported materials. Reinforce the flood dike near the police station that is vulnerable to floods by installing 10m-high timber piles and reinforcing the 67m-long protective belt. 4. Pekin: build a new 120m-long drainage channel. 5. Iguanera: build a new 140m-long drainage channel. 6. San Rafael : reinforce the 260m-long flood dike with imported materials and build a new 110m-long concrete pipeline and a rain water pumping system.	
11	El Piñón	1. Build a new 2,140m-long flood dike with imported materials along the river channel in the north east part of the downtown. 2. Build a new 500m-long flood dike with imported aterials along the river channel in the northern part of the downtown to connect Salamina. 3. Build a new 2,440m-long flood dike in the southern part of the downtown.	3.244
12	Remolino	1. Downtown: reinforce the flood dike along the river channel in the south which stretches to the Salamina City and the length for reinforcement is 1,450 m. 2. Build a new 900m-long flood dike with imported aterials. 3. Build a 9km-long flood dike from the downtown to Renegado with imported materials.	4.590
13	Tamalameque	1. Reinforce the flood dike from the suburb of Alegre to Jobo District, totally 5,600m-long.	3.030
14	Yondo	1. Casabe Port and Tomas Port areas: build a new 860m-long flood dike with imported materials. Install gates to control discharge volume and build drainage channels. 2. San Luis: protect the river banks with gabions. Build a flood dike on the top the slope protection structure. Build drainage ditches in the surrounding area to control the drainage of rain water. Build concrete docks at the portals of the communities along the banks. 3. Casabe Port and Mangos Port areas: build a 1,060m-long flood dike with imported materials. Reinforce the existing flood dikes with local materials, totally 315m-long. Build an approach dike with local materials, totally 377m-long. Build sluices to control the discharge volume.	3.610
15	Ponedera	The Plazitas - Uvero river channel 1. Reinforce the flood control works of the river channel between k2+800 and k4+268 with imported materials. 2. Build two new box culverts and provide gates for them.	2.435
16	Peñón	1. Build a new flood dike between Humareda and Totumos and reinforce the existing flood dikes. 2. Último Caso: build a 320m-long flood dike with local materials and reinforce the flood dike between Peñón and Humareda, totally 1,500m-long.	2.913
17	Barrancabermeja	San Rafael Town: build a new 150m-long slope protection structure. Set timber piles along the 150m-long river bank and pave a 120m-long gravel layer to reinforce the slope protection structure. Pave a 150m-long gravel layer to strengthen the river dike. Install a gabion structure of 855 m^3 along the slopes and pave 1183 m^3 of cobble stone to protect the slopes. Build a 110m-long ordinary concrete flood wall.	0.782

5.2 Conservation Measures for Swamps and Wetlands (Outcome of this Project)

(1) Current regulations: Ronda Hidrica

As described in the section 1.3, in Colombia there is a decree that regulates the administration of areas surrounding the river (Ronda Hidrica):

Decree 2811 1974 Article 83 D: Except for rights acquired by individuals, the following areas are inalienable and imprescriptible goods of the State: d) a strip parallel to the line of maximum tides or to the permanent channel of rivers and lakes, up to thirty-meters wide.

Ronda Hidrica was defined in this way and is understood as an area that consists of the "normal width of the river + 30m", where activities such as urban development and construction among others are regulated. This concept is the basis of river management related to floods.

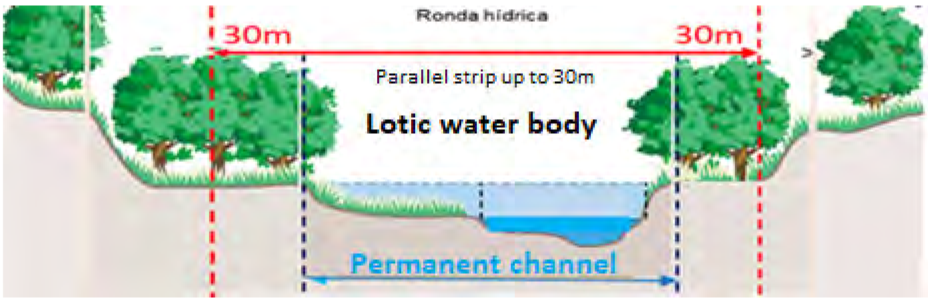


Figure 5.2.1 Ronda Hidrica

① Objective of the Decree (without considering the Floods), Prohibited Activities within 30m

DECREE 2811 OF DECEMBER 18, 1974 is called the National Code of Renewable Natural Resources and Protection of the Environment, and its objective is the protection of the environment, since Article 1 stipulates that "The environment is a common heritage.

The term "flood" appears once in Article 306; however, it was noted that it was not intended for the use in the context of flood control measures.

Article 306: In case of fire, flood, pollution or other similar events that threaten to harm the natural resources or the environment, necessary measures will be taken to avoid, contain or repress the damage, which will last for the duration of the danger.

② Definition of 30m

It is also mentioned that the area of 30m wide is public land in Article 83 D.

Decree 2811 of 1974 Article 83 D: Except for rights acquired by individuals, the following areas are inalienable and imprescriptible goods of the State: d) a strip parallel to the line of maximum tides or to the permanent channel of rivers and lakes, up to thirty-meters wide.

In this section, there is no explanation of the maximum water level in the 30m section, and in the Article 11 of Decree 1541 of 1978, the definition of the natural channel was added as "its maximum levels as a result of ordinary floods.

It should be mentioned that there is no definition of "ordinary floods".

③ Activities Forbidden within the 30m

> Article 86: Everyone has the right to use waters of public domain to meet his basic needs, those of his family and those of his animals, provided that this does not cause harm to third parties. The use must be without derivations or machinery or apparatus, it may not stop or divert the course of the waters, deteriorate the channel or the margins of the stream, or alter or pollute waters in such a way that their use by third parties is rendered impossible.
>
> … After a while, the prohibition on urban development and construction was added.

Here, the following concept established in the Decree 2811 of 1974 applies more: Article 204 "The forest protective area is understood as the zone that must be preserved permanently with natural or artificial forest, to protect these resources or other natural renewable resources. The protective effect must prevail the in the protective forest area, only the harvest of secondary products from the forest will be permitted."

As there are no real examples of restrictions on construction and development within the 30m strip on the Magdalena River, we will present an example from Bogotá.
http://ambientebogota.gov.co/normatividad2

> Agreement 6 of 1990, Mayor's Office of Bogota-Bogotá Council
>
> The Ronda Hidrica is defined as "the area of non-buildable ecological reserve for public use, consisting of a strip parallel to of the edge of the Permanent channel of rivers, reservoirs, lagoons, ravines and canals, up to 30 meters wide, side-to-side. This includes flooded areas for the passage of non-ordinary floods and those necessary for rectification, buffering, protection and ecological balance, which cannot be used for purposes other than those indicated, either urban development or road constructions.

The Article 78 from the District Decree 190 of 2004 defines Ronda Hidrica and Zone for Preservation and Environmental Management in the following terms:

"Ronda Hidrica: environmental and hydraulic protection zone for public use where construction is prohibited. It is constituted by a parallel strip or a strip around water bodies, measured from the high tide line (maximum flood) up to 30 m in width, mainly for the hydraulic management and ecological restoration."

"Zone for Preservation and Environmental Management" is the strip of land from public or private property next to the Ronda Hidrica, mainly to promote a proper transition from the constructed city to the ecological structure and the construction of infrastructure for the public use linked to the defense and control of the hydric system.

Such definitions correspond to the established definitions in the Article 206 from the Law 1450 of 2011(Ronda Hidrica = Fringe up to 30m from the permanent riverbed + the surrounding conservation and protection area).

④ Who delimits Ronda Hidrica

Article 206 of Law 1450 of 2011 The law gives CAR the authority to delimit Ronda Hidrica (area)

⑤ Sanctions

Article 104 of Law 388 of 1997 Fines will be applied to those who parcel, urbanize or construct in environmental protection zones such as the Ronda (=30m).

This is the summary of Ronda Hidrica.

(2) Problems in the Management of Floodplains

For flood control of a rather wide river that has large flood plains without dikes such as the Magdalena River, one of the feasible measures is to retain flooding on floodplains and reduce flood damage.

For this purpose, "floodplain management = land use restrictions" is quite important. This point has been confirmed both in the M/P and in the workshops carried out in this project.

As a legal basis for this, the interpretation of the Ronda Hidrica based on Decree 2811 is important.

Real situations were also confirmed in the field study, and the following concerns were expressed:

- For his concept, the definition of "natural channel + 30m" is not appropriate for a river that has a great width of the channel and the flood such as the Magdalena River.
- Although it is assumed that the area of normal channel width + 30m should be under the jurisdiction of CORMAGDALENA, there are several restrictions upon administering it in reality.

Taking the above into account,

…The big challenge is to review the Ronda Hidrica from a flood protection point of view

……This includes the revision of the 30m delimitation of the Ronda as an observation from the actual administrator.

(3) New Efforts

According to the Ministry of the Environment, progress is being made in the review of the Ronda Hidrica, taking the experiences of the 2010-2011 floods into account.

The key points of this process are:

- The Ronda Hidrica will be delimited from the hydrological (flooding), ecosystemic and geomorphological points of view,
- The Ronda Hidrica will be defined using the surrounding line of the three elements described above.
- The zone between the previous Ronda Hidrica and the new Ronda will remain a conservation area.
- The hydrological point of view (floods) takes the flood of the return period of 25 years into account (calculation in progress).

Legalization process is in progress. The image summarizing these concepts is shown below:

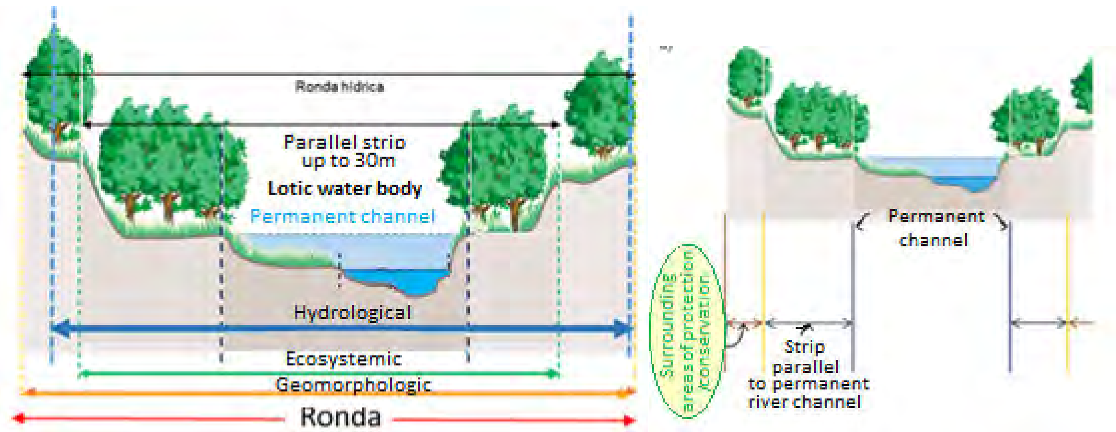


Figure 5.2.2 Ronda Hidrica taking 3 Elements into Account / Definition of the Conservation Zone

In the figure on the right, there is an example of Puerto Wilches created by MADS.

It is important to mention that the ecosystemic analysis (riparian vegetation) was not carried out in this example because it is included in the geomorphological-hydrological analysis. Such analysis will be carried out after the implementation of environmental management measures (in this particular case)

Red : Surrounding line : Ronda Hidrica (new)

Green : Hydrological (flood) area, according to the flood area with 25 years Return period

Blue : Ecosystemic area (permanent channel)

Purple : Geomorphological area

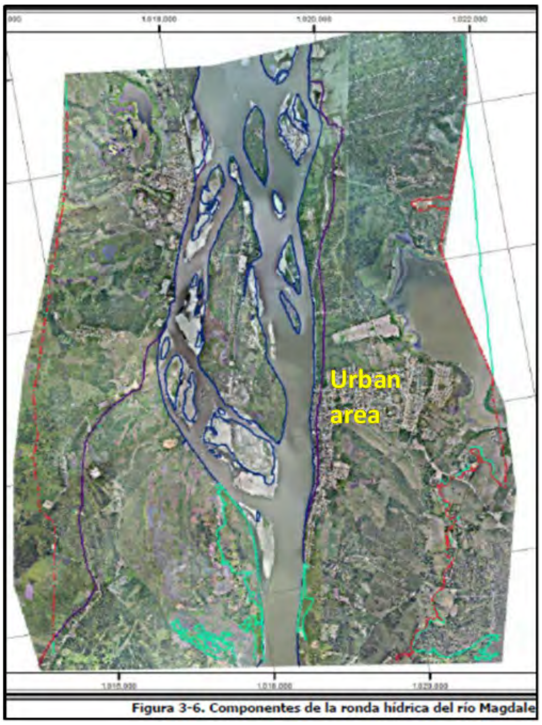


Figure 5.2.3 An example of a Ronda Hidrica Delimitation (new) in Pto.Wilches

(4) Additional Efforts

In the discussion with the C/Ps, mutual understanding was achieved regarding the management of floodplains in order to reduce flood damage.

However, in the opinion of some, legal regulations are not enough to create effective floodplains management measures.

Specifically, the following ideas that incorporate economic incentives were proposed (Mr. Cesar Garay, CIRMAG).

- Subsidy system for farmers on floodplains
- Introduction of flood insurance

The following ideas and opinions were expressed:

Expected measures (ideas) …Introduction of economic incentives

a. Forbidden or Restricted Activities
   - Construction of houses
   - Cancelation of agricultural subsidy
   - Prohibition of activities that impede the flow of flood: sanctions and fines

b. Incentives

- Subsidy for houses and crops resettlement
- Subsidy for flood proof constructions

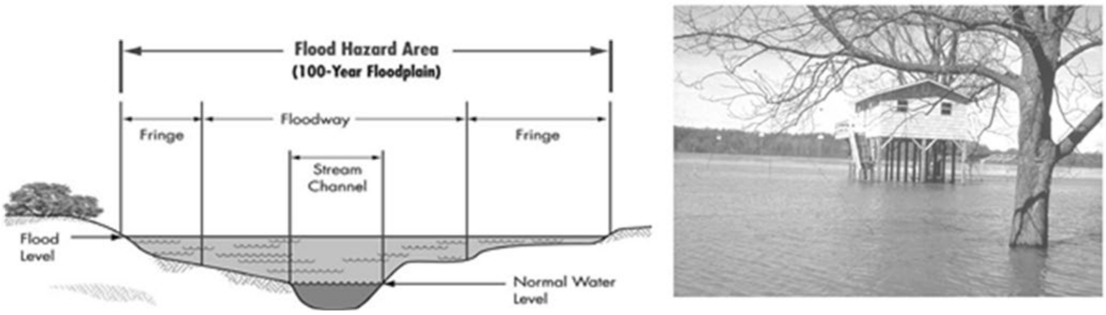


Figure 5.2.4 Flood Hazard area in the Flood Insurance System in the USA (Left), Small constructions Allowed in the Insurance System (Right)

As for the introduction of incentives, this is outside the scope of this project, and no conclusion will be made. However, it is considered to be an important issue for the management of large rivers such as the Magdalena River.

The exchange of information on the National Flood Insurance Program (NFIP) with the example of the Mississippi River, which has a relatively similar administration, will especially be useful for river management onwards. Therefore, continuous investigation will be expected in the future.

Appendix-7 Road Map for Formulation of IFMP-RP (principal plan) for Magdalena River

Road Map for the formulation of IFMP-RP for Magdalena River

Leading entity : MADS, CORMAGDALENA and IDEAM

Supporting entities: UNGRD, DNP, CAR (Cundinamarca) and Department of Cundinamarca (and National University)

No.	Necessary Activity	No.	Secondary Activity	Explanation/Comments	2018	2019	2020	2021	2022	2023	Main Responsilble entity(entities)
0	Development of framework among main entities in order to formulate and implement this plan	0		Need to gather all related organizations							
1.1	Review of the existing national regulations and planning tools	1.1.1	Identification of the topics related to the Magdalena River basin in the national development plan								DNP
		1.1.2	Identification of the topics related to the Magdalena River basin in the current regulations								MADS
		1.1.3	Evaluation of the scope of the flood component in planning tools (Macro-Basin Strategic Plan, River Ordination and Integrated Management Plan, Basin Management Plan, Master Plan by CORMAGDALENA, Coastal Environmental Unit Plan (UAC),Municipalities and Departmental Risk Plans, among others)								All
		1.1.4	Revision of existing regulation and formulation of a proposal to correct loopholes and improve institutional coordination	This activity will be carried out based on activities of 1.1.1 to 1.1.3.							CORMAGDALENA, MADS, IDEAM
1.2	Review of previous technical studies	1.2.1	Analysis of available information	Gather existing information at various levels from relevant organizations as well as related materials produced by the academy, research centers and institutions.							All
		1.2.2	Definition of mechanism for sharing available information	Gathered information will be carefully reviewed and shared among entities to use in next activities							MADS, IDEAM
		1.2.3	Make an inventory of historical extreme hydroclimatic events and historical disaster events								UNGRD, IDEAM
		1.2.4	Create an inventory of information (documents and maps) with their original metadata and wih the possibility of feeding official data bases								MADS
2	Definition of the scope of the IFMP-RP for Magdalena River	2.1	Definition of the objective and expected outcomes of IFMP-RP	To study and clarify what we want to achieve. A possible objective: "Main target is flood, but water related issues such as drought and etc. are also partially included. Upper, middle, lower basin will be investigated separately and in an integrated manner. River flood influenced by marine conditions such as high tide will be also included."							All
3	Analysis of use and impact on the river dynamics from sectors	3.1	Analysis of navigation and transportation								CORMAGDALENA, MADS, IDEAM, DNP
		3.2	Analysis of hydropower generation								CORMAGDALENA, MADS, IDEAM
		3.3	Analysis of the environment and environmental services								CORMAGDALENA, MADS, IDEAM, DNP
		3.4	Analysis of the agriculture sector								CORMAGDALENA, MADS, IDEAM
		3.5	Analysis of other sectors								CORMAGDALENA, MADS, IDEAM, DNP
4	Characterization of the flood in the Magdalena River basin and definition of the flood sector	4.1	General characterization of the flood phenomenon in the main river (and floodplains)	*Organization of flood patterns/mechanisms *Organization of river profile and topographic characteristics *Organization of hydraulic an hydrological characteristics *Organization of geomorphological characteristics and river dynamics *Organization of the inventory of mitigation and regulation structures							IDEAM, CORMAGDALENA
		4.2	General characterization of the tributary basins	*Organization of flood patterns/mechanisms *Organization of river profile and topographic characteristics *Organization of hydraulic an hydrological characteristics *Organization of geomorphological characteristics and river dynamics *Organization of the inventory of mitigation and regulation structures							IDEAM, CORMAGDALENA
		4.3	Identification of benefits and damages from the flood in the main river and tributaries	Consult river-related NGOs, University of Magdalena, University of Atlantico, technical studies for the construction of works by CORMAGDALENA, WWF, AFD							All
		4.4	Definition of "flood risk" for Magdalena River Basin								MADS
		4.5	Identification and characterization of exposed elements	The scale will be defined depending on the prioritization and the scope of the project							UNGRD
		4.6	Analysis and identification of the relationship between flood and each economic sector								MADS and DNP
		4.7	Definition of target area								CORMAGDALENA, MADS, IDEAM, DNP
5	Detailed analysis of flood in identified sections	5.1	Organization of socioeconomic characteristics								MADS and DNP
		5.2	Study of topographic condition	To survey detailed topographic condition including flood plain by LIDAR survey or acquisition of detailed topographic data such as satellite DEM							Leading entity
		5.3	Study of river condition	To carry out topographic survey of longitudinal and cross sectional condition of rivers in key sections							Leading entity
		5.4	Study of hydrological and hydraulic condition	*Study of rainfall condition *Study of water level and discharge *Study of flow regime, etc.							IDEAM (and National University)
		5.5	Study of geomorphology and fluvial dynamics								MADS, IDEAM (and National University)
		5.6	Detailed analysis of past flood phenomena	*Study of time-series variation of basin rainfall *Study of time-series variation of flood area *Study of relationship between observed water levels in stations and flood areas, etc.							IDEAM (and National University)
		5.7	Reproduction and prediction of flood hazard area	*Preparation of model and calculation of flood including flood plain *Preparation of possible inundation area map and hazard map *Setting of the hydrological (floods) area for RONDA							IDEAM (and National University)
6	Land use and disaster risk management for the flood zones	6.1	Definition of "critical flood hazard zone" and identification of critical flood hazard zone in the basin	*To define "critical flood hazard zone" *To identify critical flood hazard zone based on results of "5. Detailed analysis of flood"							All
		6.2	Risk assessment including flood vulnerability analysis inside the flood zone	*Definition of "critical flood risk zone" *Evaluation of risk							All
		6.3	Identification of critical flood risk areas	*Identify critical flood risk areas *Preparation of risk map							All
		6.4	Study of the necessity of response in front of flood risks	*Definition of areas to be protected against floods *Definition of Design Scale							All
		6.5	Study of structural measures	*Study of types and scale of measures (river channel improvement, dikes, dams, reservoirs). *Measures for drought management will be included as part of the activities							All
		6.6	Study of non structural measures	Study of types and scale of measures (organization of early warning system, elaboration and publication of hazard and risk maps, land use regulation, proposal of financial protection measures, etc.)							All UNGRD-SAT & financial protection for early warning only
7	Formulation of the IFMP-RP for the Magdalena River	7.1	Elaboration of IFMP-RP	To summarize results of all the studies To investigate and set ordering of priority of measures To investigate implementation plan							All
		7.2	Clarification of the sharing of responsibilities								All

Appendix-8 IFMP-SZ (provisional plan) in Rio Negro Basin

Japan International Cooperation Agency (JICA)
National Unit for Disaster Risk Management (UNGRD)
Institute of Hydrology, Meteorology and Environmental Studies (IDEAM)
Autonomous Regional Corporation of Cundinamarca (CAR)
Department of Cundinamarca
Ministry of Environment and Sustainable Development (MADS)

Project for Strengthening Flood Risk Management Capacity in the Republic of Colombia

Integrated Flood Management Plan for Sub-Zone (IFMP-SZ) in Rio Negro Basin

June 2018

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0. Background and General Overview

1. Background

1.1 IFMP / IFMP-SZ

Comprehensive management of flood risk is to "study damage and measures against floods, taking into account the entire basin from upstream to downstream from a broad point of view that includes social conditions such as the distribution of population or assets, fauna and flora, land use, distribution of precipitation, topography and geology in the basin and other information. " IFMP is a plan of the measures that are products of this study process."

This IFMP for Sub-Zone (IFMP-SZ) will be developed with the support of JICA based on the River Management Plan in Japan. The River Management Plan in Japan is elaborated by studying river conditions from the point of view of flood control, the use of water and the environment as well as an integral point of view. The IFMP-SZ for this project will study the basin from an integral point of view and will be elaborated with a focus on flood control.

1.2 Process of IFMP-SZ

IFMP-SZ will be developed following the process shown in the graph below.

1. Understand the characteristics of the river.

2. Determine the basic guidelines of the plan.

3. Determine items in the plan (design scale, etc.).

4. Study and evaluate the measures.

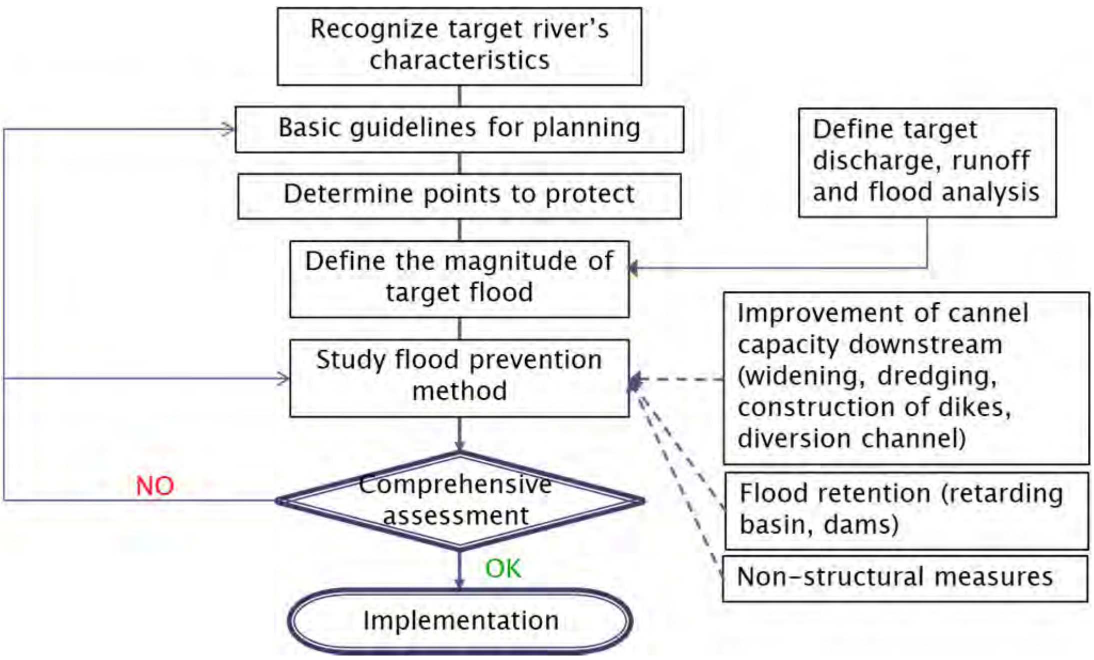


Figure 1.2.1 IFMP-SZ Formulation Process

The process described above is based on the processes of formulating the river (ordination) plan. As a reference, the general characteristics of river management plans in Japan are as follows.

- The "design discharge" and points of construction of structural measures based on methodologies and scientific data are determined
- A plan that understands and respects the natural and social characteristics of the target river
- A plan that considers the balance of importance between the main river and tributaries
- A plan with economic rationality based on the cost-benefit analysis
- A plan that has 20-30 years as the target period to complete the works

The characteristics of the content and structure of the plan are shown below.

1. Not only the profile of the river but also the profile of the basin (topography, geography, industry, land use, etc.) are presented.
2. The characteristics of past floods and damages are clearly presented, as well as the concept of flood control that has been used in the basin.
3. The target section, the period and the goals of the works are clearly presented.
4. The purpose, type and place of implementation of the river works are clearly presented.
5. For each river, unique items are clearly presented according to the characteristics of the river. For example, in a river with aggressive sediment production, an item "sediment control" is added, explaining the cause of sediment production and the relationship it has with flood damage.

1.3 Needs in POMCA

The POMCAs are plans to be formulated for each basin, as part of the national policy of integrated management of water resources published in March 2010. Its objective is to establish guidelines for the use and sustainable management of renewable natural resources, in order to conserve or replenish the balance between the use of resources and biological physical structures, in addition to formulating the guidelines for the use and occupation of lands in basins in accordance with the strategic objectives, and finally reaching an agreement and formulating the plans for each basin.

The Ministry of Environment and Sustainable Development in section 5, article 2.2.3.1.5.1 of decree 1076 of 2015, regulates the instruments for the sophistication, ordination and management of watersheds and aquifers. The Ministry of Environment and Sustainable Development issued the methodological guide for the formulation of the POMCA throuth resolution 1907 of 2013, in which the Ministry stressed the risk management, because the country experienced damages and losses associated with floods during the years 2010 and 2011.

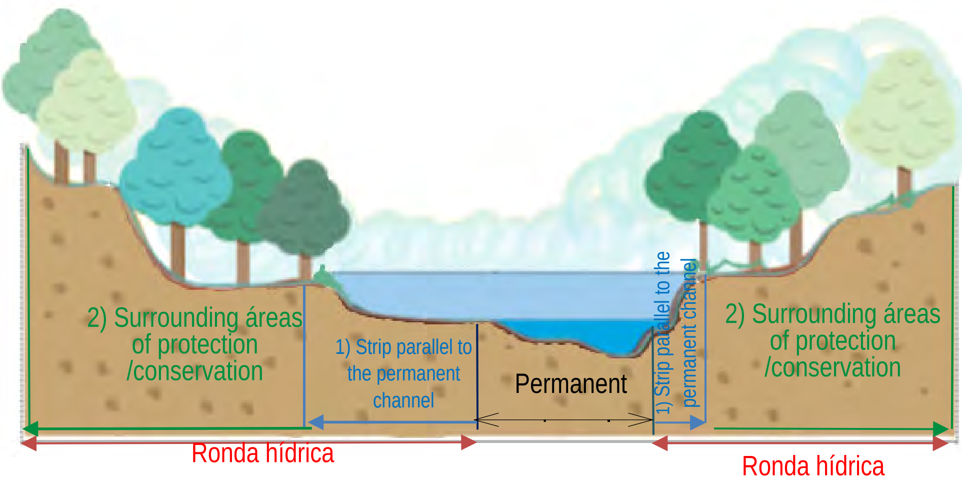
1.4 Concept of Hydraulic RONDA

In Colombia, there is a decree that regulates the administration of areas adjacent to the river (Ronda Hidrica):

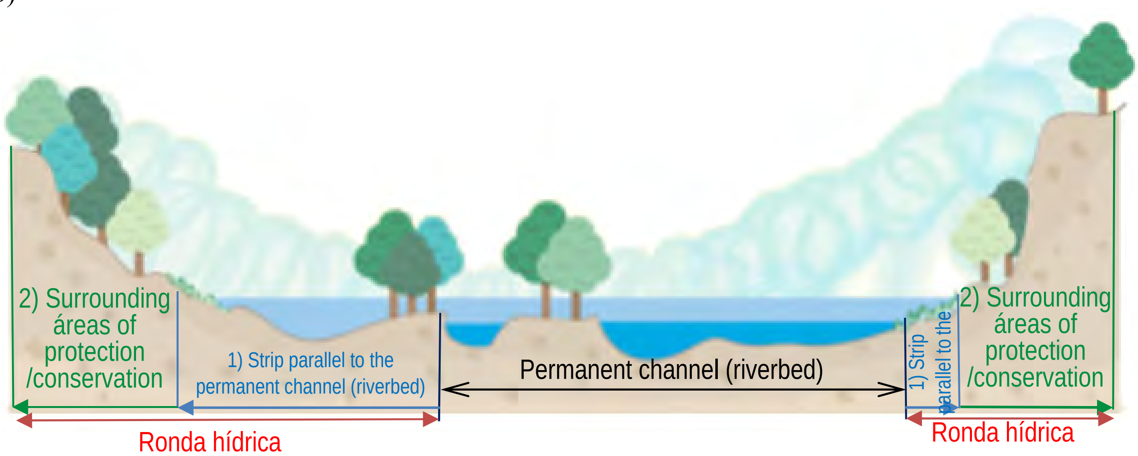
Decree 2811 of 1974 Article 83 D: Except for rights acquired by individuals, the following are inalienable and imprescriptible property of the State: d) A belt parallel to the maximum tide line or to the permanent channel of rivers and lakes, up to thirty meters wide.

Considering that the said area with the width of 30m may be insufficient in most of the rivers in Colombia that are located in valleys and praries, the Article 206 of Law 1450 of 2011 established that Hydraulic Ronda is “a strip of land pararel to the maximum level of water or that of the permanent channel of rivers and lakes, up to 30 meters in width, and the protection or conservation areas around it”. In this zone, activities such as urban development and construction, land use and others are subjected to certain conditions. This concept is the base of the river administration related to floods.

a)



b)



Constituent elements of the *ronda hídrica* in accordance with article 206 of Law 1450 of 2011 for lotic system (a) and lentic system (b). Images adapted from FISRWG (1998).

Figure 1.4.1 Ronda Hídrica (River Area)

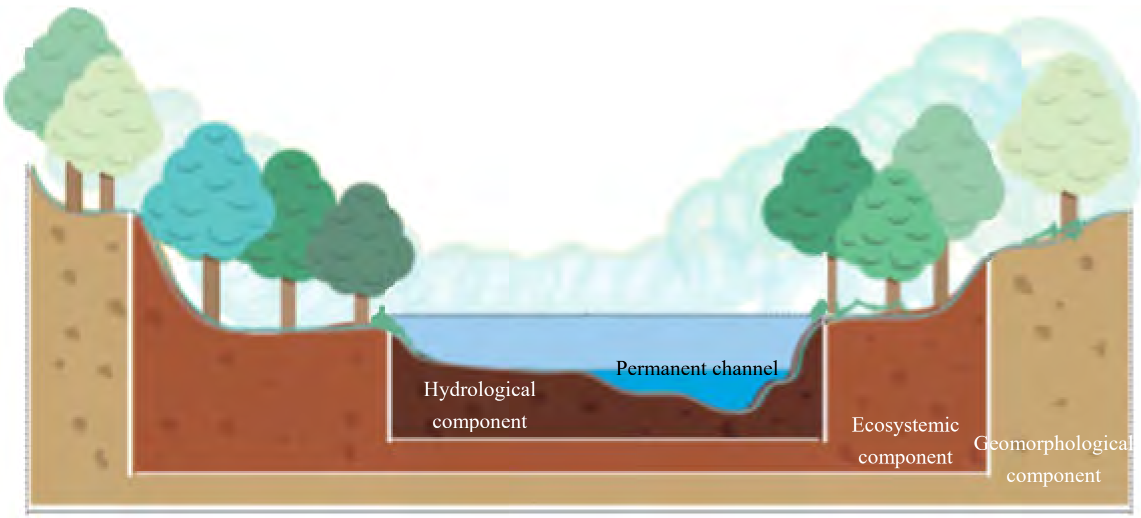
Progress is being made in revising the Ronda, taking into account the experiences of the 2010-2011 flood.

The key points of this process are the following:

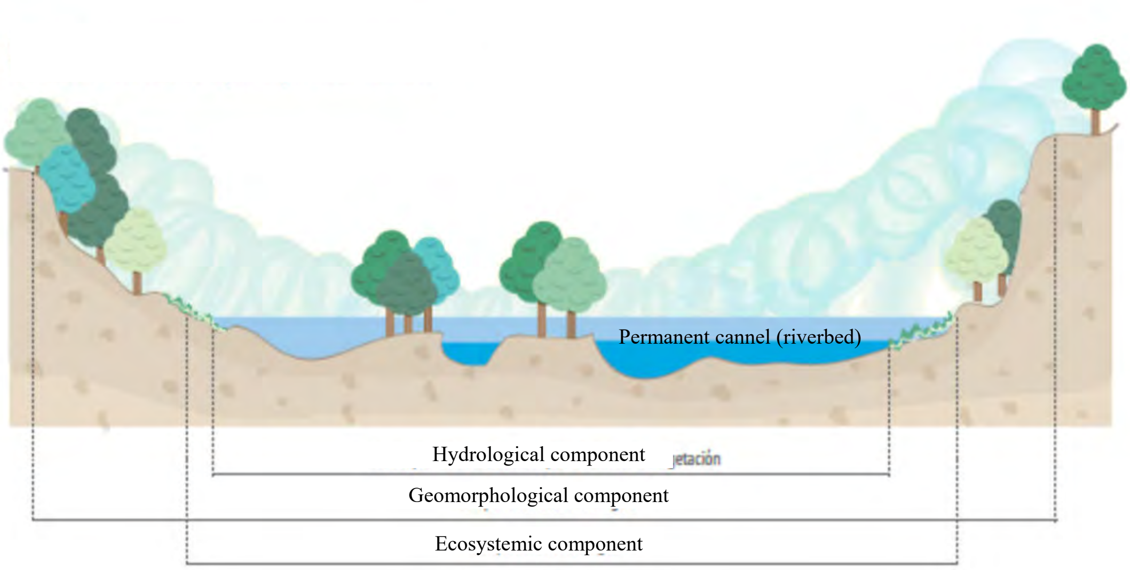
- The Ronda Hidrica will be deleanated from the hydrological (floods), ecosystemic (riverside vegetation) and geomorphological (morphostructural, morphogenetic and morphodynamic aspects) points of view.
- The Ronda Hidrica will be defined using the envelope line of the three elements described above.
- The area becomes a conservation area with the purpose of conservation in which preservation strategies can be given (maintenance of the native forest coverage), restauration (recovery of the native vegetation), or sustainable uses (e.g. seasonal crops, infrastructure for passive recreation).
- Regarding the hydrological point of view (floods), the flood of the return period of 15 years is taken into account (in systems where morphology has not been altered) and 100 years (in systems where the plains are densely occupied). In the latter, the concept of floodway from FEMA (U.S) is used.

The guideline was finalized through the Resolution 957 of May 31, 2018.

A figure that summarizes these concepts is presented below:



Physical-biotic components to define the physical limit of the *Ronda Hídrica* in lotic systems. Image adapted from FISRWG (1998).



Physical-biotic components to define the physical limit of the *Ronda Hídrica* in lentic systems. Image adapted from FISRWG (1998).

Figure 1.4.2 Hydraulic Ronda taking into account 3 physical-biotic components

1.5 Significance of River Planning

The river plan is elaborated for "the correct management of land and water, which are important components of the nation".

In Japan, for each main river, "Technical Criteria for River Works" and "River Management Plan" are elaborated, and rivers are administered for "water control", "water use", and "management and conservation of the enviroment".

Technical Criteria for River Works: The basic flood and proportions of the design flood discharge are defined from a long-term point of view and taking into account the balance in the entire national territory. Abstract items must be defined in a scientific and objective manner. They must also define the standard that guarantees the security of the country so that citizens can enjoy it in an equitable manner.

River Management Plan: The specific contents of long-term planning are defined, in accordance with the Basic Criteria for River Works. The goals of river management in the next 20 to 30 years are clarified, detailing the concrete content of the order including individual works.

IFMP-SZ for this project will take into account these concepts on the administration and planning of the river in Japan, and it will be developed as a pilot plan in order to think about the administration and planning of the river in Colombia and the plan adapted to the flood characteristics in Colombia.

1.6 Scope of JICA Project

This project (the Project for the Strengthening of Flood Risk Management Capacity in the Republic of Colombia) has an overall goal of "the reduction of flood risk in Colombia" and the project purpose "Capacity of Colombian institutions in flood management is enhanced.". The expected outputs are the following four elements, for which we carry out activities:

Output 1: Capacity on flood risk assessment is improved and concept of integrated flood management planning and river basin management is introduced

Output 2: Capacity on flood forecasting, warning and information dissemination to relevant organizations is improved (mainly IDEAM and UNGRD)

Output 3: Roles and responsibility of the central and local government for flood risk reduction are elucidated and enhanced (mainly UNGRD and IDEAM)

Output 4: Capacity of flood management planning is enhanced through formulation of integrated flood management plan (IFMP) in the pilot river basin

This IFMP-SZ was developed within the frame of the activities for Output 4, and it is a IFMP-SZ for the Río Negro basin, which was selected as a pilot basin. This project will not carry out independent activities for the collection of new information (survey of the cross section or topographic surveys, etc.), the preexisting information will be used to the maximum. The IFMP-SZ will be formulated as a provisional plan so that the participants learn the formulation processes, with references for formulating IFMP-SZs. It should be remembered that a complete IFMP-SZ can be drawn upwith additional work and the results thereof.

2. General Overview

2.1 Purpose and Contents of IFMP-SZ in Rio Negro Basin

- Purpose

The purpose is to formulate the integral measures against floods that takes into account the entire basin for the Rio Negro basin, which was selected as the pilot basin in the JICA Project. Because this project will not carry out independent activities for the collection of new information (survey of the cross section or topographic surveys, etc.), the preexisting information will be used to the maximum, so this IFMP-SZ will not be considered a finished plan (complete plan); rather, it will be considered a provisional plan, which should be kept in mind.

This IFMP-SZ will be developed assuming that it will be part of the POMCA risk component (flood) in the future.

- Contents

This IFMP-SZ will include the following 5 components:

- 0. Background and General Overview: Summary of IFMP-SZ and the context of the formulation of the IFMP-SZ
- A. River Characteristic: Characteristics of the Río Negro Basin and the River
- B. Planning of IFMP: Basic guidelines for the IFMP-SZ
- C. Implementation Program: Concrete measures against floods
- D. Allocation of Responsibility for Planning of IFMP: Role sharing for the implementation of the IFMP-SZ

2.2 Upper Level Plan

Upper level plan is the following:

- POMCA for the Rio Negro Basin

The contents and structure of the existing POMCA for the Río Negro basin (prepared before the mandatory inclusion of the disaster risk component) are presented below:

Table 2.1 Structure of the Management and Regulation Plan for a Basin (POMCA) for the Río Negro Basin

Part 1: Diagnosis of Sub-Catchments	Part 2: Prospective and Design of Scenarios
Chapter 1: Delineation and Location of the Watershed	Chapter 1: Objective and Conceptual Framework
Chapter 2: Characterization of the Physical Environment	Chapter 2: Design of Scenarios
Chapter 3: Characterization of the Biotic Environment	Chapter 3: Formulation of the Watershed Management and Management Plan
Chapter 4: Socioeconomic Characterization	
Chapter 5: Use and Degradation of Natural Resources	
Chapter 6: Socio-Environmental Assessment	
Chapter 7: Environmental Zoning and Regulation of Use	

Upon reading the concrete content described above, there are not many mentions about the river and floods. The characteristics of the river within the basin are found in Chapter 1 and 2 of Part 1, and the specific contents include the delineation of sub-catchments (the sub-catchments have more detailed divisions by tributary), general characteristics of the tributary basin (area , length, etc.), characteristics of the main river in the tributary river basin (length, slope, etc.), meteorological conditions (precipitation, temperature, humidity, transpiration, intensity of solar radiation, etc.), information about the seasons, observed and probable discharge, flow pattern, water demand, geology, hydraulics and geology, and soil quality, etc. No information was found on the characteristics of the basin flood.

Other contents related to the subject in other chapters include erosion, water quality, current situation and challenges with respect to water sanitation in Chapter 5, as well as the risk of disaster in Chapter 6. However, only a few pages are dedicated to each type of natural disaster, and the content related to the flood is quite general, less than one page. In Chapter 7, there is a mention of the protection zones surrounding the river and water source, and in Chapter 2 there are contents related to the protection of the water source, watershed management and measures against disasters as a plan for the future, although they are very simple .

It can be concluded that current POMCA has extremely limited content related to flooding and risk management.

A. River Characteristics

1. Social characteristics

1.1 List of Municipality in the watershed

The Rio Negro watershed is part of the hydrographic basin of the Magdalena River, located northwest of Bogotá, and covers an area of 4,572 km^2, with channel length of 439km (according to IDEAM). The average annual precipitation is approximately 2000mm (according to POMCA of the Río Negro basin). The altitude difference in the Negro River basin is approximately 3,500m. The Río Negro basin covers both the Department of Cundinamarca and the Department of Boyacá; however, the majority of the basin belongs to the Department of Cundinamarca, as shown in Figure 1.1.1.

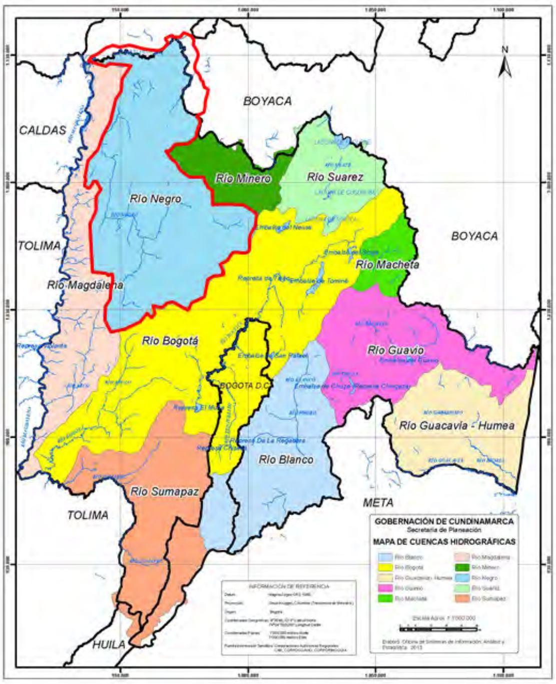


Figure 1.1.1 Delineation of the basin in the Department of Cundinamarca

As shown in Figure 1.1.2, there are 23 municipalities within the Río Negro basin (only Cundinamarca).

These municipalities are Alban, Bituima, El Penon, Caparrapi, Guaduas, Guayabal, La Palma, La Pena, La Vega, Nimaima, Nocaima, Pacho, Puerto Salgar, Quebrada Negra, San Francisco, Sasaima, Supata, Topaipi, Utica, Vergara, Viani, Villeta and Yacopi.

Figure 1.1.2 Administrative division in the Río Negro basin (municipalities) (only Cundinamarca)

1.2 Population

The total population of the municipalities that comprise the basin is approximately 260,000, as shown below (including the population outside the basin).

Table 1.2.1 Population of the Municipalities in the Río Negro basin (projection for 2017)

Municipality	Urban Population	Rural Population	Total
ALBAN	1,613	4,343	5,956
BITUIMA	446	2,054	2,500
CAPARRAPI	2,762	13,958	16,720
EL PEÑON	445	4,341	4,786
GUADUAS	20,311	19,437	39,748
GUAYABAL DE SIQUIMA	871	2,780	3,651
LA PALMA	4,129	6,783	10,912
LA PEÑA	995	6,045	7,040
LA VEGA	5,381	9,032	14,413
NIMAIMA	3,025	3,922	6,947
NOCAIMA	1,911	6,200	8,111
PACHO	15,763	11,821	27,584
PUERTO SALGAR	14,630	4,707	19,337
QUEBRADA NEGRA	390	4,369	4,759
SAN FRANCISCO	3,492	6,380	9,872
SASAIMA	2,466	8,312	10,778

SUPATA	1,531	3,496	5,027
TOPAIPI	821	3,683	4,504
UTICA	2,750	2,273	5,023
VERGARA	1,565	6,139	7,704
VIANI	1,349	2,865	4,214
VILLETA	16,403	8,978	25,381
YACOPI	4,046	13,021	17,067
		Total	262,034

Source: DANE, projection based on 2005 census statistics

This point will be elaborated in 1.6 "Conditions of land use"; however, the urban area occupies only 0.19% of the total area of the basin, and the locations of the urban areas are scattered in the basin. It means the populations are also scattered in the basin.

1.3 Agricultural Product

The main agricultural products of the basin are coffee and cane panelera. The crops associated with the coffee growing area are mainly sugarcane, banana, corn, citrus and cocoa, cassava, corn, beans, avocado, fruits (citrus, mango, papaya), and by-products in the highland area or cold weather area are potatoes and peas. The main land use in the basin is natural grass, and the secondary forest. Livestock is quite common in the basin.

Source: POMCA

1.4 Industrial Product

One of the most important economic activities in this area is the production of “panela”, or unrefined whole cane sugar.

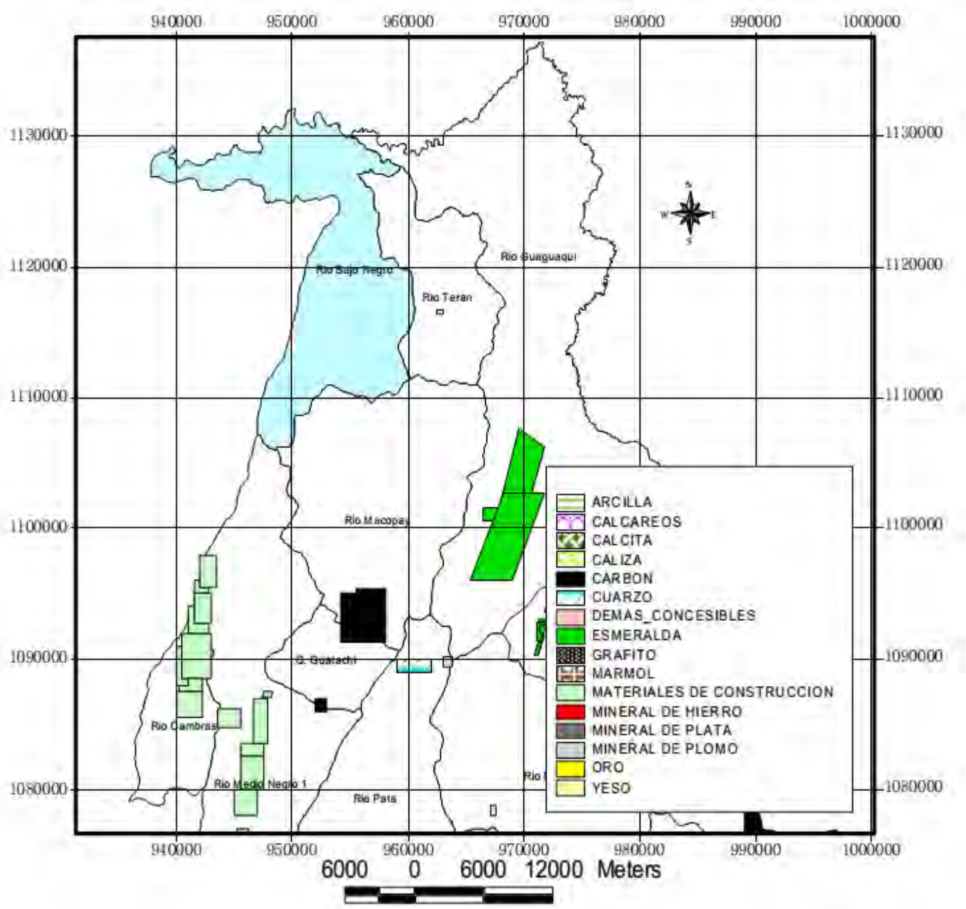
Source: POMCA Chapter 3 Perspectives RN-P2-c1-2 Ver-1.pdf P49 **Foto No. 2.19**

In Guaduas Municipality, there is oil exploration carried out by SIPETROL Company. There are 23 oil wells that produce approximately 1500 barrels daily. The municipality earned $2000.00 million pesos from royalty fee in 2003.

Source: POMCA

1.5 Mineral Product

Some mining activities are carried out in the basin. Spatial distribution of existing mining titles are shown in the following figures:

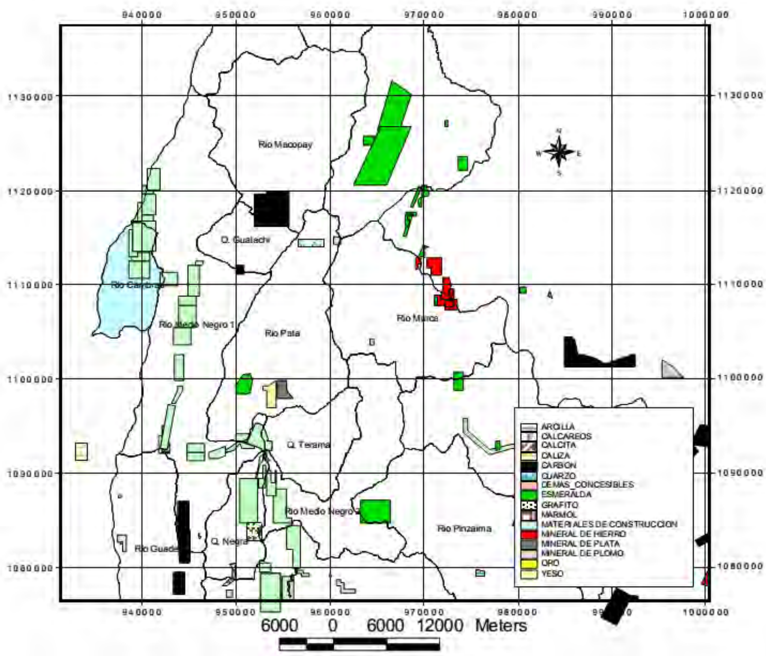


Legend

	Clay
	Calcareous
	Calcite
	Limestone
	Coal
	Quartz
	Other minerals for concession
	Emerald
	Graphite
	Marble
	Construction Materials
	Iron Mineral
	Silver Mineral
	Lead Mineral
	Gold
	Plaster

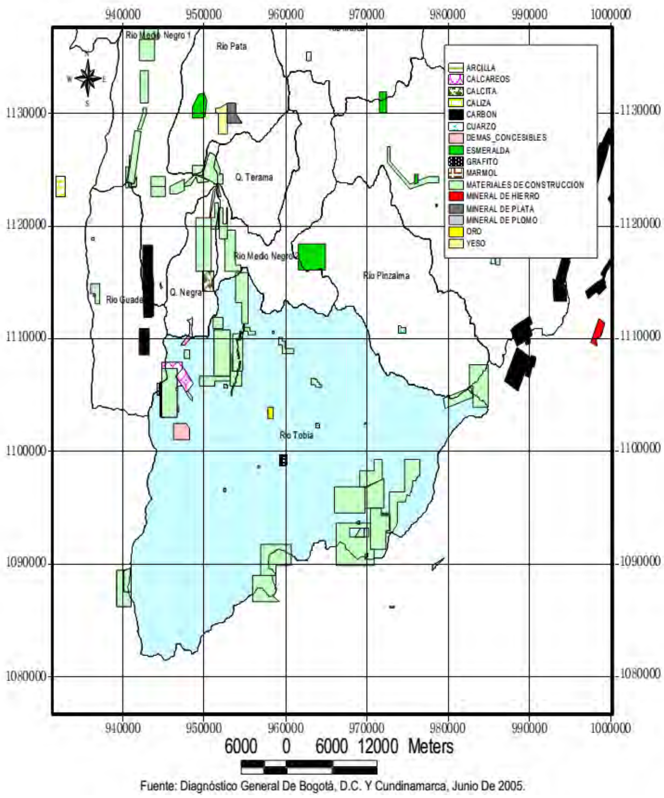
Source: POMCA

Figure 1.5.1 Spatial Distribution of Existing Mining Titles in Northen Part of Rio Negro Basin



Source: POMCA

Figure 1.5.2 Spatial Distribution of Existing Mining Titles in Central Part of Rio Negro Basin



Source: POMCA

Figure 1.5.3 Spatial Distribution of Existing Mining Titles in Southern Part of Rio Negro Basin

1.6 Landuse condition

Land coverage in Rio Negro Basin is tabulatd as shown in the following table.

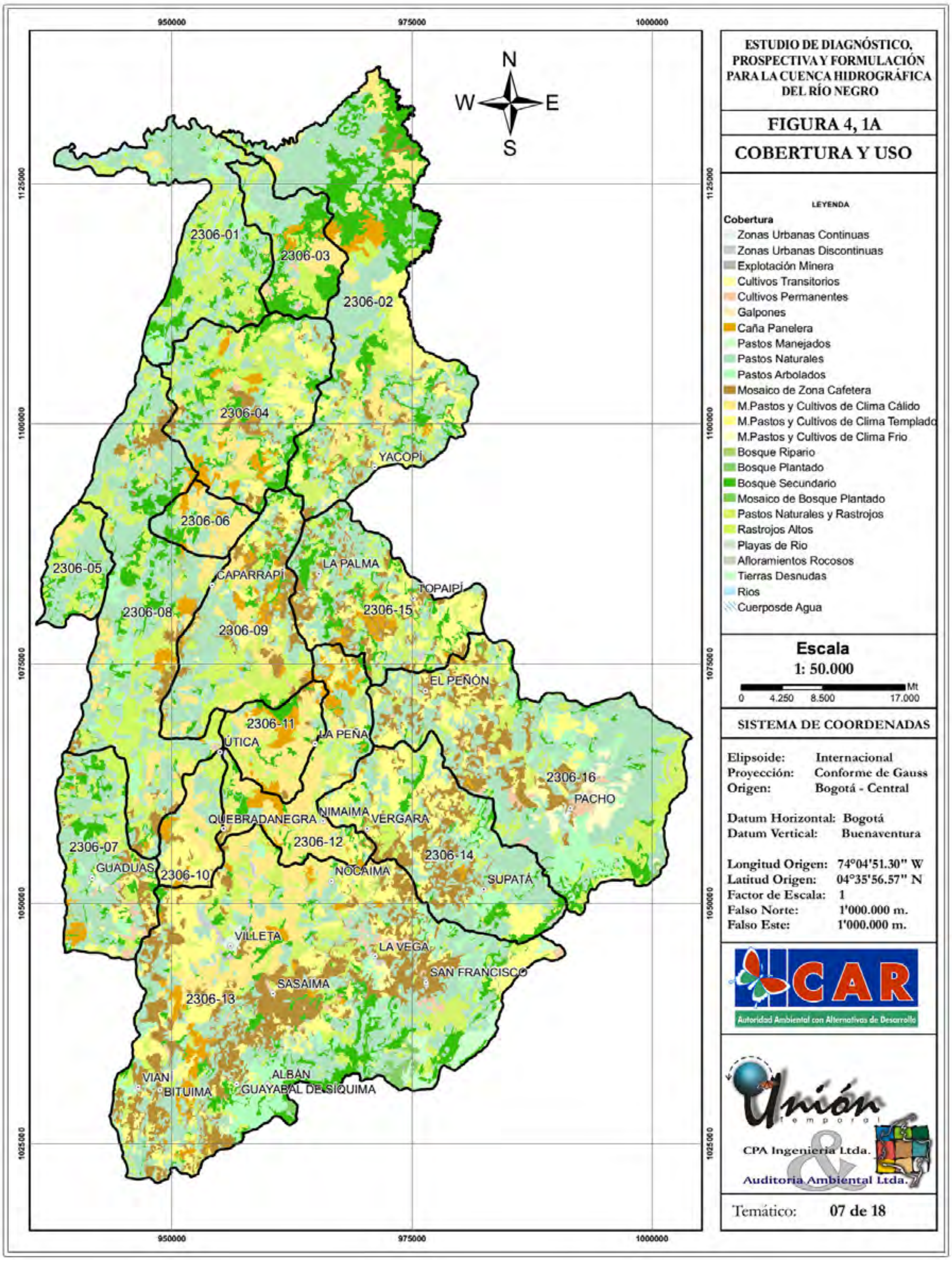
Table 1.6.1 Land coverage in Rio Negro Basin

Item	Area (km^2)	Ratio (%)
Natural Grass (Pn)	1284.94	30.34
Secondary Forest (Bs)	492.14	11.62
Coffee Area Mosaic (Cc)	439.04	10.37
Grass and Moderate-Weather Crops Mosaic (Mcm)	427.54	10.09
Tall Shrubs (Ra)	377.94	8.92
Natural Grass and Shrubs (Pr)	359.9	8.5
Grass and Warm-Weather Crops Mosaic (Mcc)	359.6	8.25
Grass with Trees (Pa)	159.36	3.76
Sugar Cane, Grass and Other Crops (Cñp)	136.79	3.23
Riparian Forest (Br)	43.97	1.04
Permanent Crops (Cp)	31.11	0.73
River Water Mirror (Ear)	23.25	0.55
Grass and Cold-Weather Crops Mosaic (Mcf)	22.12	0.52
Managed Grass (Pm)	21.46	0.51
Planted Forest (Bp)	14.42	0.34
Transitional Crops (Ct)	13.92	0.33
Discontinuous Urban Zones (Zud)	12.18	0.29
Highland and Sub-Highland Vegetation (Mp)	8.26	0.19
Urban Areas (Zuc)	8.24	0.19
Riverside Beach (Py)	3.6	0.08
Rocky Outcrop(Ar)	2.43	0.06
Barns (Gp)	1.73	0.04
Bare or Degraded Land (Ae)	1.14	0.03
Planted Forest Mosaic (Bsp)	0.62	0.01
Mining (Em)	0.22	0.01
Watter Body (Ca)	0.16	0.003

Source: POMCA

The most common type of land in this basin is Natural Grass, (Pn) with 1284.94 km^2 in area, making up 30.34% of the basin. The second most common use is Secondary Forest (Bs) with 492.14km^2 in area, making up 11.62% of the basin. The third is coffee area mosaic (Cc) with 439.04km^2 in area, making up 10.37% of the basin. The forth is the Grass and Moderate-Weather Crops Mosaic (Mcm), with 427.54km^2 in area, making up 10.09% of the basin. The fifth is Tall Shrubs (Ra) with 377.94km^2 in area, making up 8.92% if the basin. The sixth is Natural Grass and Shrubs (Pr), with 359.9km^2 in area, making up 8.5% of the basin. The seventh is Grass and Warm-Weather Crops Mosaic (Mcc) with 359.6km^2 in area, making up 8.25% of the basin. The eighth is Grass with Trees (Pa) with 159.36km^2 in area, making up 3.76% of the basin. The ninth is the Sugar Cane, Grass and Other Crops (Cñp) with 136.79km^2 in area, making up 3.23% of the basin. These types of coverage make up 95.08 % of the basin.

The land coverage and use in the basin is shown in Figure 1.6.1.



Legend

	Continuous Urban Area
	Discontinuous Urban Area
	Mining

	Temporary Crops
	Permanent Crops
	Barns
	Sugarcane
	Managed Grass
	Natural Grass
	Grass with Trees
	Coffee Area Mosaic
	Grass and Warm Weather Crop Mosaic
	Grass and Moderate Weather Crop Mosaic
	Grass and Cold Weather Crop Mosaic
	Riparian Forest
	Planted Forest
	Secondary Forest
	Planted Forest Mosaic
	Natural Grass and Shrubs
	Tall Shrubs
	River Beach
	Rocky Outcrop
	Bare Land
	Rivers
	Water Body

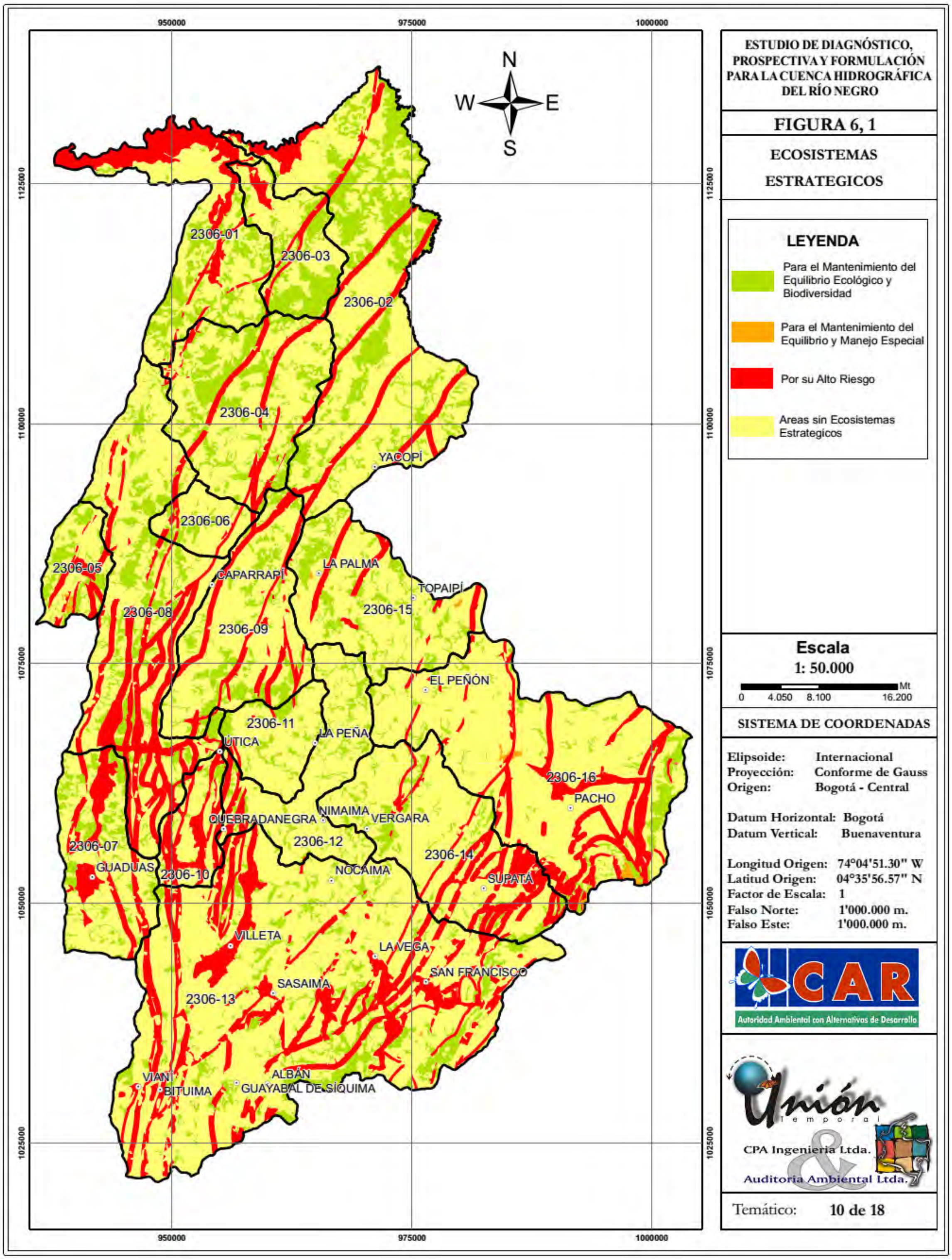
Source: POMCA

Figure 1.6.1 Land Coverage and Use in the Basin

1.7 Environmental condition including ecosystem

The problems of pollution in the basin are partially due to the dumping of residual water from urban areas of Villeta, Utica, Pacho, Supata, La Palma, Guaduas and San Francisco. This residual water is generally organic residue from municipal capitals. This causes not only damage to the scenery but also to the quality of water and soil. Another type of pollution is caused by the development of tourism industry in Guaduas-Villeta and Villeta-La Vega area. Since many condominiums for vacation were built in the area, these have had a significant impact on the basin due to the dumping of organic residues in main water bodies.

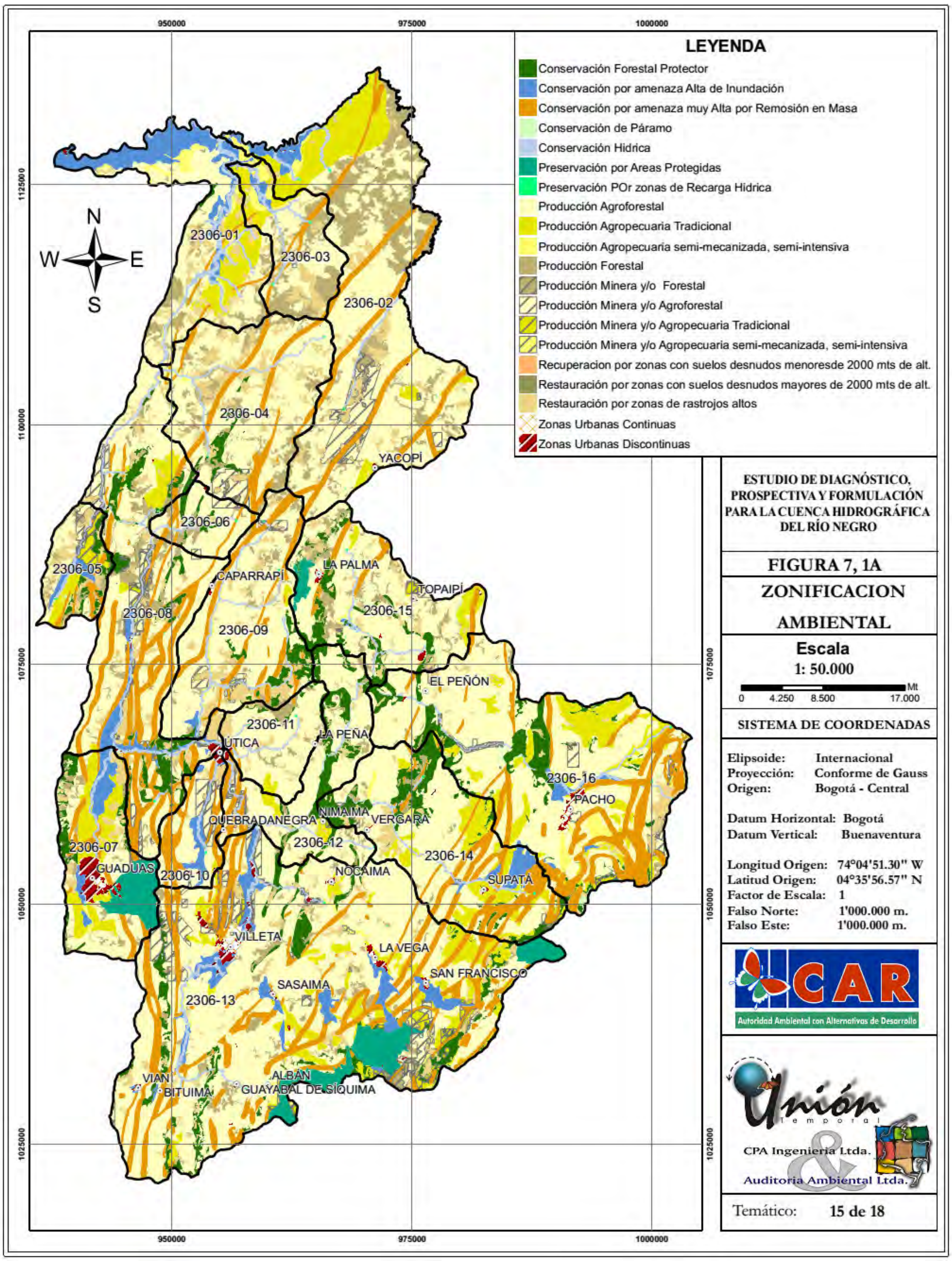
Ecosystems and Environmental zoning in the basin are shown in Figure 1.7.1 and 1.7.2, respectively.



	For maintenance of the ecological equilibrium and biodiversity
	For maintenance of equilibrium and special management
	High Risk
	Areas without strategic ecosystems

Source: POMCA

Figure 1.7.1 Ecosystems in the Basin



Source: POMCA

Figure 1.7.2 Environmental Zoning in the Basin

1.8 Water use condition

Rio Negro basin presents the total water demand of 3,739m^3/second on average. The largest water demand comes from agricultural development, with 3,221m^3/second. This is relatively low in comparison to other basins of the same size. This is mainly due to the low population density in the midstream and downstream basin, traditional agricultural methods and humid climatic conditions which are dominant in the basin, especially on the eastern side of the basin.

The domestic use occupies the second largest water demand is the domestic water use with 395 L / second. This is a consequence of the needs for water to provide for medium-sized urban centres such as Villeta, Pacho, Guaduas and Yacopi. They have a total population of 77,000 residents in the urban areas and and 148,480 residents in the rural areas.

Water demand for livestock is the smallest in Rio Negro Basin with 123 L / second. This is mainly for beef/dairy cattle (300,000 heads), chicken farms and fish farms.

Water demands of domestic use, agricultural use and livestock use and total water demand in each sub-basin are shown in Table 1.8.1 to 1.8.4, respectively.

Table 1.8.1 Water Demand for Domestic Use in Rio Negro Basin

Code	Sub-Basin	Urban Demand (m^3 / year)	Rural Demand (m^3 / year)	Total demand	
				m^3 / year	m^3 / sec
2306-01	Río Bajo Negro	0	184,829	184,829	0.006
2306-02	Río Guaguaquí	225,041	420,349	645,389	0.020
2306-03	Río Terán	0	41,340	41,340	0.001
2306-04	Río Macopay	0	298,117	298,117	0.009
2306-05	Río Cambras	0	24,579	24,579	0.001
2306-06	Q. Guatachí	0	77,774	77,774	0.002
2306-07	Río Guaduero	1,143,081	381,973	1,525,054	0.048
2306-08	Río Medio Negro 1	0	378,447	378,447	0.012
2306-09	Río Patá	169,214	320,101	489,315	0.016
2306-10	Q. Negra	0	199,044	199,044	0.006
2306-11	Q. Terama	0	185,701	185,701	0.006
2306-12	Río Medio Negro 2	378,229	459,601	837,830	0.027
2306-13	Río Tobia	1,925,390	2,739,048	4,664,437	0.148
2306-14	Río Pinzaima	148,515	489,721	638,235	0.020
2306-15	Río Murca	293,296	322,259	615,554	0.020
2306-16	Río Alto Negro	895,863	766,929	1,662,792	0.053
TOTAL	**Río Negro**	**5,178,629**	**7,289,809**	**12,468,438**	**0.395**

Source: POMCA

Table 1.8.2 Water Demand for Agricultural Use in Rio Negro Basin

Code	Sub-Basin	Water Demand (m^3/year)																								
		Tree Tomatoes	Blackberries	Onions	Vegetables	Mango	Citric Fruits	Beans	Potatoes	Green Peas	Rice	Cotton	Fruits	String beans	Yucca	Plantain	Corn	Soursop	Sugarcane	Coffee	Cacao	Gooseberry	Managed Grass	Irrigated grass	Total (m^3/year)	Total (m^3/sec)
2306-01	Río Bajo Negro														4,053	17,283	0	0	13,077	49,213	9,418			174,164	267,213	0.008
2306-02	Río Guaguaqui													0	0	11,031	0		0	118,259	0			1,288,937	1,418,226	0.045
2306-03	Río Terán														722	10,448	0		0	10,328	0			1,042,052	1,063,550	0.034
2306-04	Río Macopay												0		853	27,327	0		0	179,568	1,979			5,897,242	6,106,969	0.194
2306-05	Río Cantrás																		593,429					550,811	1,144,240	0.036
2306-06	Quebrada Guatachí																0		1,742,665	403,590				781,976	2,928,231	0.093
2306-07	Río Guaduero										3,407	2,121	799,818			251,011	0		1,699,432	3,268,791				1,021,355	7,045,935	0.223
2306-08	Río Medio Negro 1															343,040	0		4,336,526	7,226,176				2,722,876	14,628,618	0.464
2306-09	Río Patá													2,441		50,904	0		2,692,193	4,976,185				1,007,776	8,729,499	0.277
2306-10	Quebrada Negra														7,905	200,689	0		8,600,266	1,288,476				2,344,960	10,332,317	0.328
2306-11	Quebrada Terama																0		7,042,234	591,537				1,506,226	9,138,997	0.290
2306-12	Río Medio Nego 2															41,951	0		8,024,967	1,066,277				982,361	10,115,556	0.321
2306-13	Río Tobía				3,117	0	2,764	0	1,895	8,061			45,285	21,780		104,806	0		7,394,741	8,252,427	390		1,618,075	2,638,231	20,091,572	0.637
2306-14	Río Pinzaima							0			0			0		6,479			1,253,254	1,816,994				752,078	3,828,804	0.121
2306-15	Río Murca													1,407	311	52,644			1,028,617	1,158,027	373			431,684	2,673,063	0.065
2306-16	Río Alto Negro	0	0	3,730	0		0	0	19,104	0			0	0		46,696	0	0	417,139	650,488	6,732	0		907,877	2,051,766	0.065
Total		0	0	3,730	3,117	0	2,764	0	20,999	8,061	3,407	2,121	845,103	25,628	13,843	1,164,309	0	0	44,838,558	31,056,342	18,892	0	1,618,075	21,939,607	101,564,556	3.221

Source: POMCA

Table 1.8.3 Water Demand for Livestock Use in Rio Negro Basin

Code	Sub-Basin	Total Demand	
		m^3 / year	m^3 / sec
2306-01	Río Bajo Negro	269,354	0.009
2306-02	Río Guaguaquí	388,169	0.012
2306-03	Río Terán	84,731	0.003
2306-04	Río Macopay	237,085	0.008
2306-05	Río Cambras	60,853	0.002
2306-06	Q. Guatachí	54,006	0.002
2306-07	Río Guaduero	250,757	0.008
2306-08	Río Medio Negro 1	427,125	0.014
2306-09	Río Patá	166,825	0.005
2306-10	Q. Negra	39,246	0.001
2306-11	Q. Terama	43,359	0.001
2306-12	Río Medio Negro 2	72,541	0.002
2306-13	Río Tobia	1,079,218	0.034
2306-14	Río Pinzaima	171,926	0.005
2306-15	Río Murca	103,407	0.003
2306-16	Río Alto Negro	436,966	0.014
TOTAL	**Río Negro**	**3,885,568**	**0.123**

Source: POMCA

Table 1.8.4 Total Water Demand in Rio Negro Basin

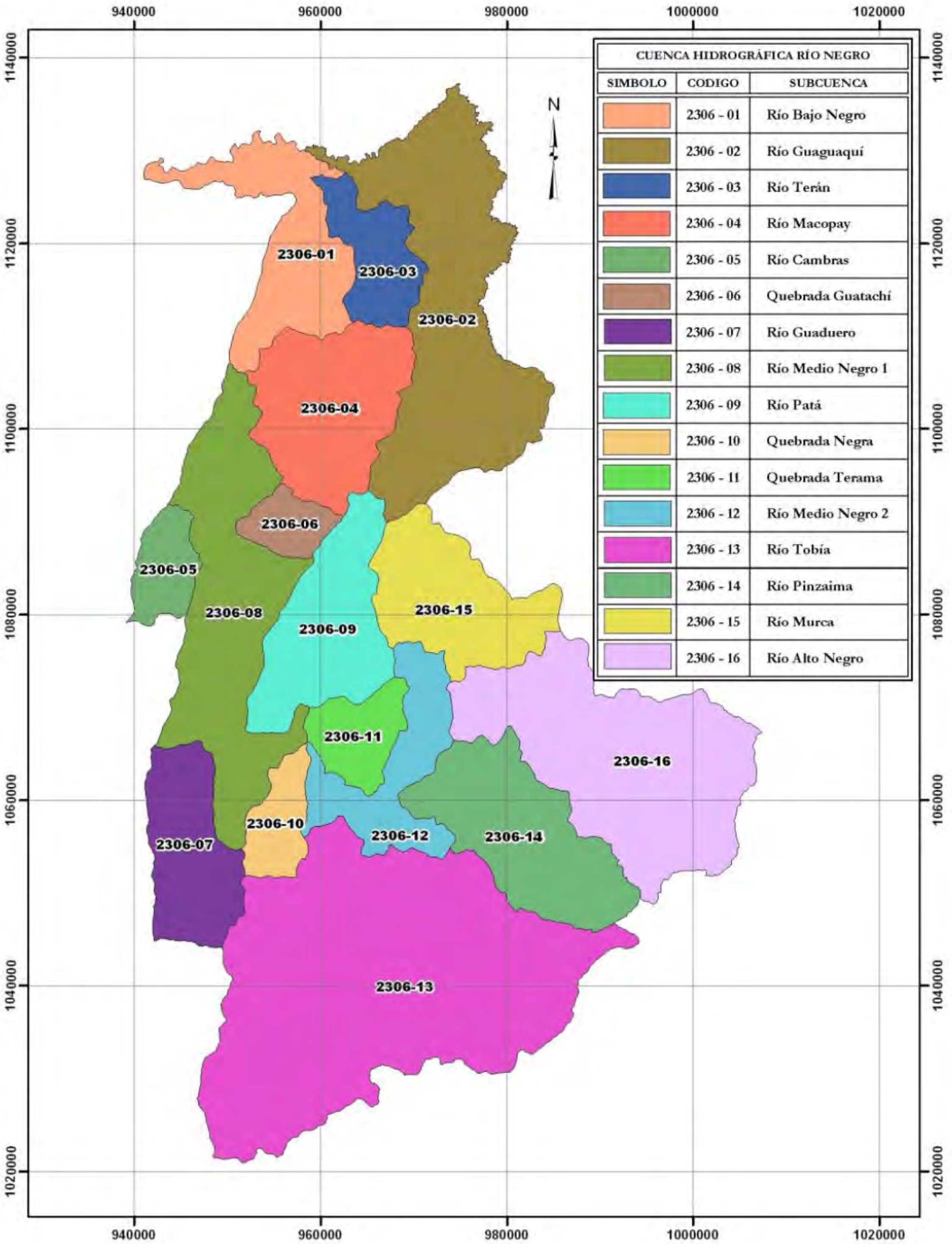
Code	Basin	Demand (m^3/s)			Total demand (m^3/s)
		Domestic	Agricultural	Livestock	
2306-01	Río Bajo Negro	0.006	0.008	0.009	0.023
2306-02	Río Guaguaquí	0.020	0.045	0.012	0.078
2306-03	Río Terán	0.001	0.034	0.003	0.038
2306-04	Río Macopay	0.009	0.194	0.008	0.211
2306-05	Río Cambras	0.001	0.036	0.002	0.039
2306-06	Q. Guatachí	0.002	0.093	0.002	0.097
2306-07	Río Guaduero	0.048	0.223	0.008	0.280
2306-08	Río Medio Negro 1	0.012	0.464	0.014	0.489
2306-09	Río Patá	0.016	0.277	0.005	0.298
2306-10	Q. Negra	0.006	0.328	0.001	0.335
2306-11	Q. Terama	0.006	0.290	0.001	0.297
2306-12	Río Medio Negro 2	0.027	0.321	0.002	0.350
2306-13	Río Tobia	0.148	0.637	0.034	0.819
2306-14	Río Pinzaima	0.020	0.121	0.005	0.147
2306-15	Río Murca	0.020	0.085	0.003	0.108
2306-16	Río Alto Negro	0.053	0.065	0.014	0.132
TOTAL	**Río Negro**	**0.395**	**3.221**	**0.123**	**3.739**

Source: POMCA

2. Topography and River conditions

2.1 Watershed delineation of Rio Negro

The part of the Río Negro basin located in the Department of Cundinamarca has 16 sub-catchments that are delineated as shown in Figure 2.1.1.



Source: POMCA Cap-0, "4. Study Area", Figure 1

Figure 2.1.1 Watershed delineation of Rio Negro Basin

Table 2.1.1 Information about the Sub-Catchments of Río Negro

Sub basin	Area Km^2
2306 – 01 Río Bajo Negro	231.95
2306 – 02 Río Güaguaquí	495.97
2306 – 03 Río Terán	108.02
2306 – 04 Río Macopay	256.11
2306 – 05 Río Cambrás	69.34
2306 – 06 Quebrada Güatachí	53.16
2306 – 07 Río Guaduero	172.38
2306 – 08 Río Medio Negro	400.77
2306 – 09 Río Patá	228.11
2306 – 10 Quebrada Negra	70.15
2306 – 11 Quebrada Terama	84.76
2306 – 12 Río Medio Negro 2	162.27
2306 – 13 Río Tobía	940.68
2306 – 14 Río Pinzaima	270.42
2306 – 15 Río Murca	219.68
2306 – 16 Río Alto Negro	489.46

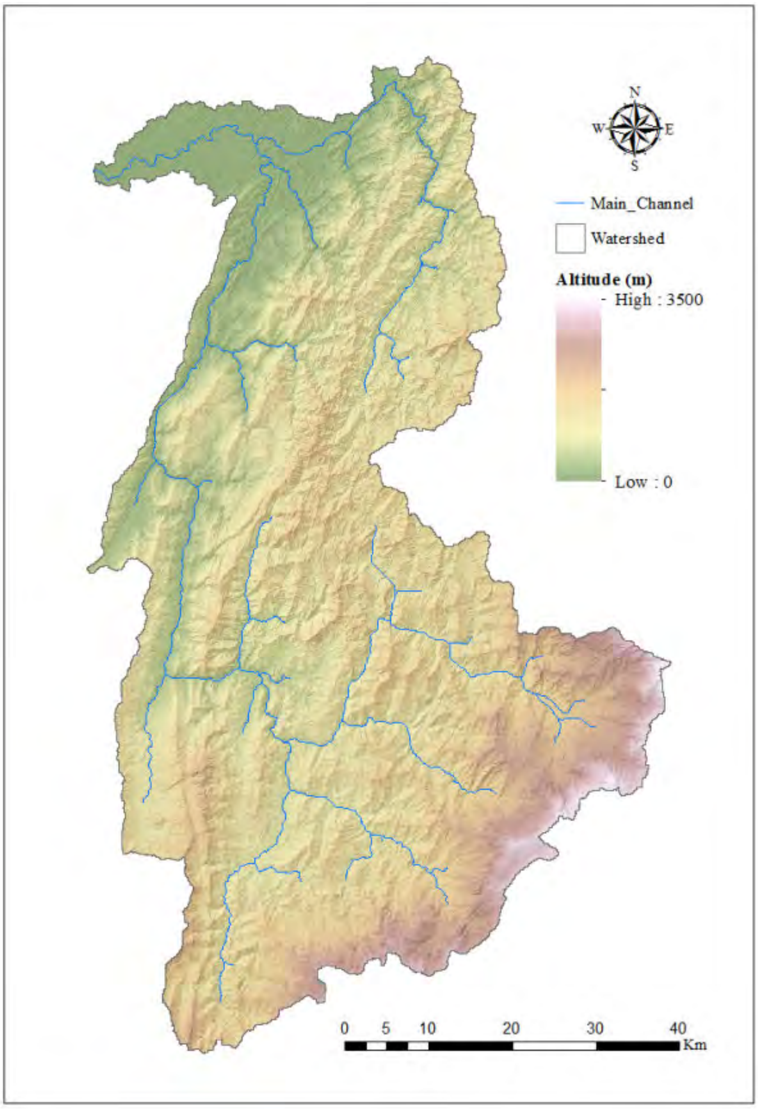
Source: POMCA Cap-0, "4. Study Area",

In this project, the analysis was carried out, dividing the basin into 3 parts: upper basin (2306-16), middle basin (2306-15, 2306-14, 2306-13, and the part to the confluence with Tobia River in 2306) -12), and low basin (all the rest of the basin).

2.2 Hypsometric Analysis

Figure 2.2.1 shows the altitude classification in the Río Negro basin. Table 2.2.2 shows the area of the basin by elevation and the proportion, and Figure 2.2.2 shows the accumulative proportion of basin area by elevation.

According to this analysis, approximately 61% of the total area of the Rio Negro basin belongs to the elevation of 500m-1500m, less than 13% belongs to the elevation less than 500m, and approximately 26% belongs to the elevation greater than 1500m. 50% of the total area belongs to the elevation of approximately 1150m. It can be concluded that the area belonging to the elevation of 500m-1500m forms a relatively flat topography.



Source: JICA Project Team

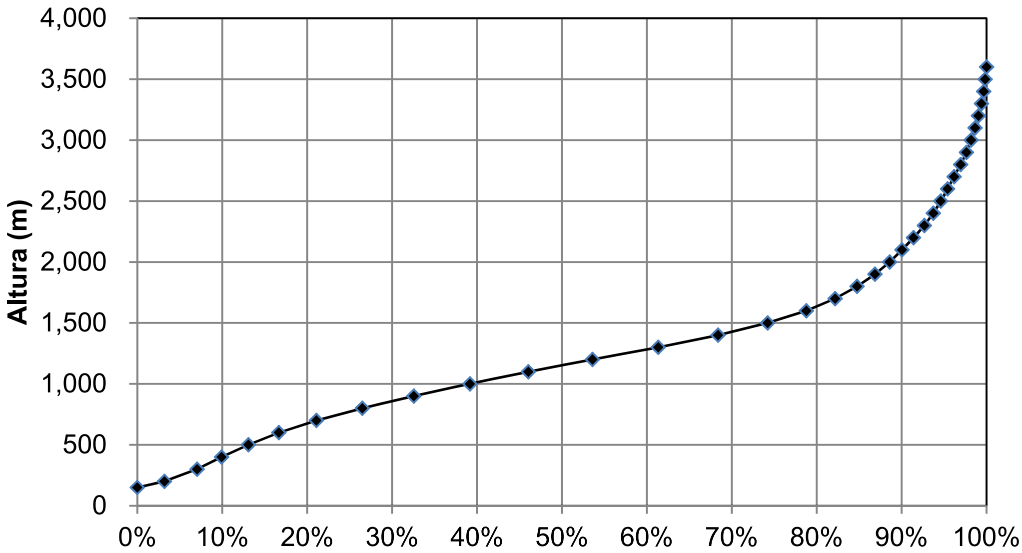
Figure 2.2.1 Hypsometric Map in the Basin

Table 2.2.1 Results of Hypsometric Analysis in the Basin

Elevation	Area (km^2)	Ratio	Acc. Ratio	Elevation	Area (km^2)	Ratio	Acc. Ratio
Less than 200m	146.6	3.2%	3.2%	1,900 - 2,000m	79.2	1.7%	88.6%
200 - 300m	176.6	3.9%	7.0%	2,000 - 2,100m	67.0	1.5%	90.1%
300 - 400m	132.1	2.9%	9.9%	2,100 - 2,200m	61.9	1.3%	91.4%
400 - 500m	144.5	3.2%	13.1%	2,200 - 2,300m	58.9	1.3%	92.7%
500 - 600m	164.7	3.6%	16.7%	2,300 - 2,400m	48.1	1.0%	93.7%
600 - 700m	202.9	4.4%	21.1%	2,400 - 2,500m	40.1	0.9%	94.6%
700 - 800m	247.6	5.4%	26.5%	2,500 - 2,600m	36.4	0.8%	95.4%
800 - 900m	278.5	6.1%	32.6%	2,600 - 2,700m	35.5	0.8%	96.2%
900 - 1,000m	302.9	6.6%	39.2%	2,700 - 2,800m	35.7	0.8%	97.0%
1,000 - 1,100m	315.7	6.9%	46.1%	2,800 - 2,900m	31.2	0.7%	97.6%

1,100 - 1,200m	345.6	7.5%	53.6%	2,900 - 3,000m	24.9	0.5%	98.2%
1,200 - 1,300m	355.2	7.7%	61.3%	3,000 - 3,100m	21.3	0.5%	98.6%
1,300 - 1,400m	322.9	7.0%	68.4%	3,100 - 3,200m	18.4	0.4%	99.0%
1,400 - 1,500m	268.0	5.8%	74.2%	3,200 - 3,300m	16.3	0.4%	99.4%
1,500 - 1,600m	209.6	4.6%	78.8%	3,300 - 3,400m	12.6	0.3%	99.7%
1,600 - 1,700m	154.7	3.4%	82.2%	3,400 - 3,500m	7.8	0.2%	99.8%
1,700 - 1,800m	119.1	2.6%	84.8%	3,500m and over	7.1	0.2%	100.0%
1,800 - 1,900m	96.5	2.1%	86.9%	**Total**	**4,586.1**	**100.0 %**	**-**

Source: JICA Project Team



Source: JICA Project Team

Figure 2.2.2 Hypsometric Curve in the Basin

2.3 River cross Section

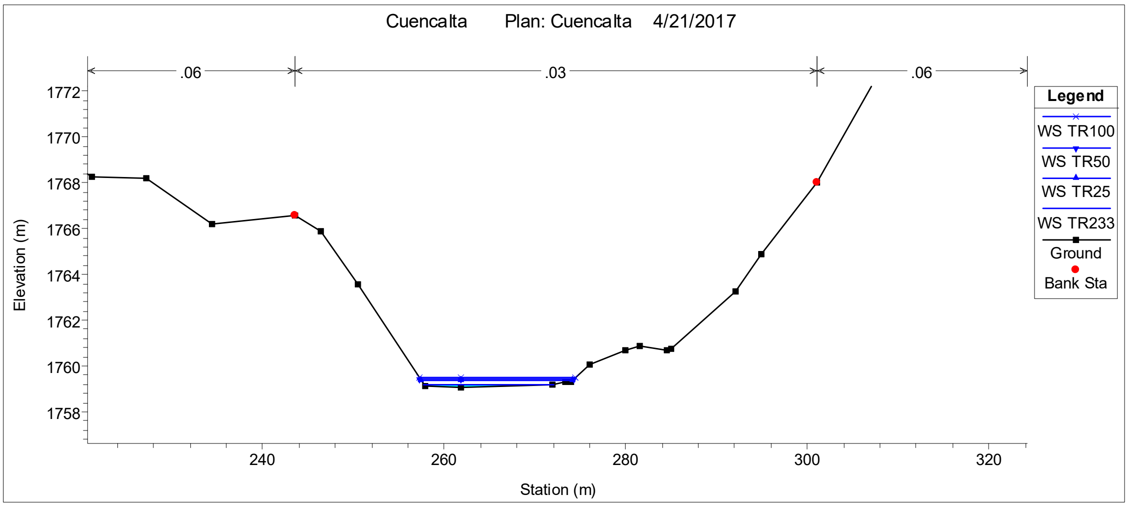
In this project, the following data were obtained as part of the topographic data to perform different types of analysis.

1) LIDAR data (result o a previous project)

2) Surveys of cross section (result of another previous project) and some surveys carried out in some points in the project.

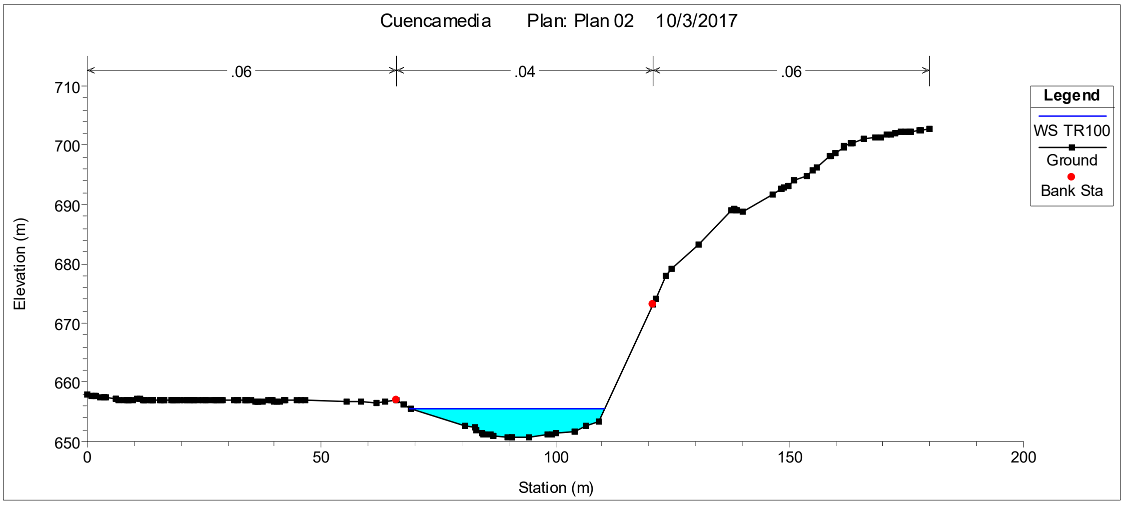
3) 2 types of DEM prepared with satellite data, one with a resolution of 12m DSM (the entire basin) and another with a resolution of 5m DSM (the main channel and zones bordering the main tributaries) (purchased in this project).

Below are the cross sections of the main points close to the main channel of upper basin, middle basin and nearby low basin, obtained from the above 3).



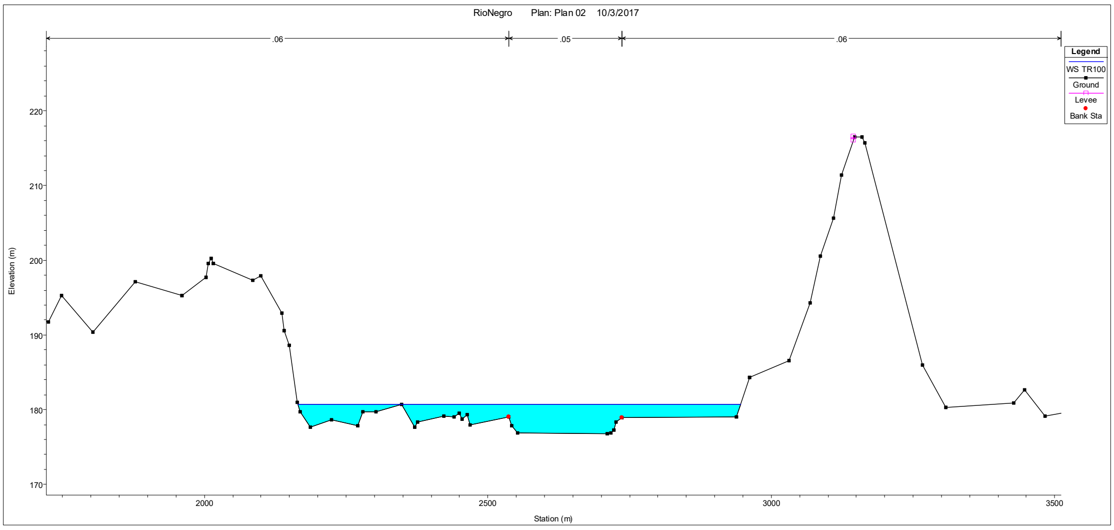
Source: WS Presentation by Mr. Juan Carlos on October 4, 2017

Figure 2.3.1 Typical Cross Section of Upstream Section of Rio Negro River



Source: WS Presentation by Mr. Juan Carlos on October 4, 2017

Figure 2.3.2 Typical Cross Section of Midstream Section of Rio Negro River

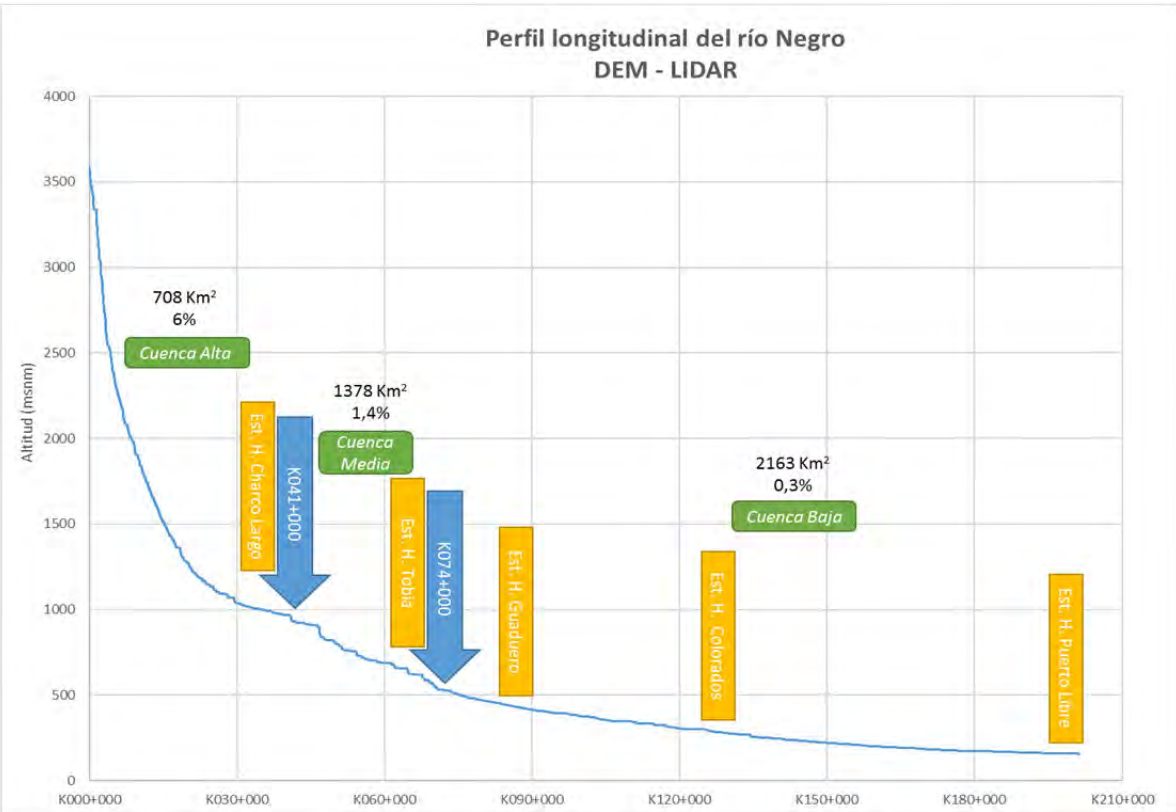


Source: WS Presentation by Mr. Juan Carlos on October 4, 2017

Figure 2.3.3 Typical Cross Section of Downstream Section of Rio Negro River

2.4 River Longitudinal Profile

The longitudinal profile of the main channel of Río Negro is presented below. Upstream, the slope is extremely high, and in the middle basin, where the height decreases, the slope begins to decrease. In the lower basin, the slope gradually becomes low.

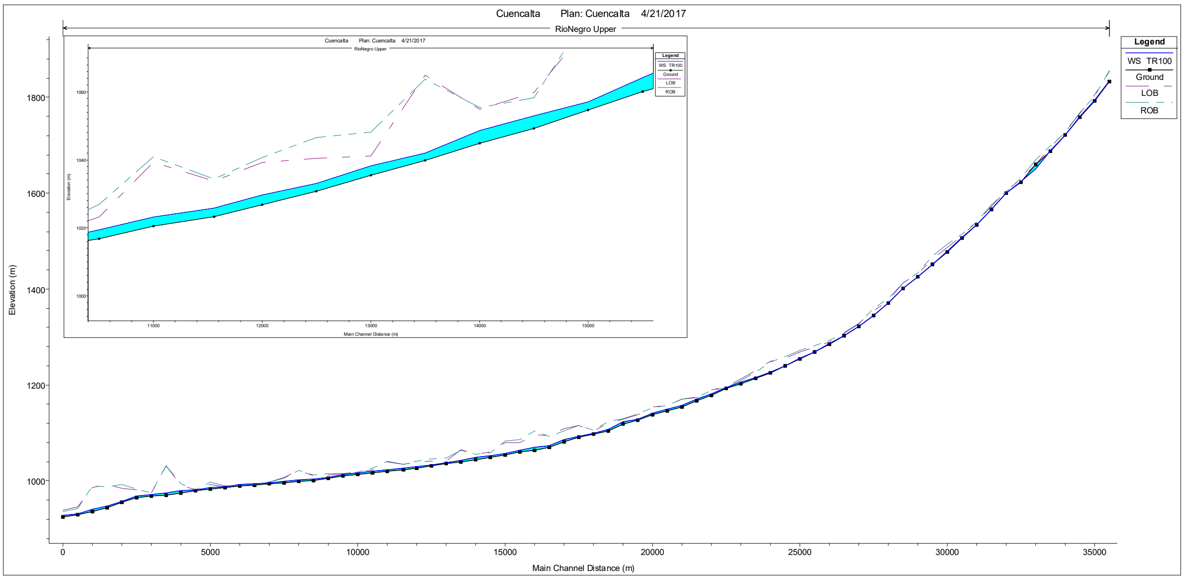


Source: WS Presentation by Mr. Juan Carlos on April 25, 2017

Figure 2.4.1 General Condition of Longitudinal Profile of Rio Negro River

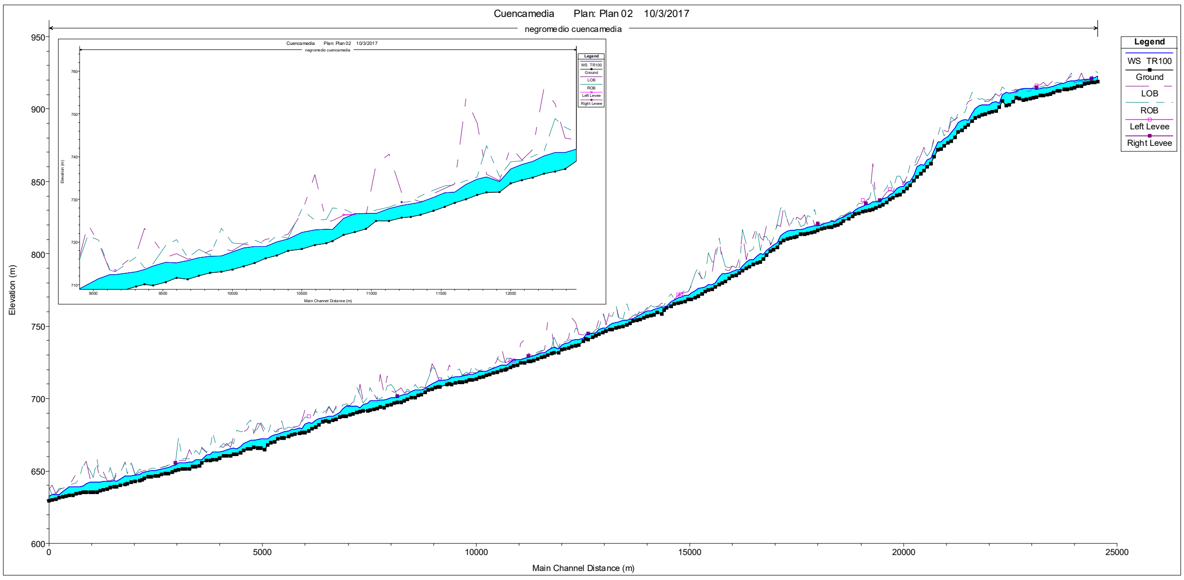
Below is the longitudinal change in the height of the riverbed and the right and left banks in the upper basin, middle basin and lower basin, in terms of the flood water level with a 100-year return period, as a result of hydraulic model calculations, from Figure 2.4.2 to Figure 2.4.4.

In the upper basin, the height of the right and left banks is higher than the level of flood water with a return period of 100 years. This also applies in most of the middle basin; however, in the lower basin, there are several sections where the height of the right and left banks is lower than the level of flood water with a return period of 100 years.



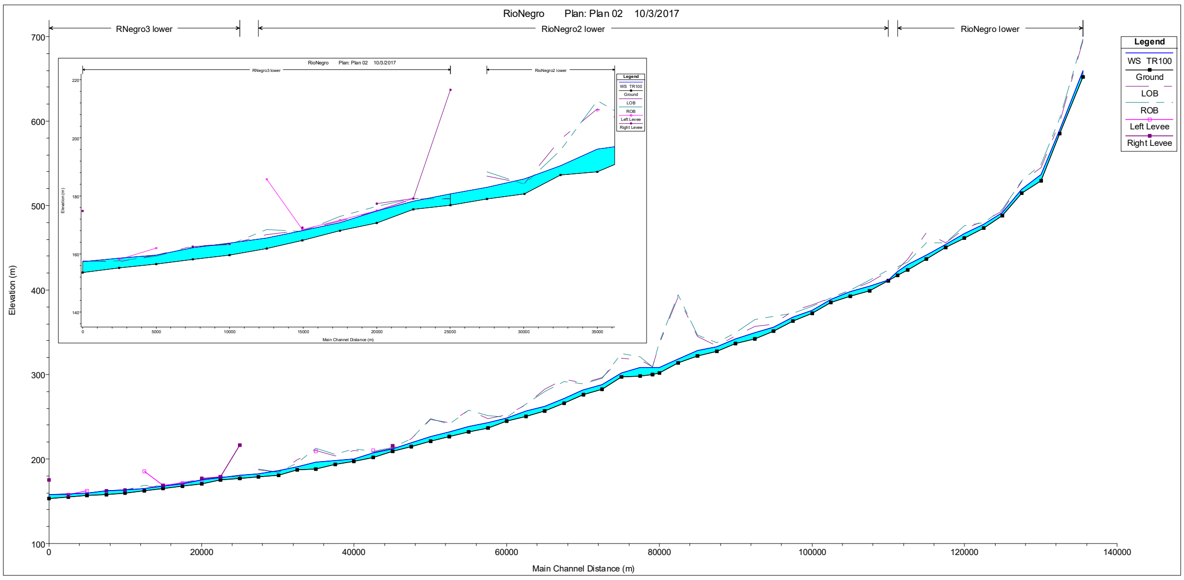
Source: WS Presentation by Mr. Juan Carlos on October 4, 2017

Figure 2.4.2 Riverbed and Riverbank Elevation of Upstream Section of Rio Negro River



Source: WS Presentation by Mr. Juan Carlos on October 4, 2017

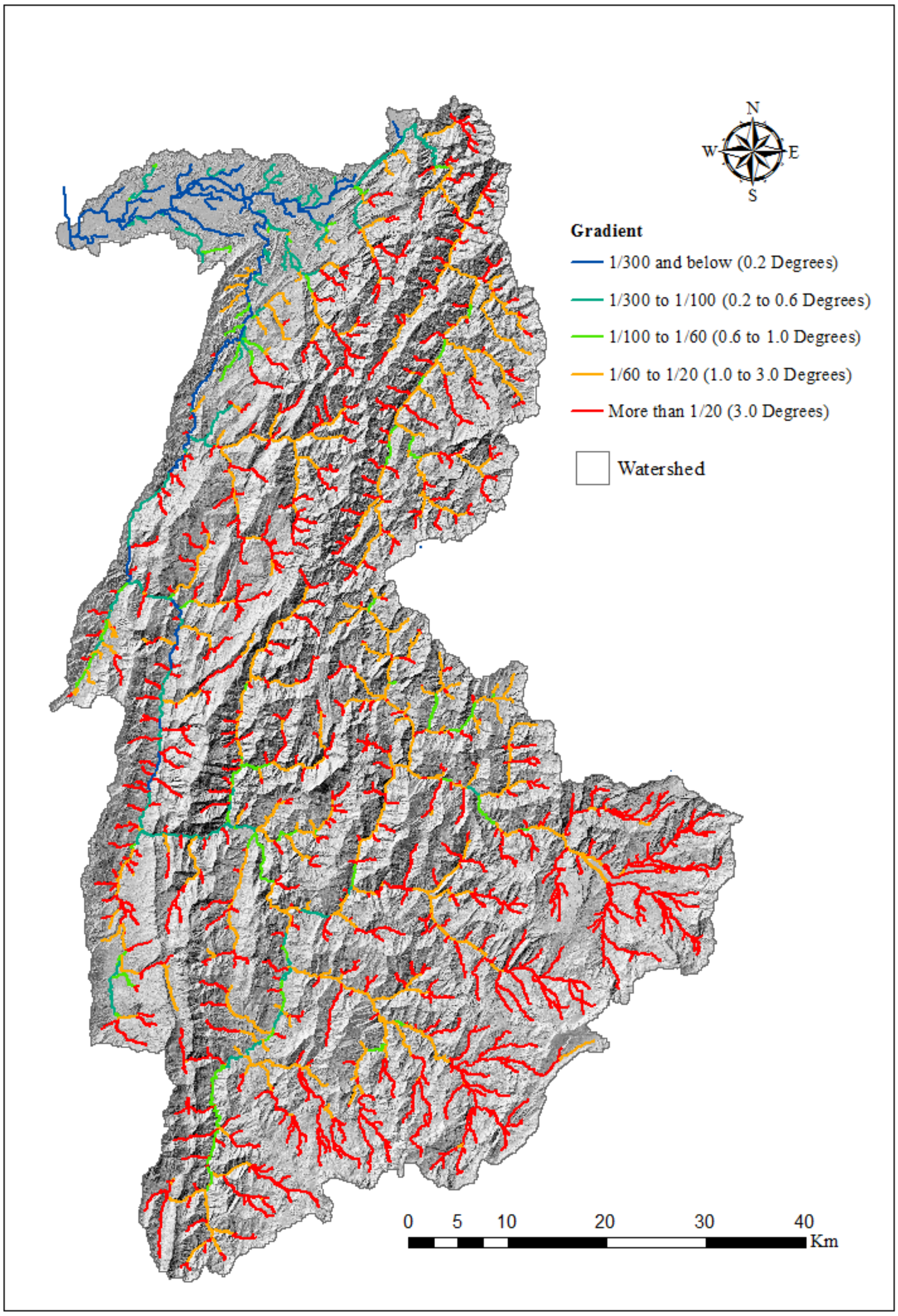
Figure 2.4.3 Riverbed and Riverbank Elevation of Midstream Section of Rio Negro River



Source: WS Presentation by Mr. Juan Carlos on October 4, 201

Figure 2.4.4 Riverbed and Riverbank Elevation of Downstream Section of Rio Negro River

Additionally, a figure that shows the channels within the basin automatically classified by slope based on the DEM data is presented below. According to this, it can be concluded that almost all the channels have slopes greater than 1/100, and there are many channels with slopes greater than 1/20 (red color). In other words, there are many channels with a steep slope, with the exception of the lower course of the main river (mainly areas downstream from Guaduero).

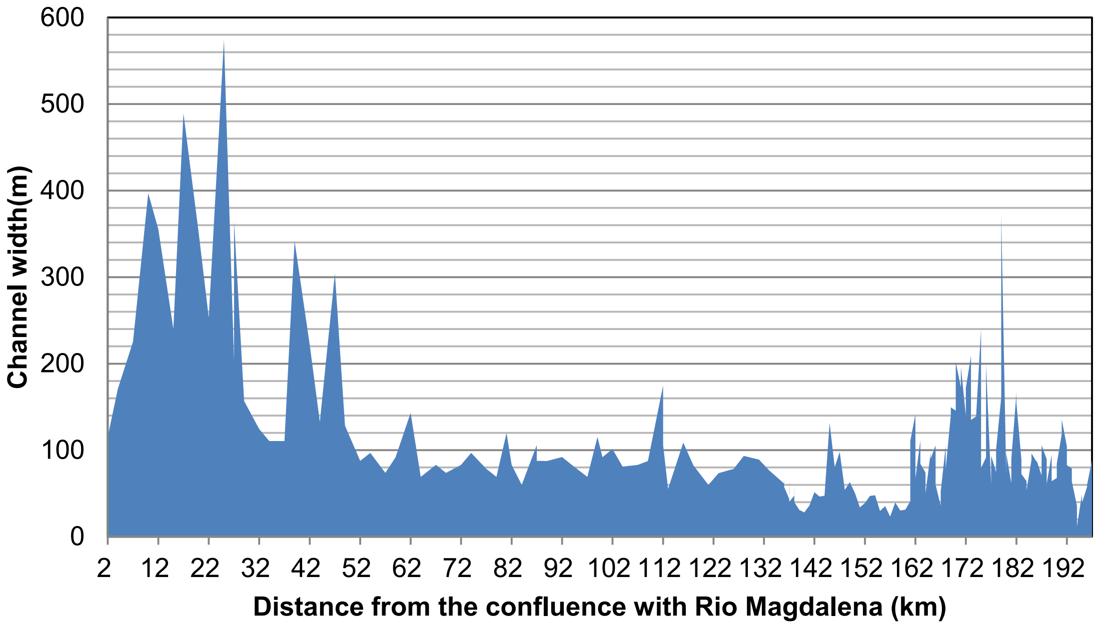


Source: JICA Project Team

Figure 2.4.5 Classifation of Channels by Slope in the Basin

2.5 Longitudinal profile of channel width

The majority of Rio Negro River is a natural river, and there are only limited parts where the channel has been fixed with dikes, etc. Therefore, determining the location of the banks and the width of the channel is extremely difficult. The figure below shows the width of the channel, assuming it is the main channel, from upstream to downstream, based on a hydraulic model built in this project. According to this figure, from the lowest point, the confluence with Río Magdalena up to approximately the 50km point, there are wide parts greater than 300m. Then, up to approximately 140km the channel stabilizes at less than 100m wide. Then, up to the 160km point approximately, sections smaller than 40m are observed, and later it widens again upstream.



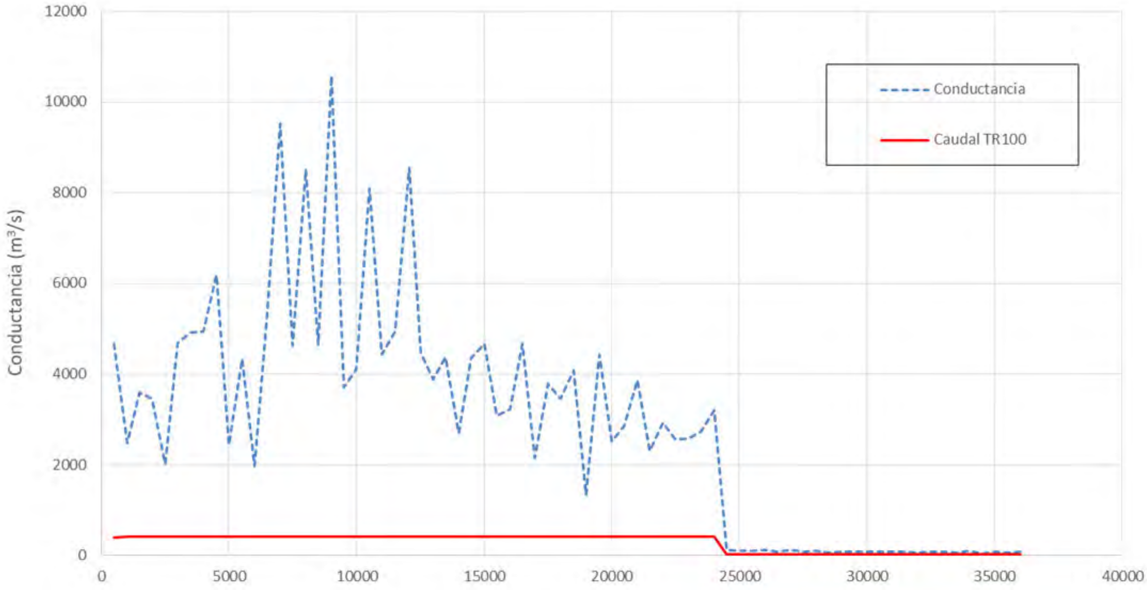
Source: JICA Project Team

Figure 2.5.1 Longitudinal Profile of Channel Width in Rio Negro River

2.6 Longitudinal profile of channel flow capacity

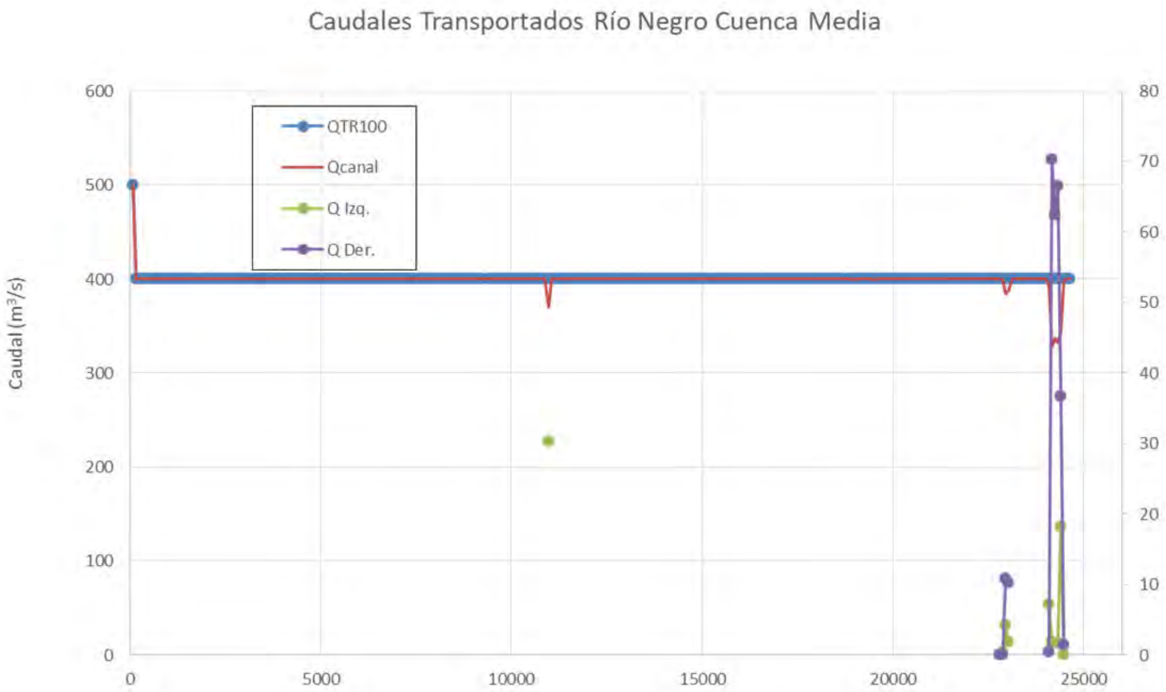
In Figures 2.6.1 to 2.6.3. the flow capacity of the riverbed for the upper, middle and lower basins of the Río Negro is presented. In the upper basin, the flow capacity of the channel exceeds the f the flood discharge with return period of 100 years in the entire stretch. In a section of the middle basin and several sections of the lower basin, the flow capacity of the channel is not sufficient with respect to the flood discharge with return period of 100 years, or the flow capacity evaluated according to the bank height Right or left or both banks is not enough.

In the figure, the parts where the line of conductance of the right and left banks is lower than the line of flow TR100 are the sections where the flow capacity is not sufficient.



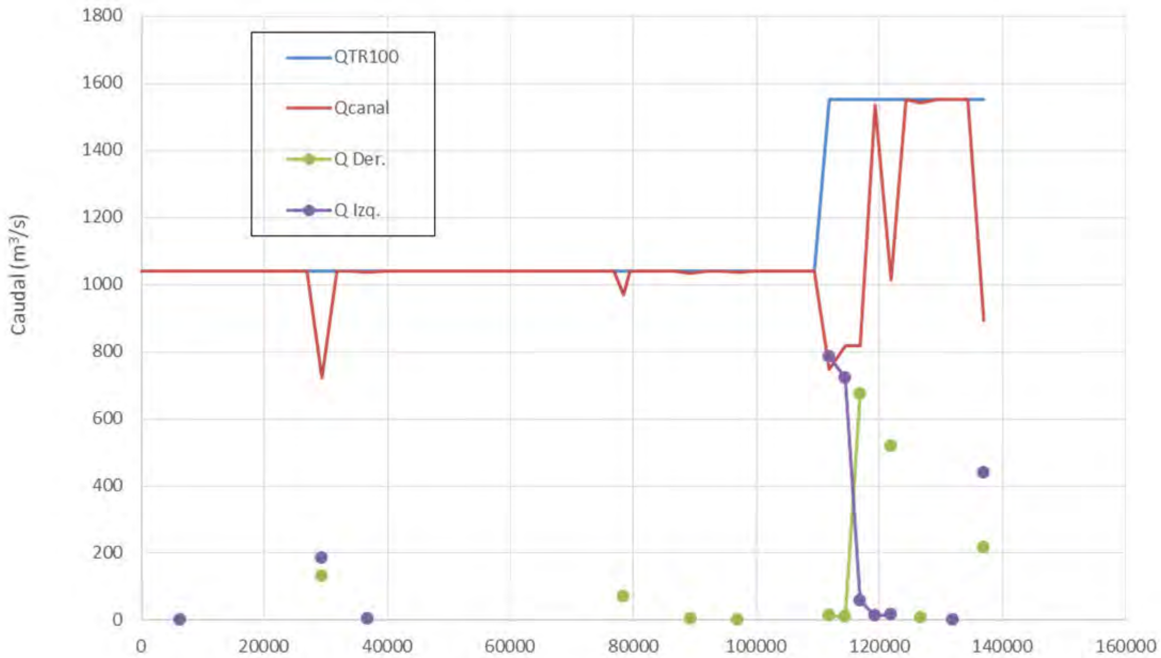
Source: WS Presentation by Mr. Juan Carlos on October 4, 2017

Figure 2.6.1 Channel Flow Capacity of Upstream Section of Rio Negro River



Source: WS Presentation by Mr. Juan Carlos on October 4, 2017

Figure 2.6.2 Channel Flow Capacity of Midstream Section of Rio Negro River



Source: WS Presentation by Mr. Juan Carlos on October 4, 2017

Figure 2.6.3 Channel Flow Capacity of Downstream Section of Rio Negro River

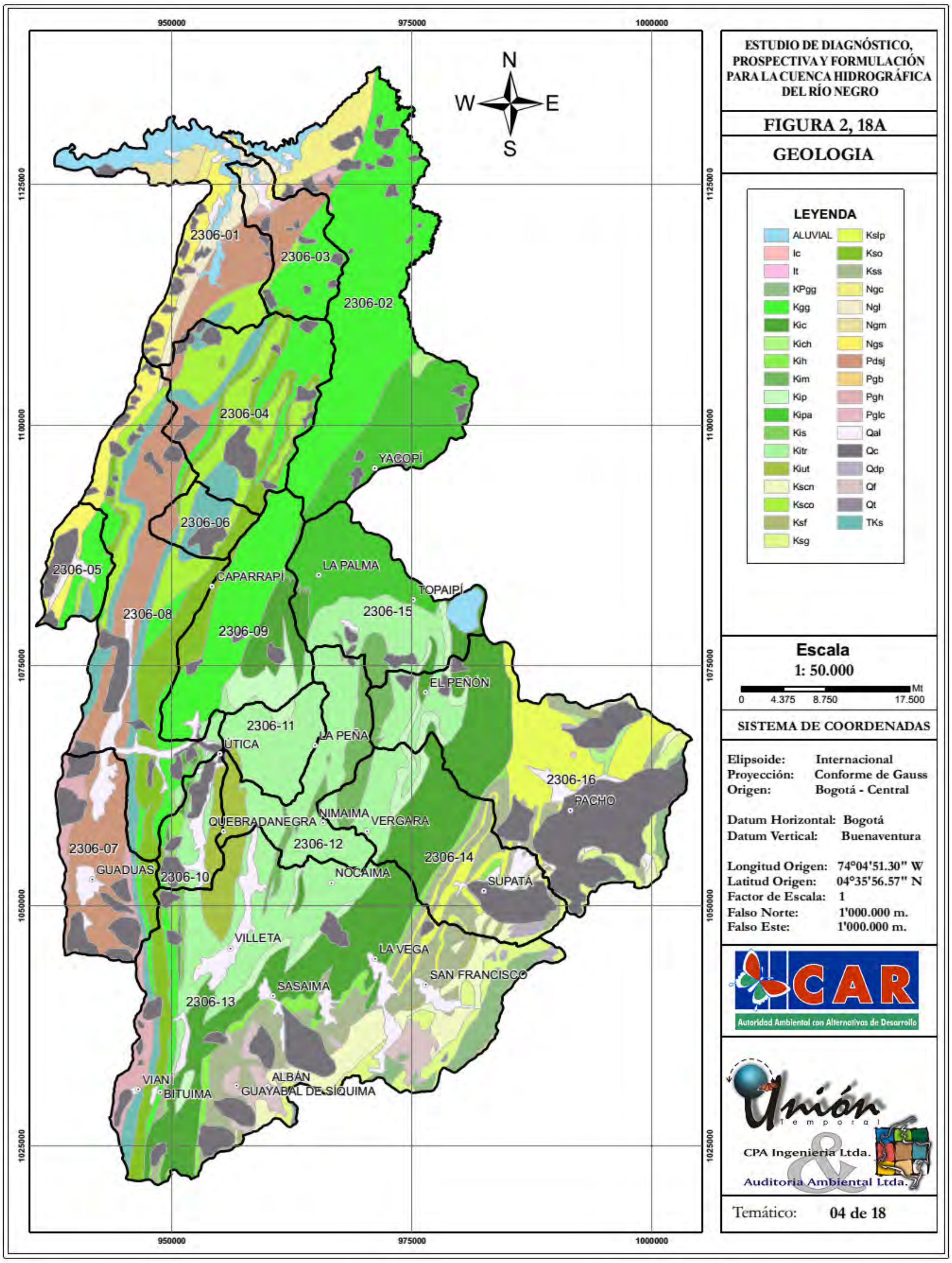
2.7 Geological condition

The Rio Negro basin is comprised mainly of rocks of sedimentary origin and the presence of two intrusive bodies stands. These rocks are located in basins or blocks, constrained together by major faults, where units have particular facial features.

The description of the exposed lithostratigraphic units in the basin has been based on three types of stratigraphic nomenclature according to the three main building blocks of the area:

- Guaduas - Middle Magdalena Valley.
- Anticlinorium of Villeta.
- Sabana de Bogotá.

Geological condition in the basin and explanation of classified items is shown in Figure 2.7.1 and Table 2.7.1, respectively.



Source: POMCA

Figure 2.7.1 Geological Condition in the Basin

Table 2.7.1 Explanation of Classified Items/Legend of Geological Condition Map in the Basin

Unit	Unit/Location	Lithology	Hydrogeological Characteristics
ALUVIAL	Alluvions	Land created along the river or lake by deposited alluvium	Information unavailable
Ic	Information unavailable	Information unavailable	Information unavailable
It	Information unavailable	Information unavailable	Information unavailable
KPgg	Fm Guaduas	Laminated to non-laminated, light gray, variegated clay stones with intercalations of quartz-sandstones.	Predominance of levels of clay stones with low permeability, units of low hydrogeological importance.
Kgg	Gr. Guaguaquí	*Lodositas* (translation not found)	Impermeable rocks with low capacity to accumulate groundwater
Kic	Fm Capotes	Laminated black calcareous siltstone and muddy claystone	Semi-permeable layers to impermeable layers of moderate hydrogeological importance. Secondary porosity due to fractures and due to dissolution of limestone at some levels.
Kich	*Chiquinquirá Region*	Fine quartz, light gray, dark gray and black sandstones, in thin to thick layers, with intercalations of lodolites and siltstone.	Information unavailable
Kih	Fm Hiló	Sequence of siliceous and calcareous siltstone	Semi-permeable layers to impermeable layers of moderate hydrogeological importance. Secondary porosity due to fractures and due to dissolution of limestone at some levels.
Kim	Fm Murca	Sub-arkosic sandstones and black mudstones	Good permeability conditions and good hydrogeological conditions
Kip	Fm El Peñón	Mudstone and calcareous siltstones	Semi-permeable layers to impermeable layers of moderate hydrogeological importance. Secondary porosity due to fractures and due to dissolution of limestone at some levels.
Kipa	Gr. La Palma	A monotonous and thick series of siltstone, shale, and light gray to black clay soil, muscovite, with intercalations of dark green clayish sandstone of fine grains, in thick layers with thin and sporadic levels of calcareous. Towards the middle part of the sequence, siltstone and holes up to 30cm in diameter.	Information unavailable
Kis	Fm Socotá	Gray shales	Semi-permeable layers to impermeable layers of moderate hydrogeological importance. Secondary porosity due to fractures and due to dissolution of limestone at some levels.
Kitr	Fm Trincheras	Mudstone with intercalation between limestone and sandstone	Semi-permeable layers to impermeable layers of moderate hydrogeological importance. Secondary porosity due to fractures and due to dissolution of limestone at some levels.
Kiut	Fm Útica	Sub-arkosic sandstone and sublitharenite with fine to sometimes very thick grains and sometimes conglomerate, mudstone with intercalation between limestone and sandstone	Good permeability conditions and good hydrogeological conditions.
Kscn	Fm Conejo	Mudstones with some sandy banks (*bancos*)	Semi-permeable layers to impermeable layers of moderate hydrogeological importance. Secondary porosity due to fractures and due to dissolution of limestone at some levels.
Ksco	Fm Córdoba	Calcareous siltstone, stratified with	Permeable and semi-permeable rocks

Unit	Unit/Location	Lithology	Hydrogeological Characteristics
		sandy, black limestones and calcareous sandstones	with high capacity to dissolve carbonates and with moderate hydrogeological capacity
Ksf	Fm La Frontera	Mudstone with some sandstone banks (*bancos*)	Semi-permeable layers to impermeable layers of moderate hydrogeological importance. Secondary porosity due to fractures and due to dissolution of limestone at some levels.
Ksg	Gr. Guadalupe	Massive sandstones and crumbly sandstones	Good permeability conditions. Within the savannahs of Bogotá, this makes up units of high hydrogeological importance.
Kslp	Fm. Pacho	An alternating succession of lodolites with undulating lamination, interspersed with siliceous siltstones and quartz sandstones, in thin to medium rippled layers. As a special feature there are concretions of siderite up to 1.5m in diameter.	Information unavailable
Kso	Gr. Olini	Superior black compact chert	Semi-permeable rocks with low hydrogeological capacity
		Level of shales	Impermeable rocks with low capacity
		Inferior black compact chert	Semi-permeable rocks with low hydrogeological capacity
Kss	Fm Simijaca	It consists principally of laminated, black to dark gray claystone.	Information unavailable
Ngc	Fm Cambrás	Gray, greenish or violet claystones, with fine to medium grain quartz-sandstone	Impermeable rocks with low capacity to accumulate groundwater
Ngl	Fm Los Limones	Succession of sandstones and red shales in thin to medium layers	Semipermeable layers of moderate hydrological importance
Ngm	Fm Mesa	Gravels and sands, with intercalation of layers of clay	Good permeability conditions and good hydrogeological conditions
Ngs	Stock de Sucre	Monzodiorites, pyroxenic and homblendic diorites.	Information unavailable
Pdsj	Fm San Juan de Río Seco	Sequence of sandstone and clay stone	Good permeability conditions and good hydrogeological conditions
Pgb	Fm Bogotá	Sandstones, mudstones, clay stones	Levels of clay of low hydrogeological importance in the savannahs of Bogotá. This unit in the levels of sandstones make up the regional aquifer of the savannah of Bogotá. (Direct translation, not comprehensible in Spanish)
Pgh	Fm Hoyón	Conglomerate sequence intercalated between quartz-sandstone and lime-sandstone	Good permeability conditions and good hydrogeological conditions
Pglc	Fm La Cira	Compound of blueish clay alternating with sandstone	Impermeable rocks with low capacity to accumulate groundwater
Qal	Alluvial deposits. *Rivers and streams*	*These deposits consist of rounded and sub-rounded blocks, especially of sandstone and limestone, in a non-consolidated matrix of sands and clays.*	Moderate to high hydrogeological importance especially for the free or unconfined aquifers
Qc	*Colluvial deposits Slope Deposits*	*Colluvial deposits consist of accumulations of materials of heterogeneous composition and of variable size, predominant in an angular form due to the little and iniquitous transport by the different erosive agents that result in varied composition and coloration without stratification.*	Information unavailable
Qdp	*Slope Deposits.*	They are deposits accumulated during the recent Quaternary, of different granulometry ranging from silty to	Information unavailable

Unit	Unit/Location	Lithology	Hydrogeological Characteristics
		sandy with blocks. Alluvial and lacustrine sediments, all of local origin.	
Qf	Fluvioglacial deposits	Deposits associated with meltwater from glaciers.	
Qt	Beach Deposits	Deposit found on river, lake or seaside beaches.	Information unavailable
TKs	Fm Seca	A monotone sequence of black, calcareous lodolites with parallel flat lamination. Above, calcareous rocks with lamina flaser and lenticular corresponding to biosparite are present. This package reveals calcareous sandstones in thin layers with intercalations of lodolite and sporadically calcareous concretions. Towards the upper part of the sequence there are packages of medium to thick calcareous sandstone, with green and red conglomerate sandstone interlacing.	Information unavailable

Note: Fm = Formation, Gr = Group

Sources:

POMCA Chapter 2 Diagnosis
INGEOMINAS: http://www.simec.gov.co/portals/0/Mapas/Mapa_Miner_Metal.pdf
SGC:
http://aplicaciones1.sgc.gov.co/Bodega/i_vector/130/10/0100/20400/documento/pdf/0101204001101000.pdf

3. Hydrology and Hydraulics

3.1 General meteorological, hydrological conditions

3.1.1 General meteorological and hydrological conditions

The distribution of rainfall throughout the year is marked by the movement of the Intertropical Convergence Zone (ITCZ) over the equatorial zone, corresponding to a strip of low pressures where they arrive currents of warm air and wet from large high pressure belts located in the subtropical zone of the Southern and Northern hemispheres, giving rise to the formation of large cloud masses and abundant rainfall. The ITCZ tends to follow the apparent movement of the sun with a delay of approximately two months.

The occurrence of two rainy seasons throughout the year, the first from early April to late June and the second from September to late November, are caused by the passage of the ITCZ on the Colombian Andean region, with the movement of south to north of the ITCZ for the first wet period and the downward movement from north to south for the second period; intermediate to the occurrence of the two wet periods two dry periods interspersed.

In addition to the passage of the ITCZ, the second climatological process that determines the behavior of precipitation in the basin has its origin in local convective systems, generating character orographic rainfall especially in the highlands of the Rio Negro basin.

The average annual rainfall in the basin is about 2,000mm ranging from 1000 mm in the upper part of the basin in the birth of Batan River in the southeastern part of the basin up to 2950 mm in the northeastern margin of the basin, in the sub-basins of Mores Guaguaquí rivers.

Source: POMCA

3.1.2 Conditions of Hydrological Observation

(1) Meteorological Stations (Rainfall Stations)

There are approximately 20 precipitation stations that IDEAM administers within the basin, of which 2 count with the real-time communication (Quebrada Negra and Villeta, installed in 2006), and these record data per hour. Other stations record only daily precipitation.

In the analysis carried out in this IFMP-SZ, the data of the stations administered by the CAR were also used. The following table shows a list of the stations administered by IDEAM and the CAR. The stations with the 7-digit code are the stations administered by the CAR.

Table 3.1.1 List of Meteorological Stations in the Basin

Code	Name	Type	Basin/River	Department	Municipality	Latitude	Longitude	Elevation (m)
23060150	PTO LIBRE	PM	NEGRO	Cundinamarca	PUERTO SALGAR	5.758278	-74.627333	1836
23060090	YACOPI	PM	HATICO	Cundinamarca	YACOPÍ	5.500000	-74.366667	1416
23060110	CAPARRAPI	PM	PATA	Cundinamarca	CAPARRAPÍ	5.352194	-74.494778	127
23060140	TUSCOLO EL	PM	NEGRO	Cundinamarca	GUADUAS	5.078222	-74.611806	975
23060160	SAN PABLO	PM	QDA PITA	Cundinamarca	CAPARRAPÍ	5.485083	-74.462417	12
23060170	PALMA LA	PM	MURCA	Cundinamarca	LA PALMA	5.349361	-74.389111	1462
23060180	PENON EL	PM	NEGRO	Cundinamarca	EL PEÑÓN	5.253444	-74.294500	14
23060190	UTICA	PM	NEGRO	Cundinamarca	ÚTICA	5.196083	-74.485500	497
23060200	SUPATA	PM	SUPATA	Cundinamarca	SUPATÁ	5.059694	-74.239167	1798
23060260	CHILAGUA FCA	PM	TOBIA	Cundinamarca	NOCAIMA	5.064639	-74.382028	15
23060270	CABRERA LA	PM	NEGRO	Cundinamarca	PACHO	5.133333	-74.150000	2
23060290	SILENCIO EL	PM	NEGRO	Cundinamarca	SASAIMA	4.973167	-74.412056	1425
23060370	ESTANCIA LA	PM	TOBIA	Cundinamarca	LA VEGA	4.966667	-74.366667	128
23065060	STA TERESA	CO	NEGRO	Cundinamarca	ALBÁN	4.842167	-74.461694	22
23065100	SABANETA	CO	NEGRO	Cundinamarca	SAN FRANCISCO	4.901750	-74.307389	2475
23065110	YACOPI	CO	MORAS	Cundinamarca	YACOPÍ	5.484167	-74.354583	1347
23065120	CABRERA LA	CO	NEGRO	Cundinamarca	PACHO	5.141556	-74.139361	2
23065130	MONTELIBANO	CO	MORAS	Cundinamarca	YACOPI	5.466667	-74.366667	1340
23065140	STA BARBARA	CP	DULCE	Cundinamarca	SASAIMA	4.950000	-74.416667	1450
23065150	STA ROSITA	CP	NEGRO	Cundinamarca	EL PENON	5.283333	-74.283333	1430
23065200	TRAPICHE EL	CO	VILLETA	Cundinamarca	VILLETA	5.028194	-74.503917	1068
2306033	AGUA FRÍA	PM	QDA. CHARCON	Cundinamarca	QDA. NEGRA	5.100222	-74.472167	1319
2306034	SAN ISIDRO	PM	CUNE	Cundinamarca	VILLETA	5.049556	-74.506361	1136
2306039	TIESTOS LOS	PM	NEGRO	Cundinamarca	LA PALMA	5.355917	-74.408222	1664
2306308	NEGRETE	PM	RIO NEGRO	Cundinamarca	PACHO	5.096861	-74.154083	2318
2306507	INST. AGRÍC. ESC. VOCACIONAL	CP	RIO NEGRO	Cundinamarca	PACHO	5.158639	-74.023889	1932
2306516	ACOMODO EL	CP	RÍO NEGRO	Cundinamarca	LA VEGA	5.017667	-74.309667	1384
2306517	GUADUAS	CP	RÍO GUADUERO	Cundinamarca	GUADUAS	5.056500	-74.597972	1052
2306519	CAPARRAPI	CP	RÍO NEGRO	Cundinamarca	CAPARRAPÍ	5.340389	-74.495167	1311

PM: Rainfall

CP: Climatological main

CO: Climatological ordinary

Source: Data from Fabio, July 11, 2017

The following figure shows the periods for which there are daily rainfall data available in the stations on the previous list. There is data available since 1958 in one case, although the periods for which observational data are available vary according to the station.

Número de para estaciones IDEAM en la cuenca de Rio Negro

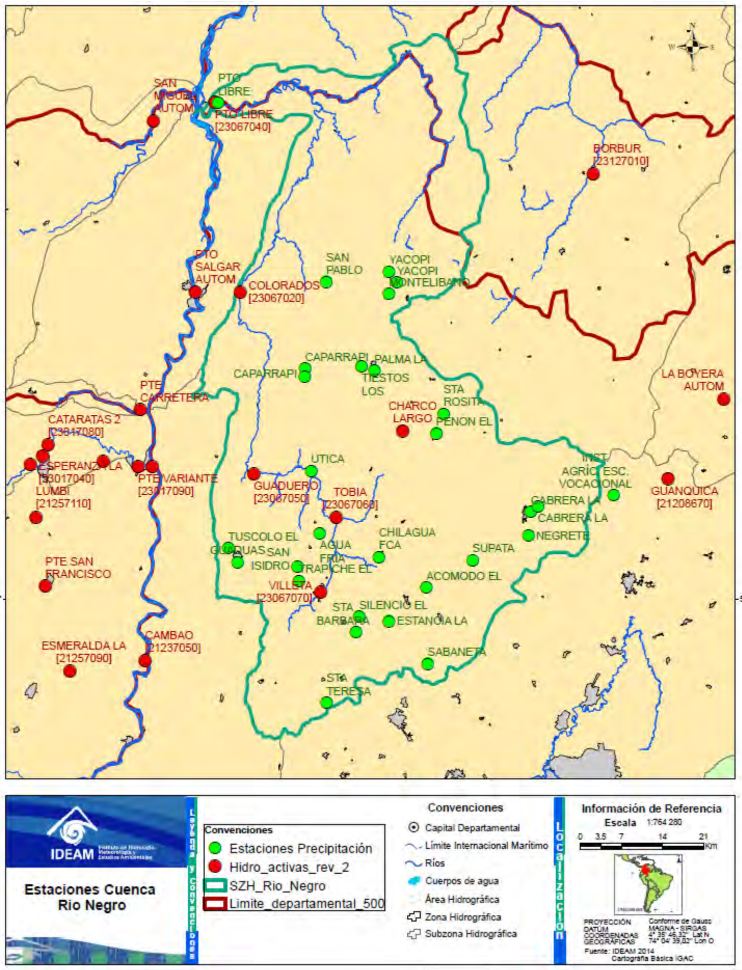
Código	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
23060150																	146	365	364	365	334	365	366	365	352	364	241	334	329	349
23060090	166	365	60	153	365	365	366	365	365	365	366	365	352	291	366	354	348	56												
23060110		252	366	365	365	325	305		365	365	366	365	365	365	366	365	365	365	282	306	365	365	244	365	365	365	366	365	365	365
23060140														322	366	365	365	365	366	365	360	365	366	365	365	365	366	335	365	365
23060160																	105	364	275	304	365	365	366	365	365	365	365	365	365	365
23060170																						31	122	365	365	365	365	335	245	365
23060180																	119	365	366	365	353	365	364	365	365	365	366	365	365	365
23060190																	122	340	366	365	363	365	366	365	365	365	366	364	365	365
23060200																	28	365	366	365	365	361	360	365	365	362	365	364	364	365
23060260																														31
23060270														214	365	334	31													
23060290																													297	365
23060370																														
23065060																														
23065100																													31	365
23065110																	92	365	304	339	340	341	257		365	364	365	363	364	365
23065120																	116	364	366	365	365	365	334	220	360	365	365	364	365	92
23065130													364			365	365	365	366	365	365	365	366	365	365	365	366	365	365	365
23065140																														
23065150																														
23065200																														
2306033																														
2306034																														
2306039																														
2306308																														
2306507									207	365	366	361	365	365	365	365	365	365	366	365	365	365	366	365	365	365	366	365	322	365
2306516																														
2306517																														
2306519																														

Código	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
23060150	366	365	365	365	366	365	365	365	366	365	365	365	366	365	365	334	334	365	273	365	366	274	244	364	304	304	365	272	
23060090																													
23060110	366	365	365	354	366	352	365	365	366	365	334	325	272	365	365	365	366	365	293	362	336	365	365	365	182	59	365	365	305
23060140	366	282	365	365	366	365	365	365	366	353	365	365	366	365	334	365	366	365	365	365	365	365	364	365	366	302	90		
23060160	366	365	1	365	366	364	365	365	366	365	365	305	366	365	365	365	336	365	365	363	366	334	365	364	366	364	304	329	300
23060170	366	365	365	365	366	292	365	365	366	365	364	334	336	365	365	274	214	365	362	269	358	303	303	365	366	365	365	363	267
23060180	366	365	365	365	366	365	365	365	366	365	365	365	366	365	365	365	366	365	365	364	335	361	365	334	366	365	364	365	276
23060190	320	122	364	365	365	364	365	365	366	365	365	365	307	335	365	335	366	365	333	365	365	361	365	107	255	334	364	365	121
23060200	366	365	358	364	305	365	365	364	337	365	365	365	366	365	365	365	366	362	363	362	365	335	304	365	366	362	365	363	305
23060260	366	364	365	365	366	364	365	365	366	365	365	365	366	365	365	365	365	363	365	364	366	332	365	334	366	334	333	304	244
23060270																													
23060290	366	365	365	365	366	365	365	365	366	365	334	312	366	365	364	365	366	365	363	365	362	364	363	365	363	365	364	365	305
23060370																						365	363	365	336	365	365	334	244
23065060		295	360	365	335	365	365	365	366	365	354	356	365	364	365	365	365	364	364	365	366	364	365	365	182	150	220		
23065100	358	364	364	365	366	301	364	364	364	365	365	364	361	362	362	359	348	362	363	358	356	272	365	359	360	360	16		90
23065110	366	356	365	363		365	365	365	366	365	365	351	332	359	350	271	256	354	365	301	365	365	304	226	153	363	364	302	305
23065120	275	354	365	333	366	365	365	365	366	365	365	364	359	364	361	360	365	363	362	302	364	365	365	365	274	303	181	364	275
23065130	366	365	365		366																								
23065140		365	365		366																								
23065150					366		365																						
23065200																						213	365	362	365	331	120		
2306033								228		214	365	365	366	359	364	141			365	306	336	365	364	365	366	365	365	181	
2306034																152	359	358	334	306	333	365	363	365	366	365	365	181	
2306039																				300	336	365	364	363	366	364	365	181	
2306308																				302	363	365	365	317	366	365	365	181	
2306507	365			365	366	365	361	359	366	365	303	365	366	336	350	334	366	365	363	365	365	229	365	365	358	365	365	120	
2306516													100	348	265	245	366	365	141	356	322	365	355	316	351	356	354	155	
2306517													103	329	126	226	305	249	355	361	315	312	351	342	359	362	361	53	
2306519																							342	241					

Source: WS Presentation by Mr. Fabio on July 19, 2017

Figure 3.1.1 Number and Period of Available Daily Rainfall Data of IDEAM Rainfall Stations in the Basin

The locations of the stations in Rio Negro basin are shown below.



Source: WS Presentation by Mr. Fabio on May 26, 2017

Figure 3.1.2 Locations of Meteorological and Hydrological Stations in the Basin

(2) Water Level Gauging Stations

The table below shows stations that have water level data in the basin administered by IDEAM. Within these, 2 stations (Tobia and Villeta) record hourly data, and in the remaining 6, 2 daily measurements are taken. The 6 stations have the data of the cross section of the observation point, and the stations in Colorados, Guaduero, Tobia, and Charco Largo have H-Q curves. The locations of the stations are presented in Figure 3.1.2, along with the precipitation stations.

Table 3.1.2 List of Water Level Gauging Stations in the Basin

Code	**Name**	**Municipality**	**East (m)**	**North (m)**	**Altitude (m.s.n.m)**	**Type**	**Registration Years**
2306702	Colorados	Puerto Salgar	945794	1100394	286	LG	52 – 02
2306704	Puerto Libre	Puerto Salgar	937649	1127241	180	LG	65 – 02
2306705	Guaduero	Guaduas	946145	1066476	410	LG	65 – 02
2306706	Tobia	Nimaima	959076	1059095	620	LG	65 – 01
2306707	Villeta	Villeta	957220	1046194	790	LM	77 – 02
2306708	Charco Largo	La Palma	969359	1072304	940	LG	65 – 01

m.s.n.m: Meters above sea level.

LM: Limnimnetrica

LG: Limnigráfica

Source: POMCA

The periods for which water level data (daily level) are available are presented in Figure 3.1.3. It includes the information about the stations currently out of order and the stations managed by the CAR that are not in the previous list. There are data available since 1972, and the 6 stations on the list have the data available from 1974 for the most part. The CAR stations started the operation before 2000 approximately.

Figure 3.1.4 shows the periods for which there are available discharge data (daily discharge). In the 6 stations, data are available from the second half of the 1970s onwards.

Número de datos diarios de niveles por año para estaciones IDEAM y CAR en la cuenca de Rio Negro

Código Estación	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
23067020	320	360	350	352	366	365	363	365		365	201	365	366	365	343	361	310	365	365	320	366	365
23067040				267	366	365	365	365		254	142	312	366	365	365	365	364	365	365	365	366	365
23067050			122	364	335	365	365	365		365	365	365	366	365	365	365	263	327	247	237	366	365
23067060			120	360	366	365	365	293	343	365	365	363	366	365	365	365	366	365	365	359	366	365
23067070			87	343	366	365	330	321	279	365	365	365	366	361	365	336	366	341	273	344	366	365
23067080			92	363	366	365	365	365	366	365	365	365	366	289	223	38	245	332	365	365	366	365
23067090			120	365	366	327	362	365	293	343	293	359	274	233	365	365	330	294	358	358	366	306
2306710																						
2306711																						
2306712																						
2306713																						
2306714																						
2306715																						
2306716																						
2306717																						
2306718																						
2306728																						
2306729																						
2306730																						

Código Estación	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
23067020	365	365	366	365	365	365	366	365	365	365	366	362	365	294	364	365	365	365	366	365	365	365
23067040	365	309	366	365	365	365	366	313	365	266	337	353	309	365	346	337	365	365	361	365	365	365
23067050	365	365	366	365	365	365	353	360	365	357	366	186	215	234	343	350	361	269	152	365	365	
23067060	365	365	366	365	365	365	341	359	365	365	329	364	365	345	330	365	365	360	364	365	365	
23067070	365	365	366	365	350	365	365	365	365	365	324	365	363	365	366	227	305	363	366	204	365	
23067080	365	354	366	365	340	365	118	298	357	79	119	361	365	365	366	365	365	365	366	364	365	
23067090																						
2306710		228	348	334	365	306	366	339	365	151			304	365	336	365	365	365	366	365	365	181
2306711					82	240	357	364	340	365	340	352	260	268	358	357	360	349	363	361	360	89
2306712					1	276	115	153	167	147		65	216	271	326	290	339	217				
2306713						205	234	364	356	365	365	86	365	364	356	342	305	304	361	345	364	181
2306714						182	366	365	364	365	365	364	355	356	364	365	365	365	366	365	365	181
2306715					17	320	352	85	94		353	349		257	318	347	349	201	265	352	351	79
2306716												191	364	337	262	365	365	319	365	365	365	181
2306717						190	364	365	362	179	153	243	242	337	366	274	122	222	365	365	365	181
2306718						330	366	339	178					356	364	209						
2306728																334	365	365	366	365	365	181
2306729																304	365	363	366	364	365	170
2306730																277	341	360	366	364	364	181

Source: WS Presentation by Mr. Fabio on July 19, 2017

Figure 3.1.3 Number and Period of Available Water Level Data of IDEAM and CAR Gauging Stations in the Basin

Número de datos diarios de Caudal por año para estaciones IDEAM en la cuenca de Rio Negro

Estación	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
23067020	365	365	366	365	365	365	366	365	184	365	366	365	365	365	305	365	365	351	366	365
23067040		365	366	365	365	365	366	275	122	365	366	365	365	365	364		365	365	366	365
23067050	153	365	366	365	365	365	366	365	365	365	366	365	365	365	249	296	252	237	366	365
23067060	120	360	366	365	365	303	366	365	365	365	366	365	365	365	366	365	365	359	366	365
23067070				364	352	333	291	345	359	361	366	365			366	341	270	344	366	365
23067080		365	366	365	365	365	366	365	365	365	366	335	243		263	365	365	365	366	365
23067090			366	334	365	365	31	334	274	365	305	274	365	365	330	319				

Estación	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
23067020	365	365	366	365	365	365	366	365	365	365	366	362	365	294	364	365	365	364	366	365	365
23067040	365	309	366	365	365	365	366	307	336	259	337	353	309	365	346	337	313	349	361	365	351
23067050	365	365	366	365	365	365	353	360	365	357	366	186	208	234	343	350	358	268	152	358	362
23067060	365	365	366	365	365	365	341	359	365	365	329	363	365	345	330	365	365	360	364	365	365
23067070	365	365	366	365	350	365	365	365	365	365	324	364	363	365	366	227	302	351	366	205	312
23067080	365	354	366	365	340	365	118	298	357	79	119	360	365	365	366	365	365	365	366	365	365
23067090																					

Source: WS Presentation by Mr. Fabio on July 19, 2017

Figure 3.1.4 Number and Period of Available Discharge Data of IDEAM Stations in the Basin

3.2 Water levels and Discharge at main hydrological stations

The results of the organization and analysis of the data from the 6 IDEAM stations are presented below. Keep in mind that in Colombia, there recently was a change in the standard of elevation above sea level. Water levels in the stations generally use the reference level at that point; however, there are cases in which the conversion of this value to the elevation above sea level has not been completed. Therefore, the water level data is not sufficiently reliable. As a result, it was decided to use the discharge data mainly in the analysis of river flow in this IFMP-SZ.

(1) Annual Maximum Discharge

The maximum annual flow of each station is presented in the table below. In all seasons, it is observed that the maximum flow tends to register between April and May or between October and November in most cases.

Table 3.2.1 List of Annual Maximum Discharge in Six Stations in the Basin

	COLORADOS			PTO LIBRE			GUADUERO			TOBIA			VILLETA			CHARCO LARGO		
year	**month**	**day**	**23067020**	**month**	**day**	**23067040**	**month**	**day**	**23067050**	**month**	**day**	**23067060**	**month**	**day**	**23067070**	**month**	**day**	**23067080**
1974	11	24	530.2				11	24	282.5	11	20	148.8						
1975	3	2	676.5	10	27	665	5	3	765.0	5	5	180.2				5	8	113.3
1976	11	5	469.2	5	2	671.8	11	6	293.3	11	5	124.6				4	17	80.1
1977	11	18	403.3	11	15	788	11	8	255.0	11	8	123.4	11	11	50.55	11	18	74.5
1978	4	20	431.0	4	20	560	4	3	393.7	4	20	128.4	4	20	41.64	3	25	113.7
1979	10	30	565.0	10	30	779.3	6	3	635.6	10	22	239.4	11	1	56.55	10	22	147.5
1980	2	4	220.3	11	24	229.4	5	2	209.5	2	4	88.4	10	11	41.25	2	4	42.8
1981	5	31	502.5	5	11	816.5	5	10	639.7	5	13	223.5	11	20	45.30	4	19	125.7
1982	4	6	324.9	5	5	626.1	2	21	439.8	10	22	148.6	4	6	118.00	4	12	87.8
1983	12	12	316.5	10	30	566.4	4	13	216.9	4	21	160.2	12	11	43.90	4	11	84.7
1984	5	15	461.5	5	15	882.2	5	15	407.9	5	15	205.9	5	26	110.20	5	15	95.3
1985	10	24	424.7	10	24	442.5	10	24	286.6	10	9	122.1	10	25	111.40	5	16	84.2
1986	4	20	476.1	4	19	800.7	4	21	355.9	4	21	183.0				10	28	85.0
1987	5	23	468.8	11	1	995.4	10	30	460.1	10	30	189.3						
1988	11	16	711.0	12	8	1038	11	18	527.7	11	16	223.2	11	28	195.90	11	16	116.5
1989	10	15	323.5				2	4	256.2	1	4	149.0	1	3	232.00	1	4	95.4
1990	12	5	728.0	5	3	851	4	26	501.1	4	26	227.5	12	5	534.30	4	27	152.9
1991	5	21	372.0	5	1	588	3	28	459.5	5	3	186.6	3	26	90.90	5	20	123.5
1992	11	29	205.6	5	9	400.3	11	29	199.6	5	7	75.8	12	12	232.50	5	7	46.1
1993	11	29	331.8	4	21	482.3	12	18	268.5	11	30	149.0	12	17	72.60	5	6	126.8
1994	4	29	441.1	4	30	924.9	4	29	481.7	4	29	183.4	2	4	401.80	2	4	141.6
1995	12	12	434.1	11	25	638.7	4	22	343.9	4	23	161.6	12	12	107.00	11	18	87.8
1996	10	15	447.8	10	15	955.4	3	7	510.4	3	11	249.3	5	27	87.00	3	7	134.7
1997	11	21	153.6	11	10	378.4	11	21	201.2	2	11	102.6	1	27	21.40	6	8	83.2
1998	11	14	531.0	11	14	669.7	11	22	448.2	11	14	186.5	10	29	20.00	5	4	81.1
1999	2	22	675.8	2	22	1227	2	22	565.9	10	27	240.8	4	4	190.40	2	20	127.4
2000	11	1	435.0	5	8	710	2	29	289.7	2	26	134.1	3	24	73.35	2	29	70.9
2001	11	14	279.6	5	28	412.5	12	13	289.7	12	13	156.0	3	1	89.65	12	13	110.3
2002	4	25	833.4	4	26	836.4	4	25	782.8	4	25	356.0	4	25	98.55	4	25	358.6
2003	4	20	418.6	12	3	665.4	11	22	268.4	11	22	172.2	11	22	91.90	1	19	22.4
2004	11	7	484.8	10	23	951.7	5	18	327.9	11	18	194.3	11	19	68.87	11	9	110.3
2005	5	23	979.3	5	19	687	10	28	407.2	5	3	226.9	10	28	57.20	10	28	139.3
2006	12	12	1155.0	5	9	880.4	5	8	376.0	5	10	306.0	11	16	71.72	5	9	174.7
2007	4	28	1029.0	10	29	1105	4	6	352.5	4	7	290.4	10	29	159.00	10	29	132.0
2008	5	28	632.2	5	28	932.8	5	28	232.0	5	27	201.5	3	30	88.10	5	28	140.7
2009	3	25	437.2	3	20	673	5	4	252.0	3	31	156.9	3	25	123.30	3	24	86.6
2010	12	4	643.9	12	5	618.1	12	4	390.2	12	4	182.9	3	6	38.03	7	11	237.4
2011	4	22	844.1	11	9	898.2	4	19	751.2	4	12	247.6	12	3	46.14	4	12	200.7
2012	1	6	520.2	4	21	633.1	11	15	307.5	4	21	119.9	1	6	38.20	5	2	89.8
2013	12	23	469.5	4	21	603.4	5	3	424.8	5	3	214.0	5	5	48.82	5	3	157.3
2014	3	4	635.4	5	7	561.3	3	8	381.5	5	9	284.0	3	16	33.48	3	8	145.8
Maximum			**1155.0**			**1227.0**			**782.8**			**356.0**			**534.3**			**358.6**
Minimum			**153.6**			**229.4**			**199.6**			**75.8**			**20.0**			**22.4**
Average			**522.5**			**721.7**			**396.1**			**186.4**			**109.2**			**118.7**

Source: JICA Project Team based o the data from Mr. Fabio of IDEAM in July, 2017

(2) Probable Annual Maximum Discharge

The table 3.2.2 shows the results of the probability analysis of the maximum annual discharge at each station using the observation data described above.

Table 3.2.2 Probable Discharge at Main Hydrological Stations in the Basin

Station	COLORADOS	PTO LIBRE	GUADUERO	TOBIA	VILLETA	CHARCO LARGO
No.	23067020	23067040	23067050	23067060	23067070	23067080
TR	Q (m^3/s)	Q (m^3/s)	Q (m^3/s)	Q (m^3/s)	Q (m^3/s)	Q (m^3/s)
2.33	965	976	645	356	137	254
5	1168	1184	835	449	245	334
10	1299	1346	991	526	359	398
15	1363	1435	1079	569	435	435
20	1404	1496	1142	599	493	460
25	1435	1543	1190	622	541	480
50	1520	1686	1339	693	705	541
100	1595	1825	1489	764	895	601

Source: Mr. Fabio in February, 2018

3.3 Daily Rainfall at main stations

(1) Annual Maximum Daily Rainfall and Histrical Maximum Daily Rainfall in Representative Stations

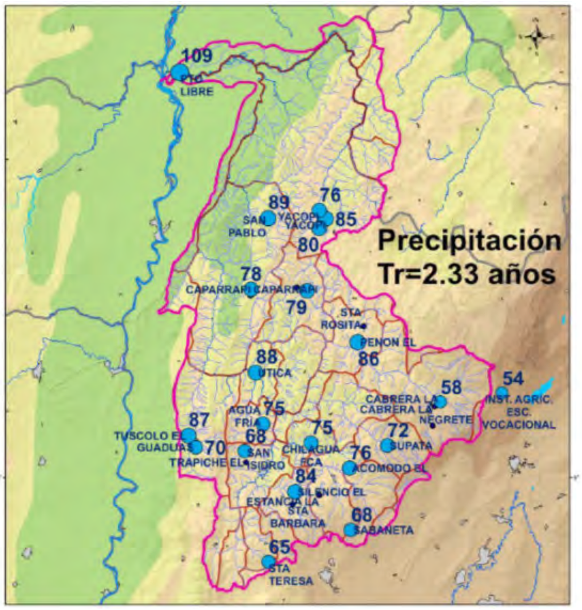
The analysis was performed with the data of the annual maximum daily precipitation in the stations that have data available for more than 15 years. In the table below, the results of the probability analysis of the annual maximum daily precipitation of each station and the historical maximum daily precipitation are presented (the example in the extreme right column on the table). In the table below, historical maximum daily precipitation of each station is observed to be approximately 100-200mm, equivalent to the maximum annual daily rainfall with return period of 50-100 years.

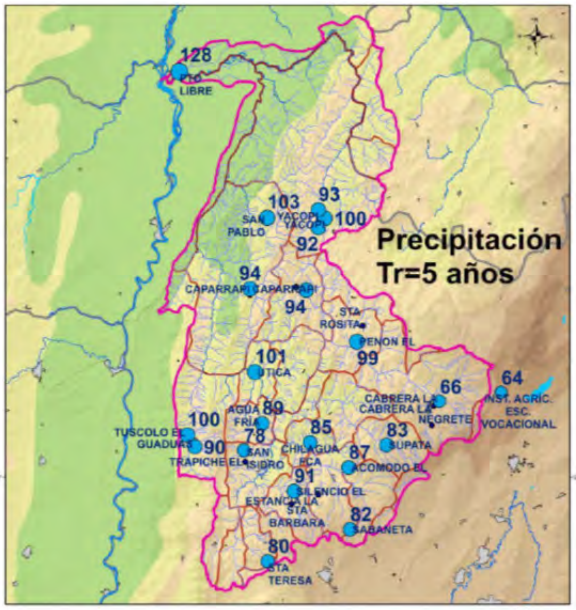
Table 3.3.1 Probability Analysis of Annual Maximum Daily Rainfall and Historical Maximum Daily Rainfall in Representative Stations in the Basin

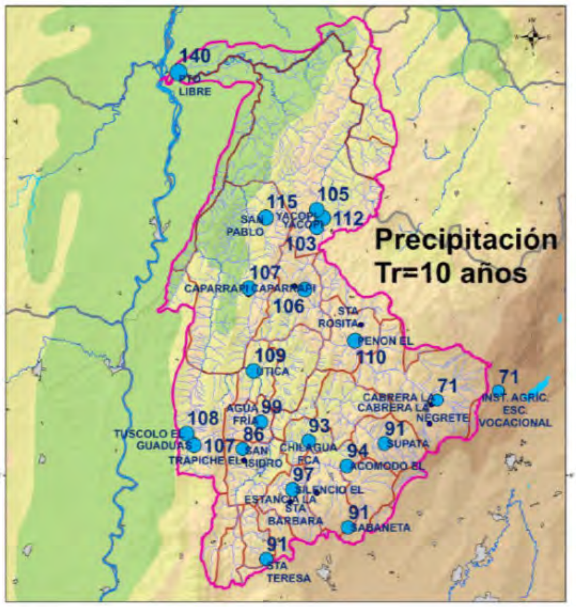
Cod - Tr (años)	Distribución	2.33	5	10	15	20	50	100	Max
23060150	normal	109	128	140	146	150	162	170	200
23060090	gamma	76	93	105	112	116	130	139	140
23060110	gumbel	78	94	107	114	119	135	147	138
23060140	normal	87	100	108	113	115	123	129	132
23060160	gumbel	89	103	115	121	125	139	150	152
23060170	log normal	79	94	106	112	116	130	139	140
23060180	gumbel	86	99	110	116	120	133	143	133
23060190	gamma	88	101	109	114	117	126	132	122
23060200	log normal	72	83	91	95	98	107	113	130
23060260	normal	75	85	93	96	99	105	110	116
23060270									
23060290	log normal	84	91	97	100	101	107	111	120
23060370									
23065060	gumbel	65	80	91	98	102	116	127	100
23065100	normal	68	82	91	95	98	107	113	105
23065110	gumbel	85	100	112	118	123	137	148	138
23065120	log normal	58	66	71	74	76	81	85	85
23065130	gumbel	80	92	103	109	113	125	135	135
23065140									
23065150									
23065200									
2306033	gamma	75	89	99	104	107	118	125	119
2306034	gumbel	68	78	86	91	94	104	112	81
2306039									
2306308									
2306507	log normal	54	64	71	75	78	86	92	90
2306516	weibull	76	87	94	98	100	105	109	110
2306517	log normal	70	90	107	116	123	143	159	150
2306519									

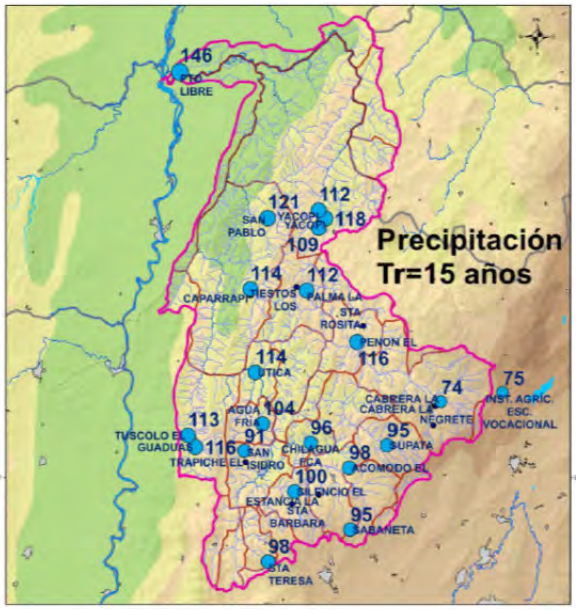
Source: WS Presentation by Mr. Fabio on July 19, 2017

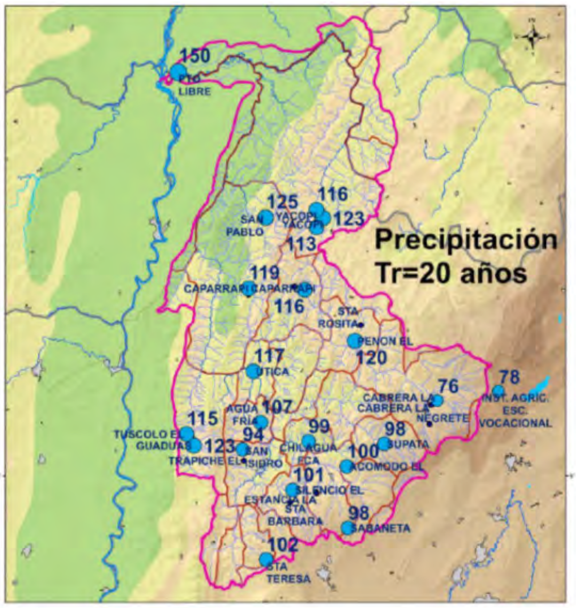
Figure below shows the distribution of daily precipitation with return periods described above in the basin. The precipitation is greater in the northwestern section of the basin, and lower in the southeast section of the basin.


Precipitación
Tr=2.33 años
109 PTO LIBRE
89 SAN PABLO
76 YACOPI
85 YACOPI
80
78 CAPARRAPI
79 CAPARRAPI
STA ROSITA
86 PEÑON EL
88 UTICA
58 CABRERA LA
NEGRETE
54 INST. AGRIC. ESC. VOCACIONAL
87 TUSCOLO EL GUADUAS
70 TRAPICHE EL
75 AGUA FRIA
68 SAN ISIDRO
75 CHILAGUA FCA
72 SUPATA
76 ACOMODO EL
84 SILENCIO EL
ESTANCIA LA
STA BARBARA
68 SABANETA
65 STA TERESA

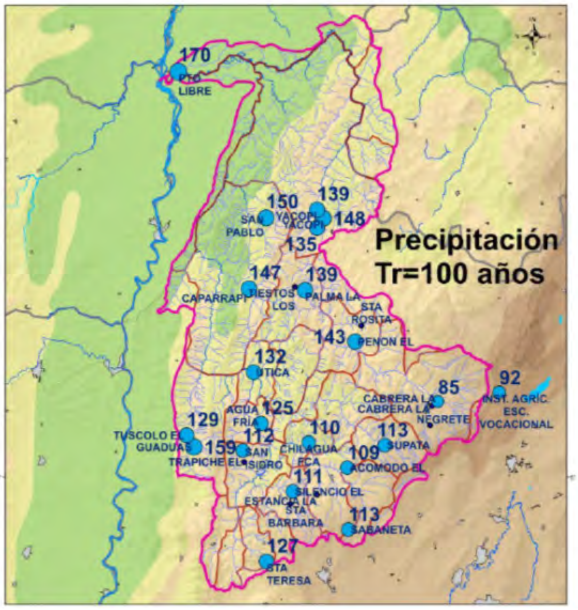

Precipitación
Tr=5 años
128 PTO LIBRE
103 SAN PABLO
93 YACOPI
100 YACOPI
92
94 CAPARRAPI
94 CAPARRAPI
STA ROSITA
99 PEÑON EL
101 UTICA
66 CABRERA LA
NEGRETE
64 INST. AGRIC. ESC. VOCACIONAL
100 TUSCOLO EL GUADUAS
90 TRAPICHE EL
89 AGUA FRIA
78 SAN ISIDRO
85 CHILAGUA FCA
83 SUPATA
87 ACOMODO EL
91 SILENCIO EL
ESTANCIA LA
STA BARBARA
82 SABANETA
80 STA TERESA


Precipitación
Tr=10 años
140 PTO LIBRE
115 SAN PABLO
105 YACOPI
112 YACOPI
103
107 CAPARRAPI
106 CAPARRAPI
STA ROSITA
110 PEÑON EL
109 UTICA
71 CABRERA LA
NEGRETE
71 INST. AGRIC. ESC. VOCACIONAL
108 TUSCOLO EL GUADUAS
107 TRAPICHE EL
99 AGUA FRIA
86 SAN ISIDRO
93 CHILAGUA FCA
91 SUPATA
94 ACOMODO EL
97 SILENCIO EL
ESTANCIA LA
STA BARBARA
91 SABANETA
91 STA TERESA


Precipitación
Tr=15 años
146 PTO LIBRE
121 SAN PABLO
112 YACOPI
118 YACOPI
109
114 CAPARRAPI
112 TIESTOS LOS
PALMA LA
STA ROSITA
116 PEÑON EL
114 UTICA
74 CABRERA LA
NEGRETE
75 INST. AGRIC. ESC. VOCACIONAL
113 TUSCOLO EL GUADUAS
116 TRAPICHE EL
104 AGUA FRIA
91 SAN ISIDRO
96 CHILAGUA FCA
95 SUPATA
98 ACOMODO EL
100 SILENCIO EL
ESTANCIA LA
STA BARBARA
95 SABANETA
98 STA TERESA


Precipitación
Tr=20 años
150 PTO LIBRE
125 SAN PABLO
116 YACOPI
123 YACOPI
113
119 CAPARRAPI
116 CAPARRAPI
STA ROSITA
120 PEÑON EL
117 UTICA
76 CABRERA LA
NEGRETE
78 INST. AGRIC. ESC. VOCACIONAL
115 TUSCOLO EL GUADUAS
123 TRAPICHE EL
107 AGUA FRIA
94 SAN ISIDRO
99 CHILAGUA FCA
98 SUPATA
100 ACOMODO EL
101 SILENCIO EL
ESTANCIA LA
STA BARBARA
98 SABANETA
102 STA TERESA


Precipitación
Tr=50 años
162 PTO LIBRE
139 SAN PABLO
130 YACOPI
137 YACOPI
125
135 CAPARRAPI
130 CAPARRAPI
STA ROSITA
133 PEÑON EL
126 UTICA
81 CABRERA LA
NEGRETE
86 INST. AGRIC. ESC. VOCACIONAL
123 TUSCOLO EL GUADUAS
143 TRAPICHE EL
118 AGUA FRIA
104 SAN ISIDRO
105 CHILAGUA FCA
107 SUPATA
105 ACOMODO EL
107 SILENCIO EL
ESTANCIA LA
STA BARBARA
107 SABANETA
116 STA TERESA



Source: WS Presentation by Mr. Fabio on June 5, 2017

Figure 3.3.1 Probable Daily Rainfall in the Basin

(2) Annual Maximum Daily Rainfall and Annual Maximum Basin Average Rainfall

When studying the runoff mechanism in the Río Negro basin, the analysis was carried out for the annual maximum daily precipitation and the maximum annual value of the average precipitation of the basin in the stations within the basin. The number of working stations varies from year to year; therefore, a simple average of the precipitation of the basin was obtained without considering the area of each station, since it would be too much work to carry out the Thiessen polygon for each case for the precipitation analysis. This is also because this analysis was carried out as an initial study in order to understand the runoff trends in the basin.

The results of the analysis are presented below.

Table 3.3.2 List of Annual Maximum Daily Rainfall and Annual Maximum Basin Average Rainfall

Estación			PTO LIBRE	YACOPI	CAPARRAPI	TUSCOLO EL	SAN PABLO	PALMA LA	PENON EL	UTICA	SUPATA	CHILAGUA FCA	CABRERA LA	SILENCIO EL	ESTANCIA LA	STA TERESA	SABANETA	YACOPI	CABRERA LA	MONTELIBANO	STA BARBARA	STA ROSITA	TRAPICHE EL	AGUA FRIA	SAN ISIDRO	TIESTOS LOS	NEGRETE	INST. AGRIC. ESC. VOCACIONAL	ACOMODO EL	GUADUAS	CAPARRAPI	PROMEDIO	Max	Tipo	
año	mes	dia	3060150	3060090	3060110	3060140	3060160	3060170	3060180	3060190	3060200	3060260	3060270	3060290	3060370	3065060	3065100	3065110	3065120	3065130	3065140	3065150	3065200	2306033	2306034	2306039	2306308	2306507	2306516	2306517	2306519	ROMEDIO	Max	Tipo	# est. Con dato
2015	10	31	0		0		7.5	5.2	32.5	122.2	11.1			53	30			34.1	1.5													27.0	122.2	max	11
2015	11	4			15		31.8	0	21.7	34.5	53.5			79.5	60.3				37													37.0	79.5	Prom.	9
2014	12	17	0		0			0	0	0	10.4	0.9		4.2	5			0.3						119	55	0	1	0	13.1	0.5		12.3	119.2	max	17
2014	11	10	38.7		26			0	60	42.8	36.6	56.6		46	70			40.6						0	5	42	6.5	3.2	79	48		35.4	79.0	Prom.	17
2013	11	6	43.9			24.8	2.7	1	54.7	4.8	50	20.2		23.5	116		12.6	4.4	27				2	7	30	1	3.3	17.7	58	10.3		24.51	116.0	max	21
2013	5	4				44.5	0.8	11	20	103	35	57.4		78.1	58		21	17					42.8	36.8	12	24.5	64.3	36.4	36.5	35.7		38.6	103.0	Prom.	19
2012	11	29	11			6.4	106	34	0	15.5	1	0.5		0	30		3.2	30					1	10	0	31	1	7.4	9	2		14.93	106.0	max	20
2012	10	15	0		14	32.6	0.4	10	15.6	16	6.8	77.8		100	22		35.2	1.5					52.7	82	40	2	18	15.3	20	19.7		27.7	100.0	Prom.	21
2011	5	11	19.9		80.3	6.7	0	0	10		5.2	48.8		6.1	11.2	0	5.1	26.9	1				5.2	3	10	9	2.5	0	15.6	0	141	17.73	141.2	max	23
2011	5	13	39.2		53	17.5	79	117	27		35.3	53.8		27.1	24.5	17.5	41.9	30.1	67				44.3	24	45	95.2	65.5	75.9	60.5	21.5	124	51.5	123.5	Prom.	23
2010	8	30	125		0	38.2	13.5	23	0	0		0.9		13.2	0	0	0.2	0	0				0	0	0	1.8	7.4	0	0	0	3.2	9.843	124.9	max	23
2010	11	16			34	20.5	8	23	32.2	25	4.1	44.2		9.1	36.3	17.6	35	31.4	73				11.6	26	0	25	50.8	63.5	61.6	17	21.9	29.2	72.5	Prom.	23
2009	3	12	0		0	0		2.5	0	0	0	0		38.2	140	2.7	22.4	6.9	0.2					9	9	0	3	0	7	3		11.61	140.0	max	21
2009	10	24			12.8	10.1	10.6	0	9.2	13	13.7	28.4		89	66	27		14.7	3.4				14.6	16.5	40	17.5	2		75.2	16.6		24.0	89.0	Prom.	20
2008	2	9	126		0	76.4	14	3	0	0	3	22.5		0		0	0	9.2	0					0	80.8	4.5	0	0	0	6.2		16.43	125.5	max	21
2008	11	25	21.6		33	44.1	23.5	68	19	9	43.4	54.6		30		35.8	24.4	31.3	42								59.6	5.6	80	44.1		37.2	80.0	Prom.	18
2007	10	11	13		0	6.2	14.3	0	22.1	15.2	0.1	24.8		74		6.5	10.8	24.5	30					7.3	38.5	54.5	15.3	1.6	5.8	150		24.5	150.0	max	21
2007	10	28	26		82.8	46.4	45.2	0	0	18.2	14.7	29.8		27.6		97.5	25	35.2	16					17.8	20	40	18	0	45	42.2		30.8	97.5	Prom.	21
2006	12	11	65.5		77	132	48.2	19	56	58	0	23.2		19.6		1	2	38.3	4					76.5	10.5			0		2.9		35.19	132.2	max	18
2006	11	14	19.5		19.4	14.2	3.9	13	54	7.2	55.1	60.5		0		56.2	24.9	0.9	35					45.7	80.5			20.7		39.8		30.6	80.5	Prom.	18
2005	4	22	140		0	2.5	2.7	5.3	0	10	3	0		0		0.7	30.4	0.4	0						0.3			3.4	1.2			11.76	140.0	max	17
2005	10	23	10		11.4	55.1	72.9	78	40	4.5	50	37.9		5.7		44	69.2	53.6	34						40.2			12.1	3.1	0.4		34.5	77.7	Prom.	18
2004	7	10	8.4		0	0	0		32	0	0	0		0		0	15	138	0						0			0	0	0		11.36	137.7	max	17
2004	5	18	65.1		68	53.5	50		37.2	64.5	5	25.9		**71.6**		36.7	5.1	0	0.5						0.7			23.6	11.5	44.2		33.1	71.6	Prom.	17
2003	11	9	0		27	20.5	27.1	8.4	130	0	0	32.6		11.7		3.3	12.6	16	12						0.3			0	51.5	25.6		21.03	130.0	max	18
2003	4	9	0		70	5.6	0	65	56	0	37	22.3		35.6		23.3	14.8	0	83					6.4				13.6	15.3	4.2		25.1	83.0	Prom.	18
2002	7	5	112		41	29.4	32.7	1	55	3.5	0	0		41.1		67.7	17.8	11	22					54.9				9.7				31.2	112.4	max	16
2002	4	24	0		42.2	36.7	80	3.6	105	34	78	19.9		60		4.6	80	68.6	68					0				64	0			43.8	105.0	Prom.	17
2001	12	11	131		0	0	32.3	0.5	4.3	8.9	0	0		0		16	0	7.9	0					0					0	0		11.83	131.2	max	17
2001	3	20	34.9		15.2	14.1	21.4	17	33	52	2.5	116		26.1		21	10	20.5	12					67.1				7.8	32.5	43.5		30.4	116.0	Prom.	18
2000	5	14	5.1		33.7	7.2	43.9	8.9	4.2	0	14.9	3.2		3.2		1.5	5.3	127	4.5					17.6				1.5				17.58	126.6	max	16
2000	9	9	**67.7**		0	4.8	41.7	39	35	17.5	43.6	17		18		0	13.4	38.7	19					15.8				12.7				24.0	67.7	Prom.	16
1999	10	7	2.5		12.8	39	21.7	1.2	1.7	10	3.4	0.7		1.5		9	2.2	127	5.7					4.5				2.5				15.3	126.9	max	16
1999	2	21	35		40	60.9	10.7	0	47	43.7	38.1	29				31.5	32	36.4	21					38.4				26.8				32.7	60.9	Prom.	15
1998	6	9	84.4		0	0	9.3	0	0	0	0	0		0		0	0	3.9	0					0				0				6.1	84.4	max	16
1998	9	22	5.5		24.8	46.9	28.2	42	17	0	0	48		76.2		53.5	24.2	46.2	28					31.9				0				29.5	76.2	Prom.	16
1997	8	16	135		0	0	0	0	0.1	0	0	0		0		0	0	0	0					0				0				8.444	135.0	max	16
1997	9	8	0		38	58.2	24	72	26	74	3.5	41.5		0		30.5	1.1	58.5	12					0				7.9				28.0	74.0	Prom.	16
1996	5	12	99.2		0	0	10.7	0	0	0	0	0		1.5		6	0.1	1.1	0									0				7.907	99.2	max	15
1996	3	6	6.2		34.5	60	36	47	37	25.7	21.5	10		53.1		33.3	32.1	33.5	27									33				32.7	60.0	Prom.	15
1995	4	7	0.2		13	0	20	103	25.5	13	2.3	37		8.2		0	4.9	45.3	12									0				18.91	102.7	max	15
1995	12	3	0		67	56	37.5	9.7	51	22	33.1	8.7		61.9		3.5	16.6	49.3	22					22.4				18.1				29.9	67.0	Prom.	16
1994	3	3	6		14.5	0	0	5.5	0	0	10	4.2		0.9		27	105	31.9	41			0.2						0				15.41	105.0	max	16
1994	11	4	23.5		27.3	41	20.7	31	34.9	38.5	40	38		51.3		32.7	26.1	82.7	27			62.6						35				38.3	82.7	Prom.	16
1993	12	16	0		3	0	9	5.7	1.6	0	29	1		120		31.5	9.1	5.9	35									37				19.16	119.7	max	15
1993	5	25	24.3		37.9	35	30.5	38	17.3	12	65	44.5		35.5		10	25	23.6	4.8									27				28.7	65.0	Prom.	15
1992	12	11	0		1.5	20	7.6	28	14.6	5.5	10	7.3		72.5		45.5	24		25	18	111	19.6						20				25.3	111.3	max	17
1992	5	30	87		51.5	20	32.1	67	40.8	47		30		54.6		0	0.7		0.7	35.5	48.6	33.3						9				34.9	87.0	Prom.	16
1991	11	13	3		24.7	120	75	26	17.4	32.7	20	22.1		77.1		9	29	36.9	5.1									2.8				33.37	120.0	max	15
1991	10	7	28		74	100	74.5	28	6.8	39.5	8.5	47.1		44.3		60	7.8	51.6	30									20				41.3	100.0	Prom.	15
1990	6	9	200		15.5	0		53	0	2.2	4	17		2		0.3	7.7	5.5	1.8	3.3	8.4											21.38	200.0	max	15
1990	11	3	47		17	40		13	43	4.2	60.7	35.1		65.3		51	16	23.5	5.3	37.6	47											33.7	65.3	Prom.	15
1989	2	7	21		0.7	132	25.8	13	7.1		12	12.3		14			0	16.5		22.3	3											21.52	132.0	max	13
1989	10	27	0		19.2	10	24.5	82	47	29.1	9.5	60		26.2		28.1	5.1	49	1.7	40.6	22											28.4	82.0	Prom.	16
1988	4	27	0		15.8	0	31.2	113	25	0	38.2	0		5.9			0	18.5	0	38.4								0				19.07	113.0	max	15
1988	4	3	0		37	50	35.2	42	33.7	22	41.2	5		36			9	34	13	58.4								12.3				28.6	58.4	Prom.	15
1987	10	23	116		16	1.4	4.1	8	12.4	13	3.8			12.2			25.6	29		11.6								7.3				20.03	116.0	max	13
1987	4	27	22		80	2.5	60.3	44	15.2	73.8	11.1			19.9			9.9	69.5		8.4								27				34.1	80.0	Prom.	13
1986	12	8	1.2		11.8	0	19.1	37	105	12	0			0			0	27	1.4	31.9								0.6				17.64	105.0	max	14
1986	4	18	103		35	1.6	50.9		50.6	2.5	28			35				43.5	30	42.8								28				37.6	102.7	Prom.	12
1985	11	8	1.8		16.8	0	0	0	44	3	0							77.5	0	135								0.1				23.16	134.7	max	12
1985	4	30	5.3		54.5	86	57.4	22	60	95	49.8							23.5	39	22.8								33.5				45.7	95.0	Prom.	12
1984	9	30	NaN		2.4	0	152	6	0	26.6	0.5							0	0.2	49								0.2				21.53	151.9	max	11
1984	11	6	NaN		38	57	38.2	55	15.7	16.3	17.4							27.6	21	28.2								69.3				34.9	69.3	Prom.	11
1983	9	27	103		0	0	0	4.8	0	0	0							0.7	0	0								0				9.042	103.0	max	12
1983	10	15	27		40.4	36	30	44	46.6	40	60.1							35.8	34	0								35				35.8	60.1	Prom.	12
1982	11	14	130		0	0	0	0	0	0	0							0	0	0.2								0				10.85	130.0	max	12
1982	10	19	0		100.1	41	1.5	59	20.9	71.3	18.3							47.5	41	19.2								23.6				37.0	100.1	Prom.	12
1981	10	23	0		10.7	24	144	76	17	24.3	8.2									56.5								0.5				36.1	143.5	max	10
1981	10	23	0		10.7	24	144	76	17	24.3	8.2									56.5								0.5				36.1	143.5	Prom.	10
1980	10	3	53			15	12	35	50.3	9.7	15.7							131	19	14.3								16.6				33.76	130.5	max	11
1980	10	3	53			15	12	35	50.3	9.7	15.7							131	19	14.3								16.6				33.8	130.5	Prom.	11

Source: WS Presentation by Mr. Fabio on May 9, 2017

4. Flood Damage

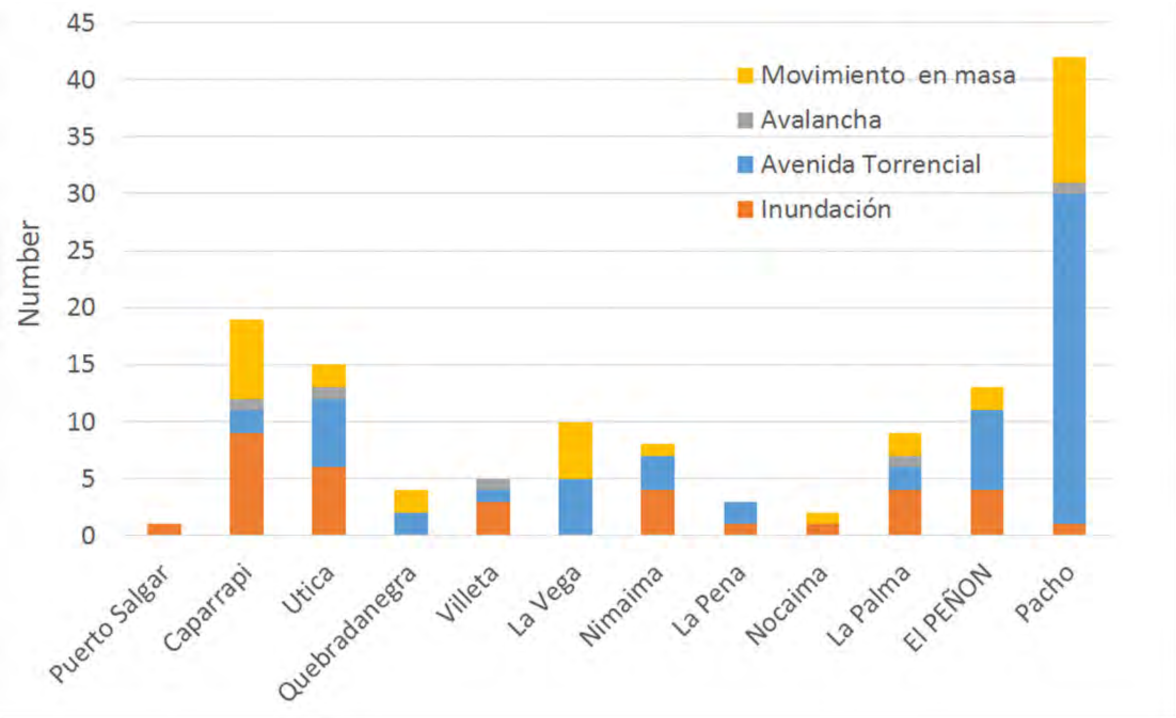
4.1 Inventory of Past Flood Disasters in the Rio Negro Basin

4.1.1 Location and Frequency of Past Water-Related Disasters

As data for past flood disasters in the Río Negro basin, lists from the Department of Cundinamarca and DNP were obtained. In many cases, the list of the Department of Cundinamarca includes not only the names of municipalities where the disaster occurred but also the name of the villages, with a detailed explanation of the conditions of the disaster, which is positive. However, it includes limited information on the number of people and homes affected. On the other hand, the DNP list does not have an explanation of the conditions of the disaster with the names of the municipalities, although it does include organized quantitative data on the people and houses affected systematically. As for the period of the data of the lists, that of the Department of Cundinamarca is from 2008-2015, and that of DNP is from 1998-2016.

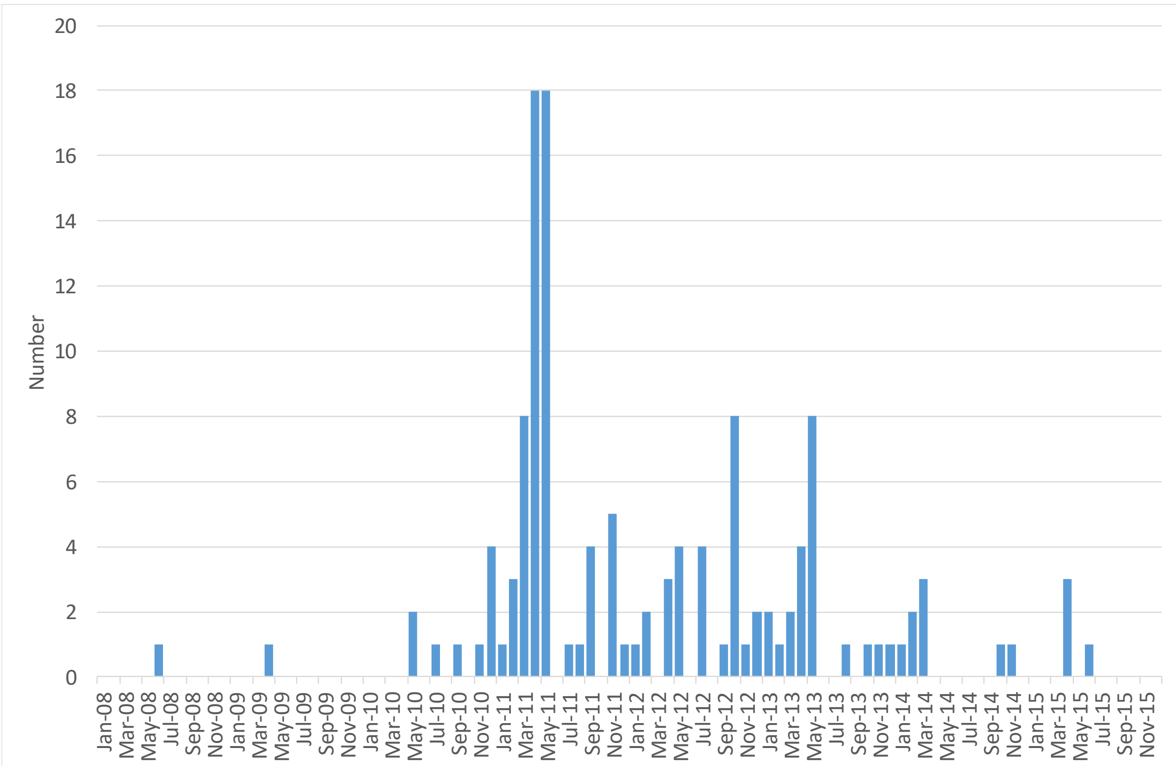
Figures 4.1.1 and 4.1.2 are results of the organization of the data of the Department of Cundinamarca, and Figure 4.1.1 lists the municipalities of the basin from downstream to upstream, categorizing the types of flood or sediment disaster. Figure 4.1.2 shows the number of disaster cases generated within the basin per month.

From these figures it can be observed that not only the floods but also sediment disasters occur in the Río Negro basin. As for floods, slow floods and flash floods occur in the same volume. There are many flash floods in the upper basin or mountainous areas, mostly in the rainy season between March and June and between September and November. It is also noted that several disasters occurred in April and May 2011.



Source: WS Presentation by Mr. Inoue on May 9, 2017

Figure 4.1.1 Historical Disaster Events by Municipalities based on Cundinamarca Department Database between 2008-2015 in the Basin

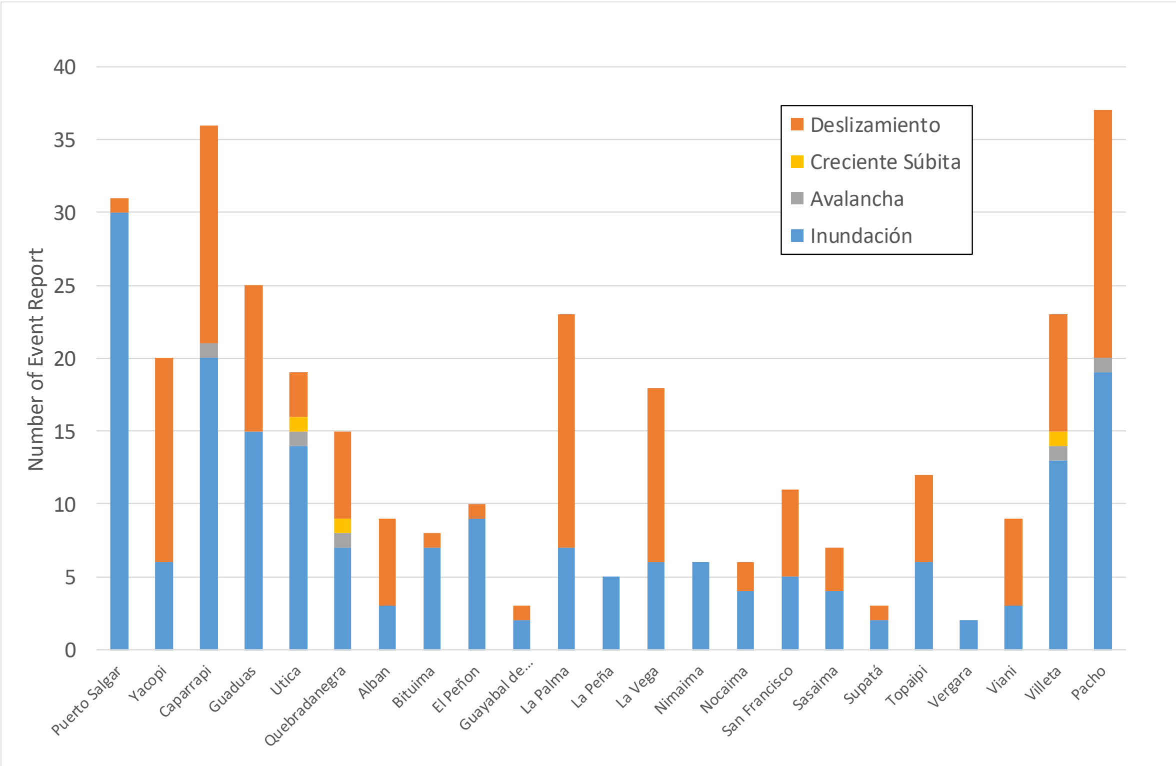


Source: WS Presentation by Mr. Inoue on May 9, 2017

Figure 4.1.2 Historical Disaster Events by Monthly Periods based on Cundinamarca Department Database between 2008-2015 in the Basi

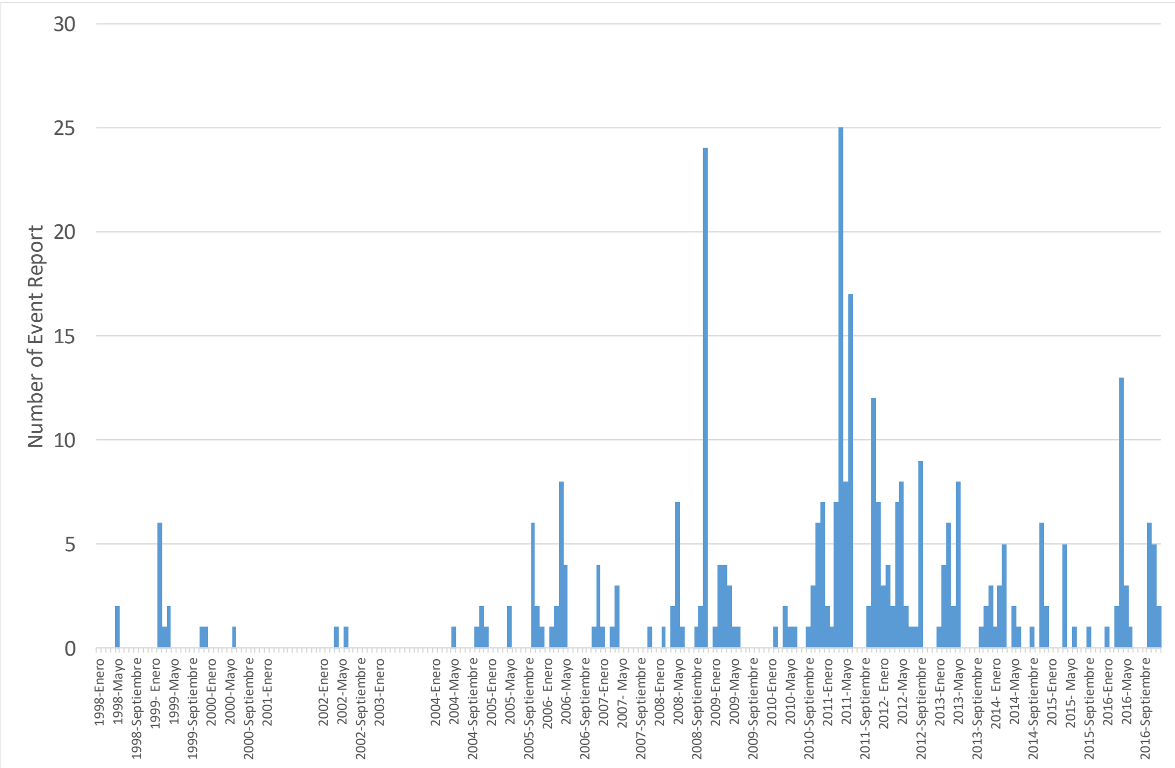
Figure 4.1.3 and Figure 4.1.4 are results of the organization of DNP data, in a similar fashion to data from the Department of Cundinamarca. Figure 4.1.3 lists the municipalities in the basin from downstream to upstream, categorizing the types of flood or sediment disaster. Figure 4.1.4 shows the number of disaster cases generated within the basin per month.

From these figures, it can be observed that not only the floods but also sediment disasters occur in the Río Negro basin. These disasters occur mostly in the rainy season between March and June and between September and November. It is also noted that several disasters occurred in November 2011 and from April to June 2011.



Source: WS Presentation by Mr. Inoue on May 9, 2017

Figure 4.1.3 Historical Disaster Events by Municipalities based on DNP Database between 1998-2016 in the Basin



Source: WS Presentation by Mr. Inoue on May 9, 2017

Figure 4.1.4 Historical Disaster Events by Monthly Periods based on DNP Database between 1998-2016 in the Basin

4.1.2 Past Major Flood Events

Table 4.1.1 is a list of ranking of disasters between 1998-2016 with indicators 1. number of affected people and 2. number of affected homes, based on DNP data. For the purpose of the list, the 40 disasters with the largest damages were selected. The yellow color indicates the first 20 disasters with the biggest damages, the orange color indicates the disasters in the 21-30 places, and the blue color indicates the disasters in the 31-40 places of the ranking. The horizontal axis is the municipalities, and the vertical axis is the number of disasters that have occurred in each of them. Likewise, in order to facilitate the understanding of the extent of disasters within the basin, disasters that occurred on the same date are presented in the same row, to verify if disasters have occurred on the previous or subsequent dates. It also includes low-level disasters (which do not fall into the top 40) if they occurred on the same or close dates. However, disasters that do not fit into the top 40 are not colored. Although DNP data only have information on the place of occurrence of disasters at municipal level, data from the Department of Cundinamarca was used in order to try to indicate the places of occurrence of disasters at the level of villages. This is because the understanding of the place of occurrence of disasters at the level of villages is more important downstream in particular.

Based on what is observed in the table below, the following can be concluded:

- There are cases where disasters occur in a large area of the watershed. The disasters that occurred on November 30, 2008, April 18 to 20, 2011, and June 30, 2011 show several disasters that occurred in different parts of the basin.
- Disasters with large damages tend to occur downstream of the basin.
- Upon observing the data at the municipal level, disasters with great damage occurred in Puerto Salgar, Caparrapi, Yacopi and Pacho. However, the disaster in Puerto Salgar can be a disaster in the urban area near the Magdalena River, outside the Río Negro basin.
- Upon observing the data at the village level, the greatest number of disasters occurred in Córdoba, in the municipality of Caparrapi.

The Table 4.1.2 presents the result of organizing the disasters occurred in Puerto Salgar, eliminating the ones caused by the Magdalena River. They are presented from the high range to the low range.

The hydrological conditions of the disaster generation (precipitation and flow) of the high-ranking disasters in this list were analyzed. The results are presented in the next section.

Table 4.1.1 List of Past Large-Scale Flood Disasters in the Basin

Date	Ranking	Pto Salgar			Yacopi	Caparrapi				Guaduas		Utica	Quebradanegra	Villeta	Sasaima	Bituima	Viani	Guayabal de Siquima	Alban	La Vega	San Francisco	Nimaima	Vergara	La Peña	Nocaima	La Palma	Topaipi	El Peñon	Supata	Pacho
		Pto Salgar	Pto Libre	Colorados		Dindal	Cambras	Cordoba	Caparrapi	Guaduero	Otros																			
1999/4/10	10	Inundación (1500)															Deslizamiento (75)													
1999/11/1	9	Inundación (1500)																												
1999/2/22	17	Inundación (1190)				Deslizamiento (25)						Avalancha (50)	Inundación (25)									Inundación (55)								
2000/6/23	16					Deslizamiento (1250)																								
2002/6/6	15	Inundación (1250)																												
2005/11/10	32					Inundación (545)																								
2006/4/13	52																			Inundación (275)										
2006/4/14	34	Inundación (527)																												
2006/4/20	21					Inundación (890)				Inundación (35)																				
2006/11/16	8	Inundación (1500)																												
2008/4/28	11	Inundación (1485)																												
2008/5/26	5	Inundación (1750)								Inundación (134)																				
2008/10/12	38																													Inundación (460)
2008/11/9	24				Inundación (750)																									
2008/11/19	1	Inundación (2900)																												
2008/11/30	29	Inundación (0)			Inundación (0)			Inundación (0)		Inundación (0)			Inundación (0)	Inundación (0)		Inundación (0)	Inundación (0)	Inundación (0)	Inundación (0)	Inundación (0)	Inundación (25)					Deslizamiento (55) Inundación (0)	Inundación (0)	Inundación (0)		Deslizamiento (610) Inundación (0)
2010/11/5	27.39				Inundación (442)					Inundación (693)																				
2010/11/6		Inundación (400)								Deslizamiento (28)																				
2010/12/4	12		Inundación (150)			Inundación (1468)																								
2010/12/5	36	Inundación (501)				Inundación (5families)		Inundación (93)																						
2011/2/3	33																							Inundación (535)						
2011/3/5	20					Inundación (250)						Creciente s úbita (0)		Deslizamiento (908)																
2011/3/6	3																						Inundación (2806)							
2011/4/12						Inundación (no data)	Inundación (170)	Inundación (260)		Inundación (70)		Inundación (200)										Inundación (70)								
2011/4/14	6	Inundación (1704)																												
2011/4/15		Inundación (480 families)																												
2011/4/18	26											Inundación (696)																		
2011/4/19	19							Inundación (240)	Inundación (728)					Inundación (50)			Deslizamiento (380)			Deslizamiento (212)						Deslizamiento (31)				
2011/4/20	28				Deslizamiento (160)					Inundación (658)																				Inundación (170)
2011/5/1	30													Deslizamiento (66)			Deslizamiento (31)													Inundación (565)
2011/6/30	2,7,13,14,25, 35,37,40				Inundación (1372)								Inundación (168)	Inundación (1522)	Inundación (259)	Inundación (160)	Inundación (317)	Inundación (338)	Inundación (272)		Inundación (486)	Inundación (510)		Inundación (435)	Inundación (1325)	Inundación (327)	Inundación (333)	Inundación (143)	Inundación (698)	Inundación (2844)
2011/11/10	18	Inundación (1000)								Deslizamiento (35)																				
2011/12/8	4	Inundación (2000)																												
2012/9/18								Inundación (0)	Inundación (0)			Inundación (0)	Inundación (0)									Inundación (0)		Inundación (0)			Inundación (0)	Inundación (0)		
2012/9/19	31												Deslizamiento (560)																	
2013/2/19	22				Deslizamiento (775)																									
2013/2/20								Inundación (60)																						
2014/11/8	115							Inundación (85)																		Inundación(0)		Inundación (0)		
2014/11/9	23	Inundación (750)																												
			1		4	5	2	11	5	1	5	1	4	3	1	2	2	2	2	2	2	3	1	2	1	2	3	4	1	4

Top 10 and 20
Top 30
Top 40

Source: WS Presentation by Mr. Morita on May 26, 2017

Table 4.1.2 List of Past Large-Scale Flood Disasters in the Basin

Date	New ranking	Ranking	Pto Salgar		Yacopi	Caparrapi					Guaduas	Utica	uebradaneg	Villeta	Sasaima	Bituima	Viani	Guayabal de Siquima	Alban	La Vega	San Francisco	Nimaima	Vergara	La Peña	Nocaima	La Palma	Topaipi
			Pto Libre	Colorados		Dindal	Cambras	Cordoba	Guaduero	Caparrapi																	
30/06/2011	1	2, 7,13,14,25,3 5,37,40			Inundación (1372)								Inundación (168)	Inundación (1522)	Inundación (259)	Inundación (160)	Inundación (317)	Inundación (338)	Inundación (272)		Inundación (486)	Inundación (510)		Inundación (435)	Inundación (1325)	Inundación (327)	Inundación (333)
06/03/2011	2	3																					Inundación (2806)				
26/05/2008	3	5									Inundación (134)																
10/04/1999	4	10	ndación (1500)														Deslizamiento (75)										
04/12/2010	5	12	Inundación(150)			Inundación(1468)																					
06/06/2002	6	15	ndación(1250)																								
23/06/2000	7	16				Deslizamiento (1250)																					
22/02/1999	8	17	ndación(1190)			Deslizamiento (25)						Avalancha(50)	Inundación(25)									Inundación(55)					
10/11/2011	9	18									Deslizamiento(35)																
18/04/2011	10	26										Inundación(696)															
19/04/2011	11	19						Inundación(240)		Inundación(728)				Inundación(50)			Deslizamiento(380)			Deslizamiento(212)						Deslizamiento(31)	
20/04/2011	12	28			Deslizamiento(160)						Inundación(658)																
05/03/2011	13	20				Inundación(250)						Creciente súbita(0)		Deslizamiento(908)													
20/04/2006	14	21				Inundación(890)					Inundación(35)																
19/02/2013	15	22			Deslizamiento(775)																						
20/02/2013	16							Inundación(60)																			
09/11/2014	17	23																									
09/11/2008	18	24			Inundación(750)																						
05/11/2010	19	27			Inundación(442)						Inundación(693)																
30/11/2008	20	29			Inundación(0)			Inundación(0)			Inundación(0)		Inundación(0)	Inundación(0) Deslizamiento(66)		Inundación(0)	Inundación(0) Deslizamiento (31)	Inundación(0)	Inundación(0)	Inundación(0)	Inundación(25)					Deslizamiento(55) Inundación(0)	Inundación(0)
01/05/2011	21	30																									
18/09/2012	22							Inundación(0)		Inundación(0)		Inundación(0)	Inundación(0) Deslizami									Inundación(0)		Inundación(0)			Inundación(0)

Source: WS Presentation by Mr. Fabio on June 5, 2017

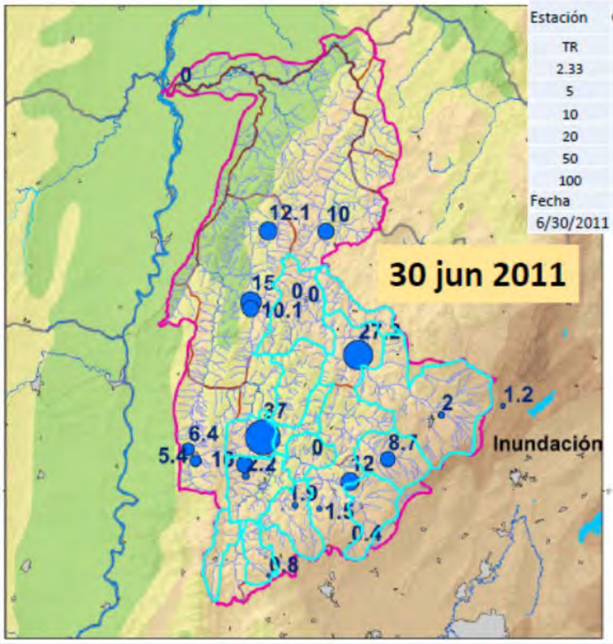
4.2 Detailed Analysis of Relationship between Flood Events and Hydrogical Coditions in the Rio Negro Basin

The detailed analysis of the flood and hydrological conditions was performed, using the results of the organization and the analysis of data in the previous section.

4.2.1 Hydrological Conditions in Flood Events

Within the floods with larger damages in Section 4.1.2, the hydrological conditions (precipitation and discharge) of the 5 biggest disasters were organized when the events occurred.

(1) Hydrological Conditions in Flood Event on June 30, 2011



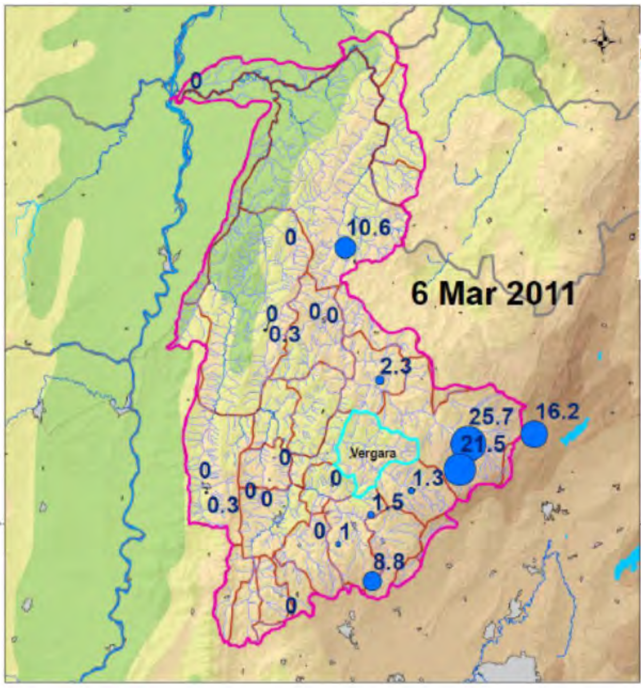
Estación	COLORADOS	PTO LIBRE	GUADUERO	TOBIA	VILLETA	CHARCO LARGO
TR	Q (m3/s)	Q (m3/s)	Q (m3/s)	Q (m3/s)	Q (m3/s)	Q (m3/s)
2.33	917.7	976.7	645.1	355.2	137.3	226.5
5	1364.2	1187.8	838.1	449.1	247.1	340.2
10	1774.5	1352.5	997.0	524.7	365.0	445.5
20	2205	1506	1151	597	504	557
50	2815	1699	1352	690	724	715
100	3314	1841	1506	759	921	845
Fecha	23067020	23067040	23067050	23067060	23067070	23067080
6/30/2011	68	282.7	100	19.65	8.675	8.5

Precipitación acumulada 5 días

			PTO LIBRE	TUSCOLO EL	SAN PABLO	PALMA LA	PENON EL	UTICA	SUPATA	CHILAGUA FCA	CABRERA LA	SILENCIO EL	ESTANCIA LA	STA TERESA	SABANETA	YACOPI	CABRERA LA	TRAPICHE EL	AGUA FRÍA	SAN ISIDRO	TIESTOS LOS	INST. AGRÍC. ESC. VOCACIONAL	ACOMODO EL	GUADUAS	CAPARRAPI
año	mes	día	23060150	23060140	23060160	23060170	23060180	23060190	23060200	23060260	23060270	23060290	23060370	23065060	23065100	23065110	23065120	23065200	2306033	2306034	2306039	2306507	2306516	2306517	2306519
2011	6	20	3.5	2.9	23.8	54.8	33.6	0	3.7	9.3	0	11	12	1.9	26.8	29.8	14.1	4.5	1.2	5	7	25	20.5	2.7	35
2011	6	21	3.5	2.9	27.2	67.4	34.6	0	3.7	9.3	0	11	12	1.9	26.9	39.3	14	4.5	1.2	5	14.9	25	20.5	2.7	36.7
2011	6	22	6.7	2.9	27.2	67.4	34.6	0	3.7	9.3	0	11	12	1.9	26.9	26.1	14	4.5	1.2	5	8.4	25	20.5	2.7	36.7
2011	6	23	6.7	2.9	36.3	70.2	32.6	0	5.8	19.2	0	12.2	12	8.1	28.7	32.1	14.2	4.5	1.2	5	11.9	22.8	33	1.9	37.5
2011	6	24	6.7	5.1	46.8	100.2	13.5	0	8.1	19.9	0	5.6	0	8.7	30.8	31.4	9.7	0	0	2	11.9	9.4	33.5	2	53.1
2011	6	25	6.7	3.6	31.3	69.1	3	0	7.7	15.1	0	3.2	0	8.8	5	28.6	3.9	0	0	0	11.9	3.5	19.5	1.2	21.1
2011	6	26	75.7	3.6	33.6	66.5	4.2	0	16	16.9	0	3.2	1	26	7.9	19.1	6.7	0	0	0	4	6.2	22	1.2	20.9
2011	6	27	69	3.6	33.6	66.5	4.2	0	16	16.9	0	3.2	2	29.2	10.9	19.1	6.5	0	0	0	3.5	6.2	22	1.2	20.9
2011	6	28	69	3.6	25	63.7	3.7	0	13.9	8.8	0	2	3	21.2	8.9	9.9	6	0	0	0	0	5	9.5	0.8	20.1
2011	6	29	110.5	3.3	7.1	20	2.7	0	10.4	9.6	0	29.3	30	24.4	6.9	14.5	7.8	1.2	10	15	0	2.7	10.5	3.1	3.5
2011	6	30	110.5	9.7	19.2	20	29.9	0	19.1	6.3	0	31.2	31.5	25	6.5	20.1	8.8	3.4	47	25	0	3.9	18.5	8	13.6

Source: WS Presentation by Mr. Fabio on June 5, 2017

(2) Hydrological Conditions in Flood Event on March 6, 2011



Estación	COLORADOS	PTO LIBRE	GUADUERO	TOBIA	VILLETA	CHARCO LARGO
TR	Q (m3/s)	Q (m3/s)	Q (m3/s)	Q (m3/s)	Q (m3/s)	Q (m3/s)
2.33	917.7	976.7	645.1	355.2	137.3	226.5
5	1364.2	1187.8	838.1	449.1	247.1	340.2
10	1774.5	1352.5	997.0	524.7	365.0	445.5
20	2205	1506	1151	597	504	557
50	2815	1699	1352	690	724	715
100	3314	1841	1506	759	921	845
Fecha	23067020	23067040	23067050	23067060	23067070	23067080
3/6/2011	364.3	371.6	358.8	59.33	28.99	54.22

Precipitación acumulada 5 días

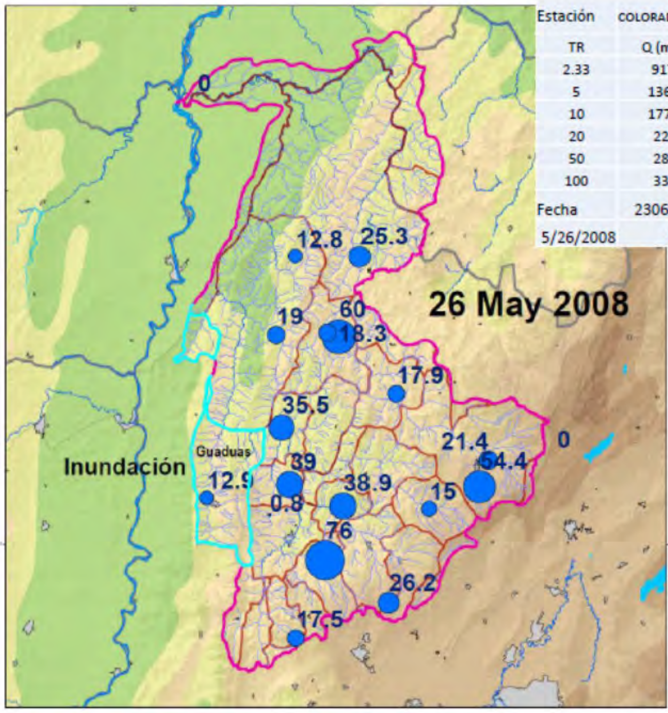
			PTO LIBRE	YACOPI	CAPARRAPI	TUSCOLO EL	SAN PABLO	PALMA LA	PENON EL	UTICA	SUPATA	CHILAGUA FCA	CABRERA LA	SILENCIO EL	ESTANCIA LA	STA TERESA	SABANETA	YACOPI	CABRERA LA	MONTELIBANO	STA BARBARA	STA ROSITA	TRAPICHE EL	AGUA FRÍA	SAN ISIDRO	TIESTOS LOS	NEGRETE	INST. AGRÍC. ESC. VOCACIONAL	ACOMODO EL	GUADUAS	CAPARRAPI
año	mes	dia	23060150	23060090	23060110	23060140	23060160	23060170	23060180	23060190	23060200	23060260	23060270	23060290	23060370	23065060	23065100	23065110	23065120	23065130	23065140	23065150	23065200	2306033	2306034	2306039	2306308	2306507	2306516	2306517	2306519
2011	3	6	32.2	0	41	23	85.2	40.4	61.7	7	35.4	125	0	160	156	49.5	106	44.2	28	0	0	0	39	37	149	56	75	41.8	77.3	19	166

Precipitación 5 días anteriores al evento

año	mes	dia	23060150	23060110	23060140	23060160	23060170	23060180	23060190	23060200	23060260	23060290	23060370	23065060	23065100	23065110	23065120	23065200	2306033	2306034	2306039	2306308	2306507	2306516	2306517	2306519
2011	3	1	12.5	30	31.3	20	31	45.1	29	49	25.5	20	63.8	17.2	22.2	8.9	30.4	53.1	35.2	40	30	12.4	26.1	16.3	5.2	94.6
2011	3	2	0	4.6	5.3	32.5	19.2	31.6	7	8.9	24.6	28	40.8	12.8	44	9	10	27.7	20	50	20	29.3	0	20.3	8	61.2
2011	3	3	2.5	0	16.4	9.8	15.2	10	0	19	14.4	15	24.6	7.5	23.5	2.4	8	6.9	0	45	8	7.3	19.7	15	4.7	43.6
2011	3	4	8.8	0	0	38.2	6	11.6	0	3.9	4.5	32	40.4	25.2	13.5	20.3	1	0	0	36	18	9.5	0.7	9	2.2	15
2011	3	5	0	28.5	1.4	0	0	8.5	0	2.5	81.1	85.4	50.5	4	24.3	0	3	1.7	17.3	10	10	18.4	9	15	2.2	25.3
2011	3	6	20.9	7.6	0	4.7	0	0	0	1.1	0	0	0	0	1.1	12.5	6	2.9	0	8	0	10.5	12.4	18	1.8	20.6

Source: WS Presentation by Mr. Fabio on June 5, 2017

(3) Hydrological Conditions in Flood Event on May 26, 2008



Estación	COLORADOS	PTO LIBRE	GUADUERO	TOBIA	VILLETA	CHARCO LARGO
TR	Q (m3/s)	Q (m3/s)	Q (m3/s)	Q (m3/s)	Q (m3/s)	Q (m3/s)
2.33	917.7	976.7	645.1	355.2	137.3	226.5
5	1364.2	1187.8	838.1	449.1	247.1	340.2
10	1774.5	1352.5	997.0	524.7	365.0	445.5
20	2205	1506	1151	597	504	557
50	2815	1699	1352	690	724	715
100	3314	1841	1506	759	921	845
Fecha	23067020	23067040	23067050	23067060	23067070	23067080
5/26/2008	**271.6**	**394.3**	**185**	**98.55**	**48.47**	**90.74**

Precipitación acumulada 5 días

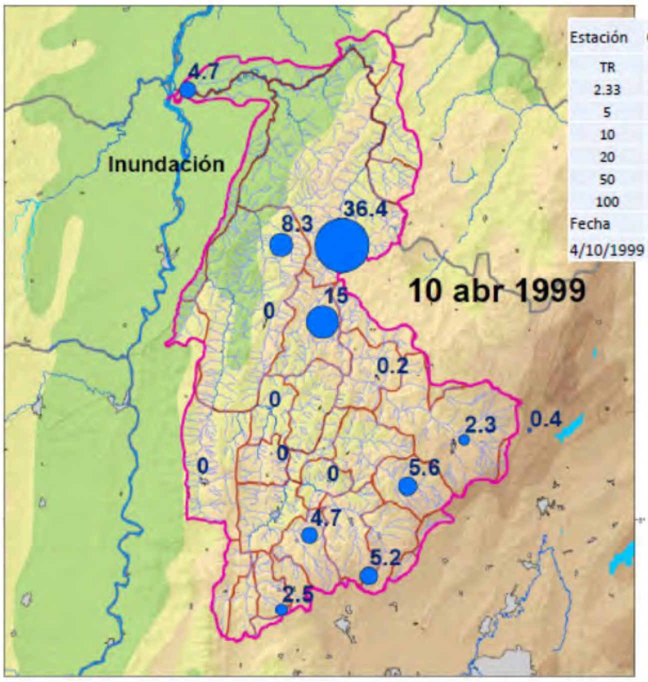
			PTO LIBRE	YACOPI	CAPARRAPI	TUSCOLO EL	SAN PABLO	PALMA LA	PENON EL	UTICA	SUPATA	CHILAGUA FCA	CABRERA LA	SILENCIO EL	ESTANCIA LA	STA TERESA	SABANETA	YACOPI	CABRERA LA	MONTELIBANO	STA BARBARA	STA ROSITA	TRAPICHE EL	AGUA FRÍA	SAN ISIDRO	TIESTOS LOS	NEGRETE	INST. AGRÍC. ESC. VOCACIONAL	ACOMODO EL	GUADUAS	CAPARRAPI
año	mes	dia	23060150	23060090	23060110	23060140	23060160	23060170	23060180	23060190	23060200	23060260	23060270	23060290	23060370	23065060	23065100	23065110	23065120	23065130	23065140	23065150	23065200	2306033	2306034	2306039	2306308	2306507	2306516	2306517	2306519
2008	5	26	5.8	0	102	86	61.3	185	88.1	54	101	102	0	153	0	51.4	112	96.3	89	0	0	0	0	81	13	140	133	63.2	0	0	0

Precipitación 5 días anteriores al evento

			PTO LIBRE	YACOPI	CAPARRAPI	TUSCOLO EL	SAN PABLO	PALMA LA	PENON EL	UTICA	SUPATA	CHILAGUA FCA	CABRERA LA	SILENCIO EL	ESTANCIA LA	STA TERESA	SABANETA	YACOPI	CABRERA LA	MONTELIBANO	STA BARBARA	STA ROSITA	TRAPICHE EL	AGUA FRÍA	SAN ISIDRO	TIESTOS LOS	NEGRETE	INST. AGRÍC. ESC. VOCACIONAL	ACOMODO EL	GUADUAS	CAPARRAPI
año	mes	dia	23060150	23060090	23060110	23060140	23060160	23060170	23060180	23060190	23060200	23060260	23060270	23060290	23060370	23065060	23065100	23065110	23065120	23065130	23065140	23065150	23065200	2306033	2306034	2306039	2306308	2306507	2306516	2306517	2306519
2008	5	22	0		42.3	35.3	12.4	56	20.1	0	5.5	13.5		35.4		15.8	15.2	36.4	6.1					10.8	0.3	18	10.2	18.5			
2008	5	23	3.5		28.6	12.5	13.7	10	28.1	0	25	2		10		6.2	12	6.2	16					2.5	10	31	10.4	33.4			
2008	5	24	2.3		12	23.3	8	30	18.1	18	36	13.8		23		8.6	46	20	35					6.8	0.8	18	27.2	11.3			
2008	5	25	0		0	2.1	14.4	29	3.9	0	20	33.3		9		3.3	13	8.4	10.5					21.4	0.8	54	31.1	0			
2008	5	26	0		19	12.9	12.8	60	17.9	36	15	38.9		76		17.5	26.2	25.3	21.4					39	0.8	18	54.4	0			

Source: WS Presentation by Mr. Fabio on June 5, 2017

(4) Hydrological Conditions in Flood Event on April 10, 1999



Estación	COLORADOS	PTO LIBRE	GUADUERO	TOBIA	VILLETA	CHARCO LARGO
TR	Q (m3/s)	Q (m3/s)	Q (m3/s)	Q (m3/s)	Q (m3/s)	Q (m3/s)
2.33	917.7	976.7	645.1	355.2	137.3	226.5
5	1364.2	1187.8	838.1	449.1	247.1	340.2
10	1774.5	1352.5	997.0	524.7	365.0	445.5
20	2205	1506	1151	597	504	557
50	2815	1699	1352	690	724	715
100	3314	1841	1506	759	921	845
Fecha	23067020	23067040	23067050	23067060	23067070	23067080
4/10/1999	**330.6**	**370**	**221.1**	**176.2**	**26.9**	**86.2**

Inundación en Puerto Libre y Colorado
Deslizamiento en Viani

Precipitación acumulada 5 días

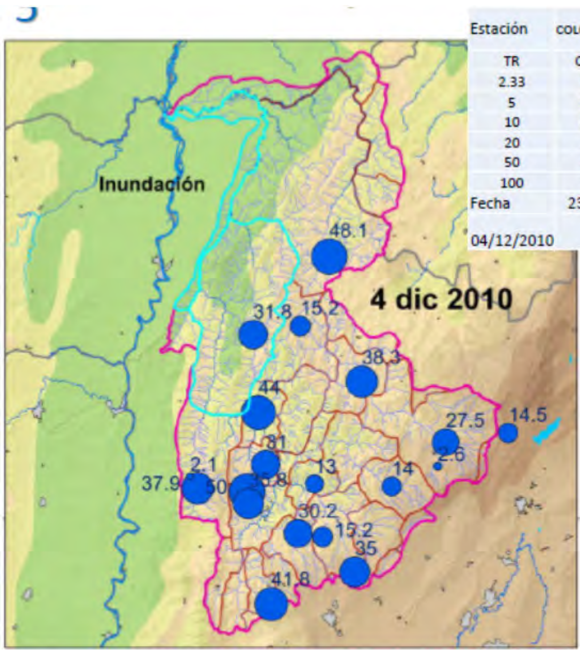
año	mes	dia	PTO LIBRE 23060150	YACOPI 23060090	CAPARRAPI 23060110	TUSCOLO EL 23060140	SAN PABLO 23060160	PALMA LA 23060170	PENON EL 23060180	UTICA 23060190	SUPATA 23060200	CHILAGUA FCA 23060260	CABRERA LA 23060270	SILENCIO EL 23060290	ESTANCIA LA 23060370	STA TERESA 23065060	SABANETA 23065100	YACOPI 23065110	CABRERA LA 23065120	MONTELIBANO 23065130	STA BARBARA 23065140	STA ROSITA 23065150	TRAPICHE EL 23065200	AGUA FRÍA 2306033	SAN ISIDRO 2306034	TIESTOS LOS 2306039	NEGRETE 2306308	INST. AGRÍC. ESC. VOCACIONAL 2306507	ACOMODO EL 2306516	GUADUAS 2306517	CAPARRAPI 2306519
1999	4	10	85.9	0	75	100	36.5	21.8	75.7	88	106	84.5	0	165	0	63.5	27.2	120	85.8	0	0	0	0	60	0	0	0	79.1	0	0	0

Precipitación 5 días anteriores al evento

año	mes	dia	PTO LIBRE 23060150	YACOPI 23060090	CAPARRAPI 23060110	TUSCOLO EL 23060140	SAN PABLO 23060160	PALMA LA 23060170	PENON EL 23060180	UTICA 23060190	SUPATA 23060200	CHILAGUA FCA 23060260	CABRERA LA 23060270	SILENCIO EL 23060290	ESTANCIA LA 23060370	STA TERESA 23065060	SABANETA 23065100	YACOPI 23065110	CABRERA LA 23065120	MONTELIBANO 23065130	STA BARBARA 23065140	STA ROSITA 23065150	TRAPICHE EL 23065200	AGUA FRÍA 2306033	SAN ISIDRO 2306034	TIESTOS LOS 2306039	NEGRETE 2306308	INST. AGRÍC ESC VOCACIONAL 2306507	ACOMODO EL 2306516	GUADUAS 2306517	CAPARRAPI 2306519
1999	4	6	0		53	55.9	4.6	0	26.1	52	2.2	14.5		28.4		1	3.6	42.6	40					25.3				35.7			
1999	4	7	81.2		11.5	0	16.6	1.9	2	0	25	0		39.8		28.2	0.9	32.8	12					6.3				6.3			
1999	4	8	0		6	33.2	4.1	0	43	0	32	50		37.8		28.5	15.4	3.3	19.5					16				15.8			
1999	4	9	0		4.5	11.3	2.9	4.9	4.4	36	42	20		53.8		3.3	2.1	4.5	12					12.2				20.9			
1999	4	10	4.7		0	0	8.3	15	0.2	0	5.6	0		4.7		2.5	5.2	36.4	2.3					0				0.4			

Source: WS Presentation by Mr. Fabio on June 5, 2017

(5) Hydrological Conditions in Flood Event on December 4, 2010



Estación	COLORADOS	PTO LIBRE	GUADUERO	TOBIA	VILLETA	CHARCO LARGO	PARAISO EL
TR	Q (m3/s)	Q (m3/s)	Q (m3/s)	Q (m3/s)	Q (m3/s)	Q (m3/s)	Q (m3/s)
2.33	917.7	976.7	645.1	355.2	137.3	226.5	76.0
5	1364.2	1187.8	838.1	449.1	247.1	340.2	100.6
10	1774.5	1352.5	997.0	524.7	365.0	445.5	121.1
20	2205	1506	1151	597	504	557	141
50	2815	1699	1352	690	724	715	168
100	3314	1841	1506	759	921	845	188
Fecha	23067020	23067040	23067050	23067060	23067070	23067080	23067090
04/12/2010	643.9		390.2	182.9		151.4	

Precipitación acumulada 5 días

			PTO LIBRE	YACOPI	CAPARRAPI	TUSCOLO EL	SAN PABLO	PALMA LA	PENON EL	UTICA	SUPATA	CHILAGUA FCA	CABRERA LA	SILENCIO EL	ESTANCIA LA	STA TERESA	SABANETA	YACOPI	CABRERA LA	MONTELIBANO	STA BARBARA	STA ROSITA	TRAPICHE EL	AGUA FRÍA	SAN ISIDRO	TIESTOS LOS	NEGRETE	INST. AGRÍC. ESC. VOCACIONAL	ACOMODO EL	GUADUAS	CAPARRAPI
año	mes	dia	23060150	23060090	23060110	23060140	23060160	23060170	23060180	23060190	23060200	23060260	23060270	23060290	23060370	23065060	23065100	23065110	23065120	23065130	23065140	23065150	23065200	2306033	2306034	2306039	2306308	2306507	2306516	2306517	2306519
2010	12	4	99.9	0	126	77	84.5	8	128	57	70.8	38.9	0	107	39.6	69.2	100	98.4	71.1	0	0	0	57	44	82	76.2	69	111.2	47.6	71	89.1

Precipitación 5 días anteriores al evento

			PTO LIBRE	YACOPI	CAPARRAPI	TUSCOLO EL	SAN PABLO	PALMA LA	PENON EL	UTICA	SUPATA	CHILAGUA FCA	CABRERA LA	SILENCIO EL	ESTANCIA LA	STA TERESA	SABANETA	YACOPI	CABRERA LA	MONTELIBANO	STA BARBARA	STA ROSITA	TRAPICHE EL	AGUA FRÍA	SAN ISIDRO	TIESTOS LOS	NEGRETE	INST. AGRÍC. ESC. VOCACIONAL	ACOMODO EL	GUADUAS	CAPARRAPI
año	mes	día	23060150	23060090	23060110	23060140	23060160	23060170	23060180	23060190	23060200	23060260	23060270	23060290	23060370	23065060	23065100	23065110	23065120	23065130	23065140	23065150	23065200	2306033	2306034	2306039	2306308	2306507	2306516	2306517	2306519
2010	11	30			20	14.2	3.5	8	30.5	13	0	1.4		12.5	5.6	19.2	18.4	18.5	11.6				0.5	5.7	32	0	49.2	6.2	16	11	2
2010	12	1	0		16.5	2.3	17.7		27.3	0	13	7.6		30	1.8	1.9	17	12	5.2				4.6	3.5	0	0	13	3.5	1.6	8.7	16.5
2010	12	2	22.1		2	18.2	0		1.2	0	6.6	6.7		9.9	5.6	1.7	14	12.4	7.3				7	4.2	0	20	4	58.8	10	2.8	2.2
2010	12	3	77.8		87	40	63.3		30.4	0	37	10.2		24.1	11.4	4.6	15.9	7.4	19.5				8.8	0	0	41	0	28.2	20	12	36.6
2010	12	4	0		0	2.1	0		38.3	44	14	13		30.2	15.2	41.8	35	48.1	27.5				35.8	31	50	15	2.6	14.5		38	31.8

Source: WS Presentation by Mr. Fabio on June 5, 2017

From the previous examples, it is evident that many of the flood events registered in the basin are the product of localized precipitation in some of the sub-basins, and that additionally they seem to correspond to the cumulative effect of rainfall that occurred prior to the date of the event. In the cases presented, accumulated rainfall stands out in periods of 5 days prior to the date of registration of the event, which are greater than 80 millimeters of precipitation. This situation could generate the saturation of the soils and the rapid response of the basin to minor precititaciones the day of the event or the previous day.

4.2.2 Relationship between Past Hydrological Conditions and Occurrence of Flood Events

An analysis of the conditions of the generation of disaster when the precipitation or flow has high volume was performed.

(1) Relationship between High Amount of Basin Average Rainfall and Flood Events

The maximum annual average rainfall from Section 3.3 (2) was ordered from the highest value to the lowest value, and disaster occurence was confirmed using the DNP disaster data. As DNP data are available from 1998, and it is not possible to confirm whether a disaster accompanied by rainfall had occured prior to the years with available data, spaces for before 1997 were crossed out. Based on the results of this exercise, it is observed that there is an obvious relationship between high volume of the average precipitation of the basin and disasters, although the magnitude of the disasters vary.

Table 4.2.1 Relationship between High Amount of Basin Average Rainfall and Past Flood Records

Rank	año	mes	dia	Promedio	Inundación en DNP	Rank	año	mes	dia	Promedio	Inundación en DNP
1	2011	5	13	51.5	Rank 142 (May 13)	24	1987	4	27	34.1	
2	2016	4	1	50.1	Rank 243 (Apr. 1) y varios (Apr. 2)	25	1980	10	3	33.8	
3	1979	10	21	49.0		26	1990	4	23	33.7	
4	1985	4	30	45.7		27	2004	5	18	33.1	No
5	1976	4	11	43.9		28	1999	2	21	32.7	Rank 17 y varios (Feb. 22)
6	2002	4	24	43.8	Rank 62 (Apr. 25)	29	1996	3	6	32.7	
7	1991	10	7	41.3		30	1978	4	19	32.4	
8	1975	5	2	40.3		31	1977	10	23	31.7	
9	1972	8	18	39.5		32	2007	10	28	30.8	No
10	2013	5	4	38.6	Rank 58, 258 (May 5)	33	2006	11	14	30.6	Rank 8 (Nov. 16)
11	1994	11	4	38.3		34	2001	3	20	30.4	No
12	1973	11	14	37.6		35	1974	10	14	30.0	
13	1986	4	18	37.6		36	1995	12	3	29.9	
14	2008	11	25	37.2	Rank 92 (Nov. 28)	37	1998	9	22	29.5	
15	2015	11	4	37.0	No	38	2010	11	16	29.2	Rank 100 (Nov. 18)
16	1982	10	19	37.0		39	1993	5	25	28.7	
17	1981	10	23	36.1		40	1988	4	3	28.6	
18	1983	10	15	35.8		41	1989	10	27	28.4	
19	2014	11	10	35.4	Rank 23 (Nov. 9)	42	1997	9	8	28.0	
20	1984	11	6	34.9		43	2012	10	15	27.7	No
21	1971	1	16	34.9		44	2003	4	9	25.1	No
22	1992	5	30	34.9		45	2009	10	24	24.0	No
23	2005	10	23	34.5	Rank 134 y varios (Oct. 24)	46	2000	9	9	24.0	No

Source: WS Presentation by Mr. Morita on July 19, 2017

(2) Relationship between Annual Maximum Discharge in Puerto Libre and Flood Events

The data from the maximum annual discharge at the Puerto Libre station, the station at the lowest point of the basin, were ordered from the highest value towards the lowest value. Then the disasters ocurrence was confirmed using the DNP disaster data. As DNP data are available from 1998, and it is not possible to confirm whether a disaster accompanied by rainfall prior to the years with available data had occured, spaces for data before 1997were crossed out. Based on the results of this exercise, it can be concluded that there are cases in which there is an evident relationship between high volume of the average precipitation of the basin and disasters. However, the correlation between the magnitude of the disasters and the value of the flow is not very strong.

Table 4.2.2 Relationship between Annual Maximum Discharge in Puerto Libre and Past Flood Records

Rank	año	mes	dia	23067040	Inundación en DNP	Rank	año	mes	dia	23067040	Inundación en DNP (top 40)
1	**1999**	2	22	1,227.0	Rank 17, 127, 137, 174, 175	21	**1976**	5	2	671.8	
2	**2007**	10	29	1,105.0	No	22	**1998**	11	14	669.7	
3	**1988**	12	8	1,038.0		23	**2003**	12	3	665.4	No
4	**1987**	11	1	995.4		24	**1975**	10	27	665.0	
5	**1996**	10	15	955.4		25	**1995**	11	25	638.7	
6	**2004**	10	23	951.7	Rank 182	26	**2012**	4	21	633.1	Rank 23 (Apr. 23)
7	**2008**	5	28	932.8	Rank 5, 98, 321 (May 26) Rank 320 (May 29)	27	**1982**	5	5	626.1	
8	**1994**	4	30	924.9		28	**2010**	12	5	618.1	Rank 36 (Dec. 5)
9	**2011**	11	9	898.2	Rank 18, 153 (Nov. 10)	29	**2013**	4	21	603.4	Rank 135 (Apr. 22)
10	**1984**	5	15	882.2		30	**1991**	5	1	588.0	
11	**2006**	5	9	880.4	Rank 56, 66 (May 10)	31	**1983**	10	30	566.4	
12	**1990**	5	3	851.0		32	**2014**	5	7	561.3	Rank 192 (May 9)
13	**2002**	4	26	836.4	Rank 62 (Apr. 25)	33	**1978**	4	20	560.0	
14	**1981**	5	11	816.5		34	**1993**	4	21	482.3	
15	**1986**	4	19	800.7		35	**1985**	10	24	442.5	?
16	**1977**	11	15	788.0		36	**2001**	5	28	412.5	No
17	**1979**	10	30	779.3		37	**1992**	5	9	400.3	?
18	**2000**	5	8	710.0	No	38	**1997**	11	10	378.4	?
19	**2005**	5	19	687.0	No	39	**1980**	11	24	229.4	?

Source: WS Presentation by Mr. Morita on July 19, 2017

(3) Analysis of Simultaneous Occurrence of High Hydrological Conditions in the Basin, and Relationship between Basin-wide High Hydrological Conditions and Flood Events

In order to confirm the simultaneity of the occurrence of floods in the basin, the dates in which the maximum annual discharge was observed in 6 stations administered by IDEAM were isolated, as presented in the Table below. In this table, the cells of the same color represent the maximum values that were observed simultaneously (the observation date of the maximum value is equal or +/- 1 day).

Based on this table, it can be concluded that the probability of the simultaneous occurrence of the maximum discharge is high.

Table 4.2.3 Basin-wide High Discharge in IDEAM Stations

	COLORADOS			PTO LIBRE			GUADUERO			TOBIA			VILLETA			CHARCO LARGO		
year	month	day	23067020	month	day	23067040	month	day	23067050	month	day	23067060	month	day	23067070	month	day	23067080
1990	12	5	728.0	5	3	851.0	4	26	501.1	4	26	227.5	12	5	534.3	4	27	152.9
1991	5	21	372.0	5	1	588.0	3	28	459.5	5	3	186.6	3	26	90.9	5	20	123.5
1992	11	29	205.6	5	9	400.3	11	29	199.6	5	7	75.76	12	12	232.5	5	7	46.1
1993	11	29	331.8	4	21	482.3	12	18	268.5	11	30	149	12	17	72.6	5	6	126.8
1994	4	29	441.1	4	30	924.9	4	29	481.7	4	29	183.4	2	4	401.8	2	4	141.6
1995	12	12	434.1	11	25	638.7	4	22	343.9	4	23	161.6	12	12	107.0	11	18	87.8
1996	10	15	447.8	10	15	955.4	3	7	510.4	3	11	249.3	5	27	87.0	3	7	134.7
1997	11	21	153.6	11	10	378.4	11	21	201.2	2	11	102.6	1	27	21.4	6	8	83.2
1998	11	14	531.0	11	14	669.7	11	22	448.2	11	14	186.5	10	29	20.0	5	4	81.1
1999	2	22	675.8	2	22	1227.0	2	22	565.9	10	27	240.8	4	4	190.4	2	20	127.4
2000	11	1	435.0	5	8	710.0	2	29	289.7	2	26	134.1	3	24	73.4	2	29	70.9
2001	11	14	279.6	5	28	412.5	12	13	289.7	12	13	156	3	1	89.7	12	13	110.3
2002	4	25	833.4	4	26	836.4	4	25	782.8	4	25	356	4	25	98.6	4	25	358.6
2003	4	20	418.6	12	3	665.4	11	22	268.4	11	22	172.2	11	22	91.9	1	19	22.4
2004	11	7	484.8	10	23	951.7	5	18	327.9	11	18	194.3	11	19	68.9	11	9	110.3
2005	5	23	979.3	5	19	687.0	10	28	407.2	5	3	226.9	10	28	57.2	10	28	139.3
2006	12	12	1155.0	5	9	880.4	5	8	376.0	5	10	306	11	16	71.7	5	9	174.7
2007	4	28	1029.0	10	29	1105.0	4	6	352.5	4	7	290.4	10	29	159.0	10	29	132.0
2008	5	28	632.2	5	28	932.8	5	28	232.0	5	27	201.5	3	30	88.1	5	28	140.7
2009	3	25	437.2	3	20	673.0	5	4	252.0	3	31	156.9	3	25	123.3	3	24	86.6
2010	12	4	643.9	12	5	618.1	12	4	390.2	12	4	182.9	3	6	38.0	7	11	237.4
2011	4	22	844.1	5	14	898.2	4	19	751.2	4	12	247.6	12	3	46.1	4	12	200.7
2012	1	6	520.2	4	21	633.1	11	15	307.5	4	21	119.9	1	6	38.2	5	2	89.8
2013	12	23	469.5	4	21	603.4	5	3	424.8	5	3	214	5	5	48.8	5	3	157.3
2014	3	4	635.4	5	7	561.3	3	8	381.5	5	9	284	3	16	33.5	3	8	145.8

Source: WS Presentation by Mr. Morita on July 19, 2017

As in the analysis described above, in order to confirm the simultaneity of the occurrence of floods in the basin, the dates in which the maximum annual level was observed in the 6 stations administered by IDEAM were isolated, as presented in the table below. The dates of the maximum annual level and the maximum annual discharge should coincide, and in this sense the exercise also serves to verify the accuracy of the data. In this table, the cells of the same color represent the maximum values that were observed simultaneously. As in the dischaarge analysis, based on this table, it can be concluded that the probability of the simultaneous occurrence of the maximum discharge is high.

Table 4.2.4 Basin-wide High Water Level in IDEAM Stations

	COLORADOS			PTO LIBRE			GUADUERO			TOBIA			VILLETA			CHARCO LARGO		
year	month	day	23067020	month	day	23067040	month	day	23067050	month	day	23067060	month	day	23067070	month	day	23067080
1990	12	5	94.52	5	3	157.19	4	26	88.97	4	26	98.27	12	5	92.58	4	27	92.03
1991	5	21	93.22	5	1	156.44	3	28	88.84	5	3	97.99	3	26	90.23	5	4	91.97
1992	11	29	92.45	5	9	156.01	11	29	87.60	5	7	97.19	12	12	91.38	5	7	91.40
1993	11	29	92.99	4	21	156.24	12	18	88.09	11	30	97.73	12	17	90.23	5	6	91.94
1994	4	29	93.42	4	30	157.16	11	7	88.59	4	29	97.97	2	4	92.33	2	4	91.92
1995	4	19	93.21	5	30	156.38	4	22	88.24	4	23	97.83	12	12	90.61	11	18	91.76
1996	10	15	93.34	3	11	157.19	3	7	88.74	3	11	98.40	5	27	90.38	3	7	92.07
1997	11	21	93.09	11	10	155.92	11	21	87.76	2	11	97.40	1	27	89.52	6	8	91.71
1998	11	14	94.74	12	9	156.36	11	22	88.49	11	14	97.98	3	30	89.48	5	4	91.69
1999	2	22	95.17	2	22	157.60	2	22	89.72	10	27	98.34	4	4	90.13	2	20	92.03
2000	11	1	94.33	5	8	156.73	2	29	88.29	2	26	97.65	3	24	89.73	2	29	91.65
2001	11	14	93.66	5	28	155.74	12	13	88.39	12	13	97.82	3	1	89.96	12	13	91.93
2002	4	25	95.71	4	25	157.84	4	25	90.49	4	25	99.12	5	29	89.98	4	25	93.13
2003	4	20	94.33	12	3	156.40	11	22	88.29	11	22	97.92	11	22	89.98	1	19	91.10
2004	5	19	94.51	10	23	157.09	5	18	88.57	11	18	98.11	11	19	90.96	11	8	91.93
2005	5	23	96.07	5	19	156.57	10	28	88.46	10	24	100.09	3	8	91.66	10	24	92.11
2006	12	12	96.54	5	9	157.47	5	8	88.32	5	10	100.82	11	16	89.88	5	9	92.33
2007	4	28	96.28	4	27	157.23	4	6	88.22	4	7	98.58	10	29	90.73	10	29	91.95
2008	5	28	95.09	5	28	156.66	5	28	87.65	5	27	98.28	5	27	89.98	5	28	92.03
2009	3	25	94.37	3	20	155.97	5	4	87.74	3	31	97.60	3	25	90.23	3	24	91.52
2010	12	4	95.13	12	4	157.04	12	4	88.38	12	4	98.06	2	24	90.16	7	11	92.36
2011	4	19	96.16	5	14	157.14	4	7	90.83	4	12	98.43	4	22	92.61	4	12	92.43
2012	1	6	94.68	4	21	156.07	11	15	88.08	4	21	97.61	1	6	89.93	1	22	91.48
2013	12	23	94.47	11	7	155.89	5	3	88.54	5	3	98.24	5	5	90.18	5	3	91.98
2014	3	4	95.00	3	8	157.07	3	8	88.42	5	9	97.52	3	16	89.86	11	11	91.58

Source: WS Presentation by Mr. Morita on July 19, 2017

Additionally, like the analysis described above, the dates on which the maximum annual level was observed at the 12 stations administered by the CAR were isolated. In this table, the cells of the same color represent the maximum values that were observed simultaneously. It can be concluded that the simultaneous occurrence of the maximum discharge is relatively frequent, although it is lower than in the IDEAM data.

Table 4.2.5 Basin-wide High Water Level in CAR Stations

year	month	day	2306710	month	day	2306711	month	day	2306712	month	day	2306713	month	day	2306714	month	day	2306715
1995	10	20	46	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN
1996	3	21	46	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN
1997	7	13	49	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN
1998	3	23	40	3	23	100	8	21	0	NaN	NaN	NaN	NaN	NaN	NaN	12	28	29
1999	11	15	35	10	15	110	4	3	200	11	18	55	10	26	90	5	4	85
2000	4	17	62	11	2	100	4	2	200	5	19	58	2	22	80	6	17	100
2001	1	10	45	12	2	170	10	27	100	1	23	45	3	22	79	3	31	17
2002	12	9	88	4	25	180	11	21	170	4	26	65	4	25	83	4	13	50
2003	3	3	35	8	18	300	3	16	160	7	8	48	12	1	78	NaN	NaN	NaN
2004	NaN	NaN	NaN	1	31	203	NaN	NaN	NaN	4	30	95	4	14	85	1	5	90
2005	NaN	NaN	NaN	11	15	260	12	16	89	2	21	80	10	24	79	1	18	90
2006	12	12	82	4	14	300	4	12	95	11	13	150	12	6	89	NaN	NaN	NaN
2007	10	22	42	12	12	290	12	9	85	4	6	150	10	20	88	1	23	70
2008	5	28	45	11	29	320	12	14	100	4	5	100	1	9	65	5	22	46
2009	5	4	48	1	19	300	1	12	100	5	3	100	3	25	85	11	5	75
2010	5	5	50	5	5	350	5	26	100	11	12	135	11	14	83	9	1	75
2011	4	22	56	5	18	450	4	10	100	4	15	140	4	20	90	12	11	69
2012	10	22	29	4	20	300	NaN	NaN	NaN	1	18	107	1	30	83	8	25	88
2013	5	5	49	11	9	360	NaN	NaN	NaN	5	21	190	11	17	80	6	21	70
2014	11	11	42	3	4	400	NaN	NaN	NaN	1	1	90	3	7	63	11	3	76
2015	3	17	33	3	16	300	NaN	NaN	NaN	1	25	90	4	16	45	4	12	68

year	month	day	2306716	month	day	2306717	month	day	2306718	month	day	2306728	month	day	2306729	month	day	2306730
1995	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN
1996	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN
1997	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN
1998	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN
1999	NaN	NaN	NaN	11	30	80	8	2	381	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN
2000	NaN	NaN	NaN	3	15	100	4	19	175	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN
2001	NaN	NaN	NaN	11	18	85	11	27	165	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN
2002	NaN	NaN	NaN	3	29	95	1	1	140	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN
2003	NaN	NaN	NaN	3	7	192	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN
2004	NaN	NaN	NaN	6	11	85	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN
2005	11	14	106	2	17	100	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN
2006	12	12	125	1	3	100	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN
2007	10	18	140	5	9	100	11	1	253	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN
2008	11	22	155	12	8	62	5	19	280	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN
2009	11	6	120	2	24	89	3	29	300	3	31	235	4	1	93	5	6	80
2010	10	6	180	6	10	30	NaN	NaN	NaN	12	4	265	11	17	99	12	4	75
2011	3	5	164	2	15	100	NaN	NaN	NaN	4	12	300	5	1	150	5	14	88
2012	3	25	148	1	26	85	NaN	NaN	NaN	4	12	215	4	25	98	5	2	50
2013	12	23	169	5	6	80	NaN	NaN	NaN	12	23	250	5	6	92	12	8	90
2014	5	23	164	3	7	83	NaN	NaN	NaN	11	11	240	3	8	85	3	26	85
2015	3	17	149	2	28	249	NaN	NaN	NaN	4	4	215	3	20	64	4	7	55

Source: WS Presentation by Mr. Morita on July 19, 2017

In the table 4.2.6, the results of the analysis are presented, which confirmed the occurrence of disasters on the dates when the maximum annual values were observed simultaneously, and with the 3 types of data described above. Since 1998, there have been 12 days in which more than 3 places registered the maximum value simultaneously in one of the 3 types of data.

Within those days, there are 6 days in which disasters occurred. Only in 2 of these 6 days disasters occurred with a magnitude that falls into the ranking of the top 10 disasters.

Table 4.2.6 Relationship between Basin-wide High Discharge/Water Level and Past Flood Records

	Date with maximum value									Disaster List	
Year	Discharge (IDEAM)			Water Level (IDEAM)			Water Level (CAR)			DNP	Governacion
1990	4/26	4/27	3	4/26	4/27	3					
1994	4/29	4/30	4	4/29	4/30	3					
1998	11/14	-	3							-	
1999	2/20	2/22	4	2/20	2/22	4				Top 17	
2001	12/13	-	3	12/13	-	3				-	
2002	4/25	4/26	6	4/25	-	5	4/25	4/26	3	Top 62	
2003	11/22	-	3	11/22	-	3				-	
2005	10/28	-	3							-	-
2006	5/8	5/10	4	5/8	5/10	4				Top 56&66	-
2007							10/18	10/22	3	-	-
2008	5/27	5/28	5	5/27	5/28	6				Top 5 (5/26)	Yes
2010	12/4	12/5	4	12/4	-	4				Top 12&36	Top 12,13,14
2013	5/3	5/5	4	5/3	5/5	4	5/5	5/6	3	-	Top 6&20
2015							3/16	3/17	3	-	-
Criteria:	more than 3 sta.			more than 3 sta.			more than 3 sta.			Affected Person	Affected Person

Source: WS Presentation by Mr. Morita on July 19, 2017

It is difficult to identify a clear relationship between hydrological conditions and flood disasters based on the results described above. A possible cause of this is that several stations only observe the water level twice a day (4 of the 6 stations administered by IDEAM), and taking into account that the flood seems to have lasted only a few hours according to interviews with residents, that the peak level very likely could not be recorded. Another possibility is that there are quality problems with the disaster records (it can be difficult to verify if the date of the data is the date of occurrence of disaster or registration of disaster record). The former possible situation it can be resolved by thoroughness of recording the peak water level by extraordinaly observation during flood or high flow. In the latter possible situation, the form of disaster record should be unified rules of keeping disaster record should be shared in a list; for example, it may be helpful to put "date of disaster occurrence" and/or "date of data recording" in the title row of the disaster list, instead of just "date".

4.2.3 Actual Flood Condition in Several Locations based on Flood Survey

In order to understand the conditions of the flood event and its characteristics in the Río Negro basin, a flood survey was carried out in the frequent flood zones.

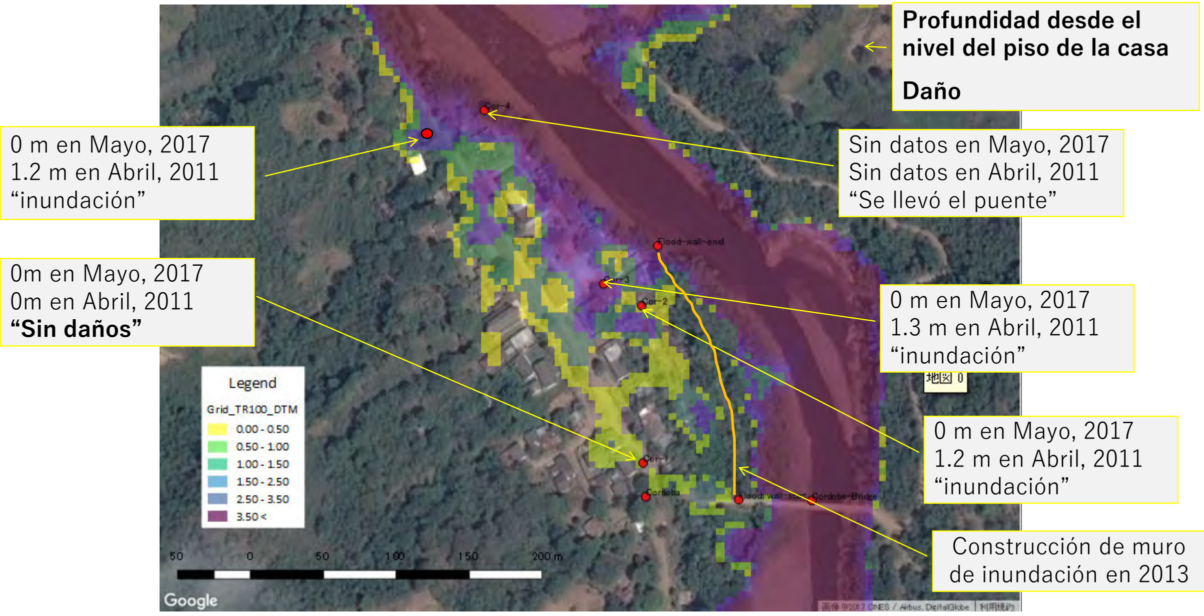
(1) Cordoba in Caparrapi Municipality

The field study was carried out in Córdoba on July 28, 2017 in order to collect the information about the flood characteristics, the current situations of the measures, the maximum past flood and the flood of May 2017.

The findings about the flood in Cordoba the following:

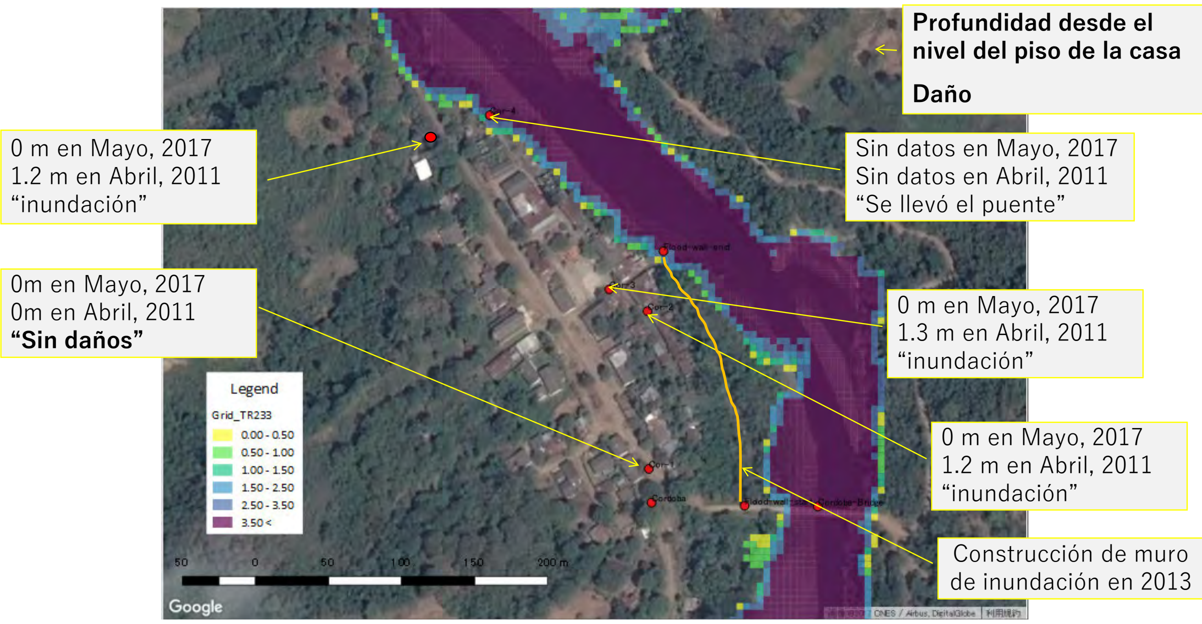
- Flood-related disasters occur frequently.
- The maximum flood occurred in 1963. The flood depth in the central part was 3m.
- Evacuation drill is performed continuously
- Residents receive alert from Útica and El Dindal
- Guatachí River also influences the flood in Córdobambién influye la inundación en Cordoba
- Regarding the flood in April 2011Peak discharge
    - Peak water level were recorded between 2-3am
    - High levels of water continued for about 3 hours
- After the flood of April 2011
    - Some affected people moved to other areas => The population was reduced from 100 homes to 70 homes
    - Dredging and gabion were implemented by CAR in 2013
- In the flood of May 2017 (increase of the level) caused no damage.

The maximum past flood according to the interview with the residents was in 1963, and the maximum flood in recent years was in April 2011. The figure below shows the depth of the flood in Cordoba in the flood of April 2011 and May 2017. The comparison was made with the flood map of the 100-year return period and 2.33 years, which are the results of the simulation (it will be elaborated on this later). The flood area and flood depth of the flood with the return period of 100 years coincide in most cases with the flood depth observed in April 2011 at several points where the surveys were conducted. Based on the flood marks, the flood of April 2011 must have been equivalent to the flood with a 100-year return period.



Source: WS Presentation by Mr. Morita on September 22, 2017

Figure 4.2.1 Survey Results and Simulation Results (100 years) Cordoba



Source: WS Presentation by Mr. Morita on September 22, 2017

Figure 4.2.2 Survey Results and Simulation Results (2.33 years) en Cordoba

(2) El Dindal en el municipio de Caparrapí

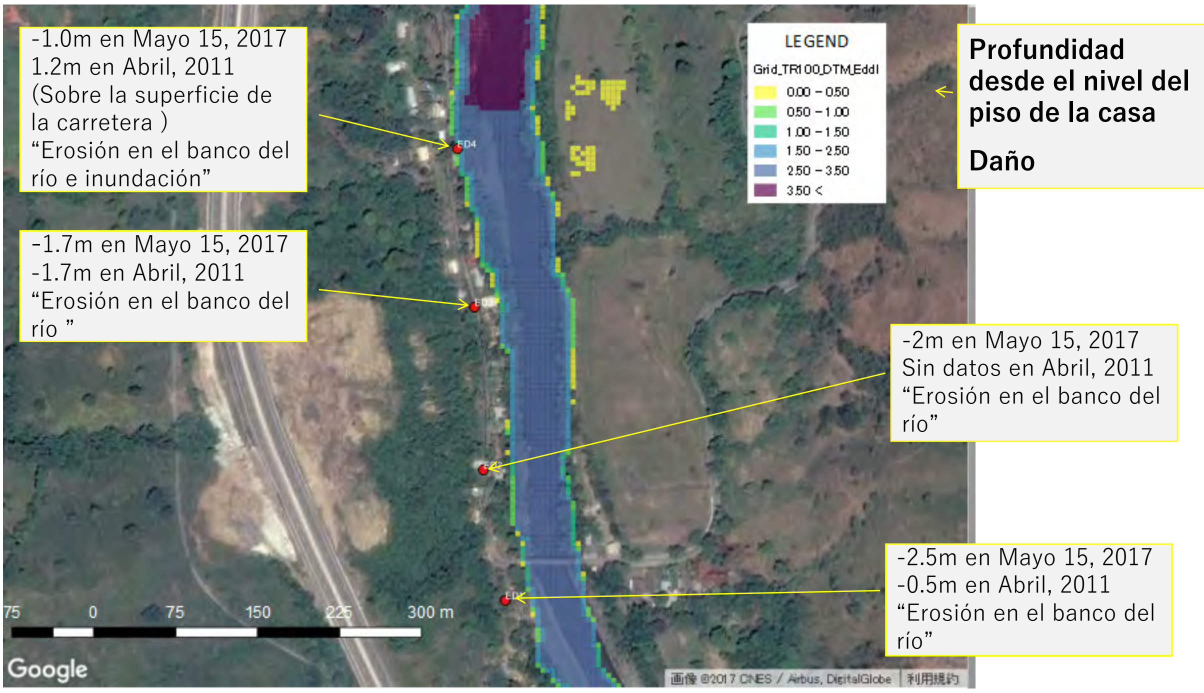
The field study was carried out in El Dindal on June 1, 2017 in order to collect the information about the flood characteristics, the current situations of the measures, the maximum past flood and the flood of May 2017.

The findings about the flood in El Dindal the following:

- Flood disaster occurs frequently in May and November.
- The greatest damage caused by the flood in El Dindal is the erosion of the river bank.
- Residents receive warning from Utica and Guaduero
- Flooding could occur due to the discharge from a tributary, such as the Guadero River that flows into in the course of the main river, Río Negro.
- In the flood of April 2011, a part of the village was flooded; however, in the flood of May 2017 (the inscrease in the level) the village was not flooded, and the water level in all the areas surrounding the river was lower than the bank.

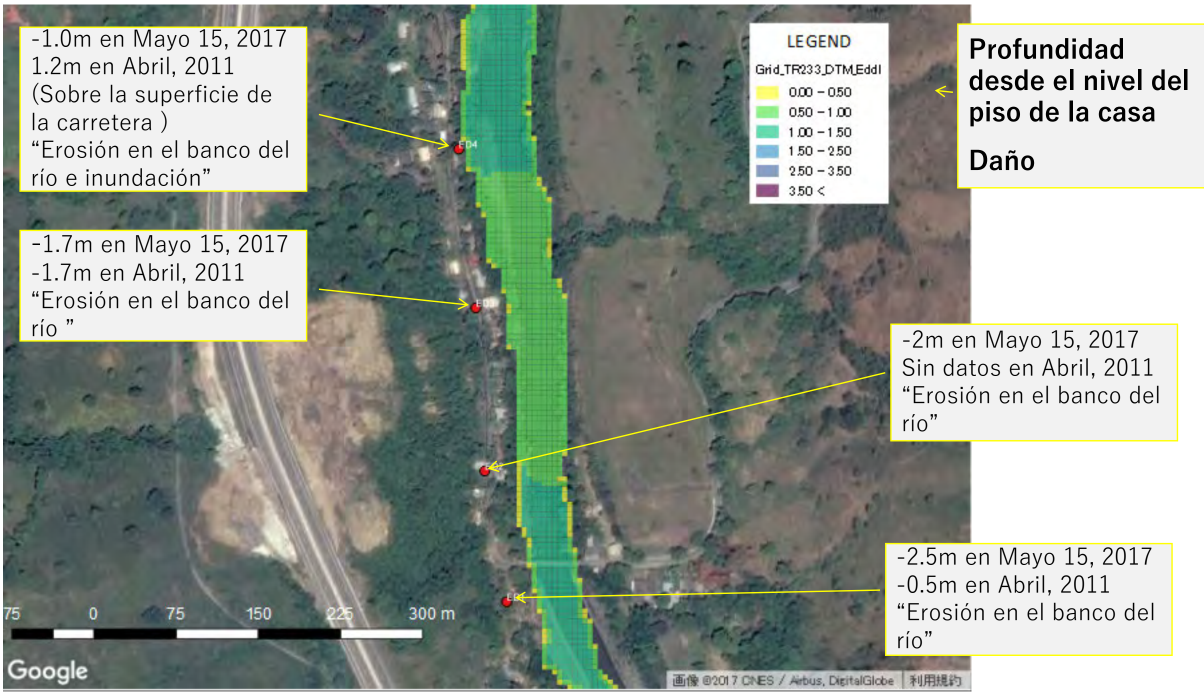
The maximum past flood according to the interview with the residents was in April 2011. The following is the depth of the flood in El Dindal (only downstream) in the flood of April 2011 and May 2017. The comparison was made with the flood map of the return period of 100 years and 2.33 years, which are the results of the simulation. The area and flood depth of the flood with the return period of 100 years coincide in most cases with the flood depth observed in April 2011, although in this municipality there was only one point that was flooded. Based on the flood marks, the flood of April 2011 must have been equivalent to the flood with a 100-year return period.

They do not present many flood damages in El Dindal, and it can be concluded that erosion damages are more serious



Source: WS Presentation by Mr. Morita on September 22, 2017

Figure 4.2.3 Survey Results and Simulation Results (100 years) in El Dindal



Source: WS Presentation by Mr. Morita on September 22, 2017

Figure 4.2.4 Survey Results and Simulation Results (2.33 years) in El Dindal

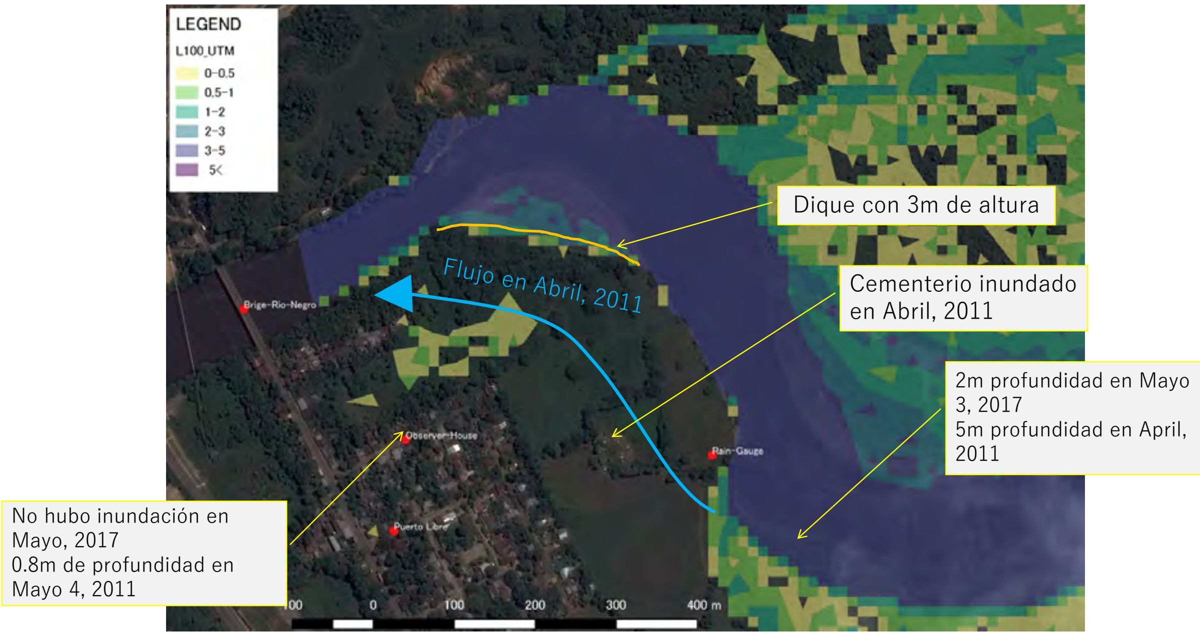
(3) Puerto Libre in Puerto Salgar Municipality

The field study was carried out in Puerto Salgar on June 1, 2017 in order to collect information on the flood characteristics, the current situations of the measures, the maximum past flood and the flood of May 2017.

The findings about the flood in Puerto Salgar are the following:

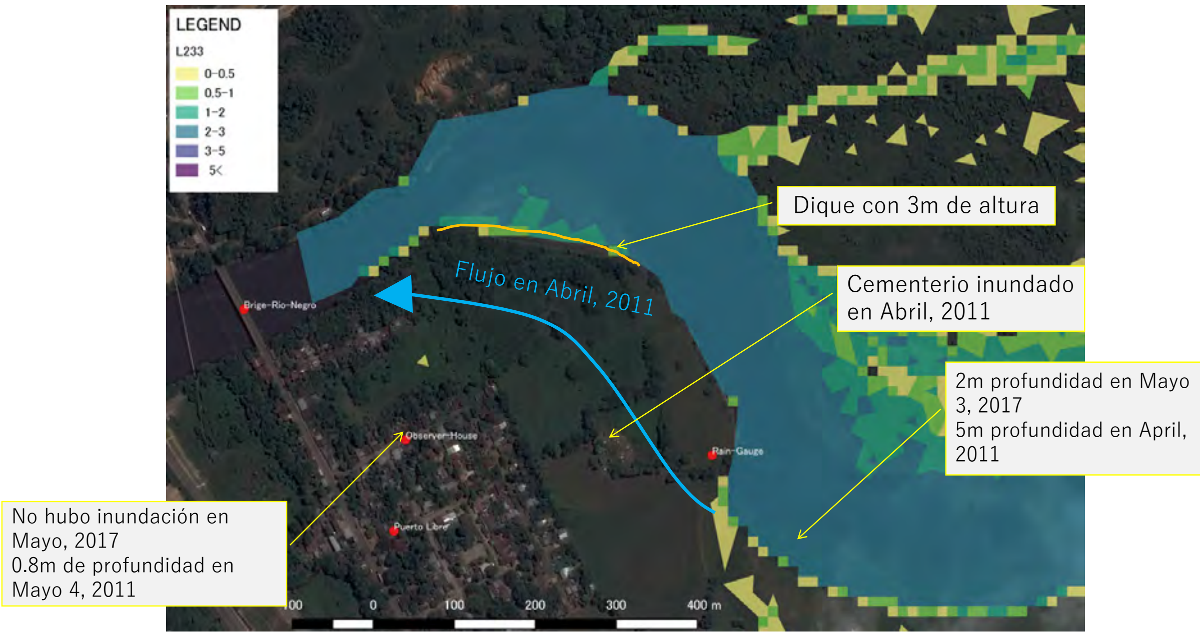
- Large-scale flooding occurs every 6 or 7 years.
- The cemetery was flooded in the flood of April 2011.
- The dike was built in 2012 by the Municipality and the Department.
- After the construction of the dike, the urban area was not affected by the flood.
- The left bank was not flooded but the right bank was flooded in May, 2017
- The maximum water level with 4.80m was recorded at 12:00 p.m. (noon) on May 18, 2017
- No damage occurred in the urban area of Puerto Libre in May 2017.

The maximum past flood according to the interview with the residents was in April 2011. Below is the depth of the flood in Puerto Libre in the flood of April 2011 and May 2017. The comparison with the flood map was made for the return period of 100 years and 2.33 years, which are the results of the simulation.



Source: WS Presentation by Mr. Morita on June 5, 2017

Figure 4.2.5 Survey Results and Simulation Results (100 years) in Puerto Libre



Source: WS Presentation by Mr. Morita on June 5, 2017

Figure 4.2.6 Survey Results and Simulation Results (2.33 years) in Puerto Libre

(4) Other points in the basin

Surveys were conducted at other points in the Río Negro basin, apart from the 3 points described above. The findings in each point are presented in the table below.

Table 4.2.7 Findings in Flood survey in Several Location

Village(Vereda)/ Municipality	Date of Survey	Findings
Utica	Aug. 1, 2015 May 19-20, 2016	• The 4 past flood disasters have occurred because of Qda. Ngera. They ocurred in 1963, 1988, 1990 and 2011. • In the flood of 2011, the natural dam of Qda. La Chorrera suffered a rupture in the middle section of Qda. Negra, and the depth of the flood was 2.8m from the side of the riverside part of the town center to Calle 6. • After the 2011 flood, dredging of the riverbed was carried out and a dike was constructed with the sediment extracted by dredging in Qda. Negra, for a stretch of 3km. The height of the riverbed was reduced by 5m with dredging.
Villeta	Oct. 20, 2015 Nov. 5, 2015	• A large discharge reached the Villeta River (tributary of Río Negro) in April 2011, and caused erosion in the left bank where the hospital is located, and the floodwater came near the hospital area. • Flood level reached 30cm in the high ground. • Flood occurred in low places on the left bank downstream (downstream from the hospital). • Flood occurred in low places on the right bank, the opposite bank from where the hospital is. • After the 2011 flood, a floodwall was built. The design (the height of the wall and the structure) was maed by the municipality of Villeta. Villeta Municipality and the CAR assumed the costs.
Pacho	Feb. 10, 2016	• During the 2011 flood, the banks of Río Negro were affected and some of the houses were damaged. After the flood, these areas were declared risk areas and there was a need to relocate the residents. • In 2011, a large amount of sediment was deposited at the bottom of the river. • 3.5 km were dredged downstream from Pacho in 2011, and 1.0 km in recent years, basically financed by CAR. • The floodwall made of sediments along the road was built financed by the Department of Cundinamarca.
Cambras	July 24, 2017	• In the flood of 2011, there was no flood in the urban center, although the parts in the west, bordering the tributary, suffered 30cm of flooding. • In the western part of the vilage, the channel used to pass more towards the south (the left bank) previously, but this changed towards the north side (the right bank) after the flood of 2011. It has not experienced flood damage again after. • They call from El Dindal and Guaduero in the flood event or communicate through WhatsApp, and the community leader notifies each household. • Drills for evacuation have been carried out.
Colorados	July 24, 2017	• There was no flood damage in the 2011 flood. • They call from Cambrás, Cordoba, El Dindal in flood event.
Guaduero	July 28, 2017	• In the flood of 2011 there was no flood caused by the main river of Río Negro, but there was flood caused by the tributary west of the village (Guaduero River) that caused damage. • In the floods of the 1960s, there was damage caused by the samem phenomenon (flood caused by the tributary). • Since about 4 years ago, a large amount sediment has been extracted from the left bank downstream of the main river (towards the west of the village) for the construction of the highway bridge, and erosion has occurred in the left bank since then. Near the base of the highway bridge, erosion has advanced. Erosion occurred in the left bank downstream of the main river in the May 2017 flood. • They receive communication from Útica and Villeta in the flood events, and the whole village is informed through the speakers of the oil company.

Source: JICA Project Team

5. Recognition of Rio Negro

The Río Negro basin, with the population of 260,000, has high population density areas that are disperse, as it typically is in Colombia.The main economic activity in the basin is agriculture, and in some parts there are mining activities, including activities related to petroleum.

An important topographical feature is that the majority of the basin belongs to the mountainous areas, and the main channel is narrow up to the point near the low section. The slope of the river is extremely high, and the floodwater does not remain in the flood area for a long time, for a few hours. The areas affected by flood damage are disperse, near areas of high population density. As for current measures against floods in the basin, structural measure are implemented as restoration works after suffering damage. In addition, the measures are implemented locally, and it can be said that this is a basin where local measures are suitable for the time being.

B. Planning of IFMP-SZ

1. Basic Policy for Planning of IFMP-SZ

- Objective of IFMP-SZ

The objectives of this IFMP-SZ is to prevent the loss of human life in the target area of the IFMP-SZ in the event of a flood event of the target magnitude of the IFMP-SZ (to be elaborated later), and to prevent damage to homes and infrastructure in the target area of the IFMP-SZ in a flood event of a magnitude (to be elaborated below) to be managed with structural measures.

In the measures against floods, structural measures are mainly implemented in order to prevent or reduce damage, against external force of a certain magnitude, such as a certain amount of precipitation/discharge.

At the same time, it is important to install these measures in such a way that the damages are reduced as much as possible even in the event of phenomena that exceed that magnitude. Although the frequency of flood damage caused by phenomena exceeding this magnitude is low, non-structural measures should be studied in order to reduce flood damage as much as possible, since in this case the projected damages are immense.

- On Relation with Rio Magdalena in terms of flood discharge and sediment runoff

Rio Negro is a first class tributary of the Magdalena River, and the lower channel of the Rio Negro River flows directly into the Magdalena River. The IFMP-SZ for the Rio Negro basin will be formulated using the condition of the confluence point with the Magdalena River as the condition of the downstream end of the Rio Negro River as well as the control element of the IFMP-SZ.

- On river planning policy inside Rio Negro watershed

In the present IFMP-SZ, the analysis is carried out for the entire basin. And based on the results, the IFMP-SZ is formulated with a focus on flood risks. The target floods of this IFMP-SZ are slow floods.

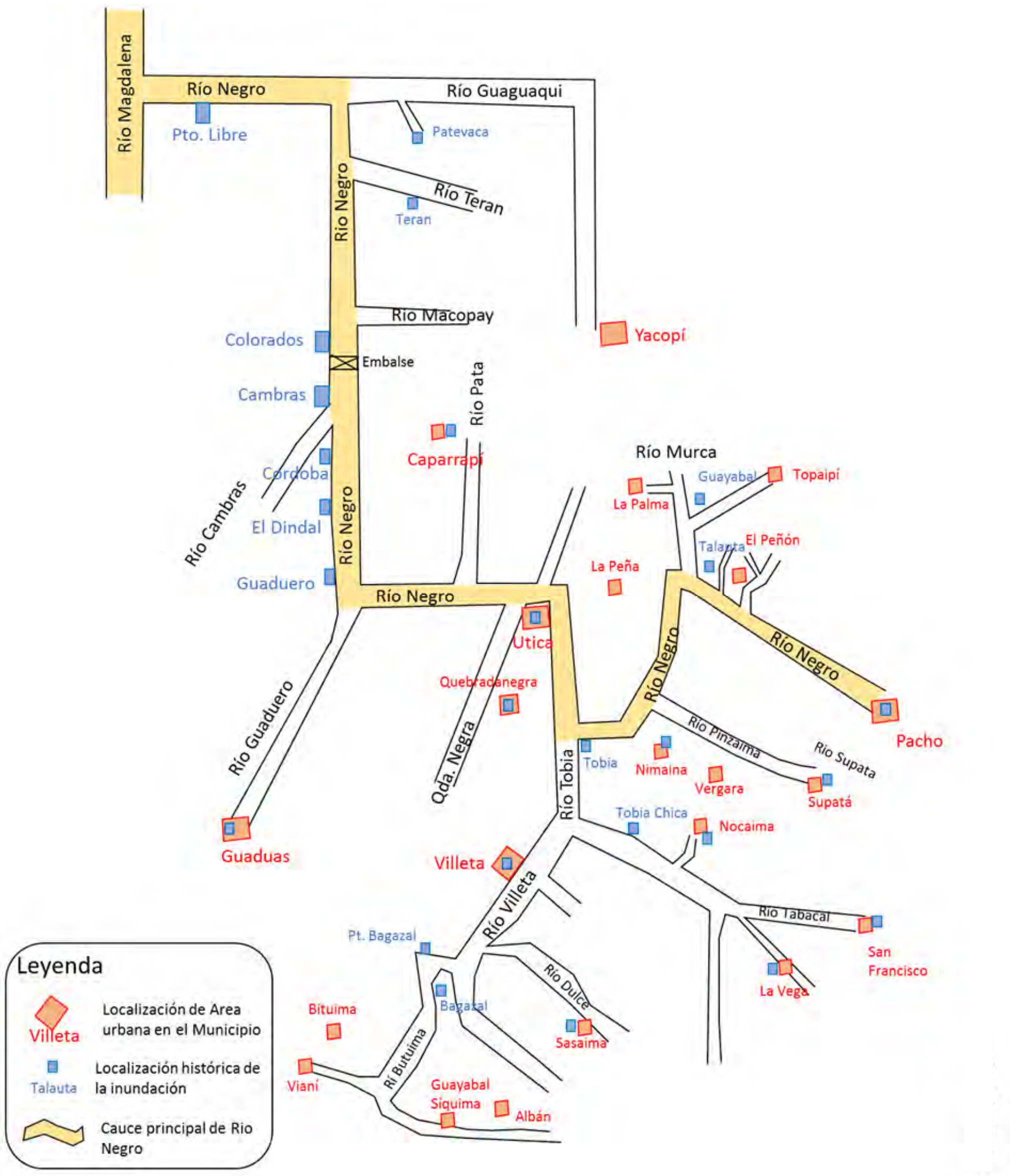
- On sediment disaster in Utica, etc.

Several sediment disasters occur in the Río Negro basin due to topographic and geological characteristics. The Utica disaster in 2011 was caused by an avalanche in the tributary (Quebrada Negra). It is clear that sediment disasters are the main disasters in the basin. However, as sediment disasters are not included in the framework of the present project, the project team does not have sediment specialists, and there is not enough information to perform sediment disaster analyzes in the whole basin, the team will only carry out a simple analysis and create a proposal of the items to study necessary in the future for sediment disasters.

2. Target Section

To study the measures against flood in the Río Negro basin, the main target section for which the measures will be studied was selected: in other words, the section where the measures for the reduction of flood damage will be studied.

For the selection, first, the location of urban centers of the municipalities within the basin and areas of high population density where there was flood damage (cities and urban centers in rural areas) in the past were studied. Then, the geographical relationship between these places and the river was studied schematically. Figure 2.1 shows a hydrological scheme, in chih the black line is the major channels within the basin, and the yellow channel is the main channel, and the orange points are the location of the urban centers in the municipalities within the basin where the population density is high and where they experienced flood damage in the past.



Source: WS Presentation by Mr. Inoue on May 9, 2017

Figure 2.1 Locations of Urban Area in each Municipality and Past Flood Events in Rio Negro River Basin for Selection of Candidates of Target Sections / Areas

After the procedure described above in which the urban centers and urban areas with high population density where they experienced flood damage in the past were identified, the target areas for the IFMP-SZ were selected. When making this selection, the following criteria (parameters) were defined.

- If it is a central part of the municipality (urban center).
- If the flood events are recorded.
- If the urban center is located in the mountains.
- If it is located in the lower basin, middle basin or upper basin.

- If it is close to the main channel, the main tributaries or the tributaries.

Table 2.1 Selection of Target Sections / Areas for River Planning

Número	Nombre de la Ubicación (Area objetivo candidata)	Nombre del Rio (Sub-cuenca)	Razón para enumerar		Características de la ubicación	Ubicación con respecto al curso principal de Rio Negro		Puntaje	Selección del Area Objetivo para el Plan de Rio (Tentativo)
			Importancia en el Municipio	Registro de Eventos pasados de Inundación		3: Bajo, 2: Medio, 1: Alto en Cuenca de Rio Negro	5: 1er orden 3: 2do orden 1: 3er orden 0: otra		
						Peso			
						2	1		
1	Puerto Libre	Rio Negro		Si		3	5	11	✔
2	Patevaca	Rio Guaguaqui		Si		3	1	7	
3	Teran	Rio Teran		Si		3	1	7	
4	Colorados	Rio Negro		Si		3	5	11	✔
5	Yacopi	Rio Guaguaqui	Municipio Urbano	No	Cima de la montaña	3	0	-99	
6	Cambras	Rio Negro		Si		3	5	11	✔
7	Caparrapi	Rio Pata	Municipio Urbano	Si	Cima de la montaña	2	1	5	
8	Cordoba	Rio Negro		Si		2	5	9	✔
9	La Palma	Rio Murca	Municipio Urbano	No	Cima de la montaña	1	0	-99	
10	Topaipi	Rio Murca	Municipio Urbano	No	Cima de la montaña	1	0	-99	
11	Guayabal	Rio Murca		Si		1	1	3	
12	El Dindal	Rio Negro		Si		2	5	9	✔
13	Guaduero	Rio Negro		Si		2	5	9	✔
14	La Pena		Municipio Urbano	No	Cima de la montaña	1	0	-99	
15	Talauta	Rio Alto Negro		Si		1	1	3	
16	El Penon	Rio Alto Negro	Municipio Urbano	No		1	0	-99	
17	Utica	Rio Negro	Municipio Urbano	Si		2	5	9	✔
18	Quebradanegra	Qda. La Negra	Municipio Urbano	Si	Cima de la montaña	2	1	5	
19	Pacho	Rio Alto Negro	Municipio Urbano	Si		1	5	7	
20	Tobia	Rio Negro		Si		1	5	7	
21	Nimaina	Rio Medio Negro	Municipio Urbano	Si	Cima de la montaña	1	1	3	
22	Vergada	Rio Pinzaima	Municipio Urbano	No	Cima de la montaña	1	0	-99	
23	Supata	Rio Pinzaima		Si		1	1	3	
24	Guaduas	Rio Guaduero	Municipio Urbano	Si		2	1	5	
25	Tobia Chica	Rio Tobia		Si		1	1	3	
26	Nocaima	Rio Tobia	Municipio Urbano	Si		1	1	3	
27	Villeta	Rio Tobia	Municipio Urbano	Si		1	3	5	
28	San Francisco	Rio Tobia	Municipio Urbano	Si		1	1	3	
29	Bagazal	Rio Tobia		Si		1	1	3	
30	La Vega	Rio Tobia	Municipio Urbano	Si		1	1	3	
31	Puente de Bagazal	Rio Tobia		Si		1	1	3	
32	Sasaima	Rio Tobia	Municipio Urbano	Si		1	1	3	
33	Bituima	Rio Tobia	Municipio Urbano	No		1	0	-99	
34	Viani	Rio Tobia	Municipio Urbano	No		1	0	-99	
35	Guayabal Siquima	Rio Tobia	Municipio Urbano	No		1	0	-99	
36	Alban	Rio Tobia	Municipio Urbano	No		1	0	-99	

Source: WS Presentation by Mr. Inoue on May 9, 2017

As a result of the study based on the selection criteria, which is summarized in the above table, the following 7 points were selected as candidate target areas of the IFMP-SZ.

- Puerto Libre

- Colorados
- Cambras
- Cordoba
- El Dindal
- Guaduero
- Utica

The analysis of the frequency of Flood disasters was performed using the organized data of the 40 biggest disasters obtained from the past disaster record from DNP mentioned above. As a result, it was identified that the two points out of the 7 points that suffered the greatest number of disasters are Córdoba and El Dindal. Therefore, it was decided to select these two points as main target areas. It was decided that in other 5 points will also be target areas for the formulation of the IFMP-SZ, within the limits of the project.

Both Cordoba and El Dindal belong to the municipality of Caparrapi. In the table below, the collected and classified information of the municipal documents regarding the population, land use, and development plan is presented. However, the information at the village (vereda) level is extremely limited, and the information in the table below is the little concrete information that was found.

Table 2.2 Population, land use, and development plan in Cordoba and El Dindal

Village	Population		Land use		Development Plan
	No. of Families	No. of Users	Urban Land (m^2)	Land for Urban Expansion (m^2)	
Córdoba	70	210	57,833	0	-
El Dindal	109	328	107,476	73,147	"Construcción y optimización de la planta de tratamiento de agua potable" y "Mejoramiento del acueducto" are proposed in PDM
Source	*PDM*	*PDM*	*EOT*	*EOT*	*PDM*

Note: PDM: Plan de Desarrollo Municipal (Municipal Development Plan) (2016-2019) in Caparrapí
EOT: Esquema de Ordinamiento Territorial (Territorial Ordinance Scheme)

Source: JICA Project Team

3. Setting Design Scale

Design scale is an indicator to set parameters of flood management measures such as river channel improvement and/or flood control structures like dam and reservoir. The design scale is equal to magnitude of disaster (flood).

In case of Japan, the design scale for the river plan is set considering the following item:

- Size of river / river basin
- Socioeconomic importance of river basin
- Magnitude of potential damages by disasters
- Record of past disasters and damages by the disasters

- Benefits => B/C analysis
- Balance between upstream and downstream
- Future image of the basin

In general, the design scale for the river plan is indicated using annual exceedance probability of hydrological data, basically rainfall, since rainfall data is generally more accumulated rather than water level/discharge data, rainfall is not affected by changing of river basin/river condition rather than WL/discharge, etc. It means it is important to grasp the relation between past disasters and those hydrological conditions as well as the scale of return periods of the past maximum flood.

In Japan, the design scale means "the magnitude of the target flood of the plan", which is understood as the same meaning of "the magnitude of the flood to be managed by the structural measures"; however, there is a methodology where "the magnitude of the target flood of the plan" and "the magnitude of the flood to be managed by the structural measures" are set separately. In the discussions with the relevant entities of the project, it was decided to set "the magnitude of the objective flood of the plan" and "the magnitude of the flood to be managed by the structural measures" separately.

3.1 Rainfall-Runoff Modeling

As described above, when determining the design scale, it is important to understand the magnitude of past flood events and the relationship between flood runoff or basin and rainfall. However, as explained in Chapter A.4, after studying the hydrological conditions of past flood events, the relationship between floods or inundation damage and hydrological conditions is not clear in the Río Negro basin. In other words, it was determined that it is difficult to clarify the relationship between runoff from the basin and precipitation with the limitations of data and time. Therefore, the precipitation-runoff model will not be constructed in the this project; instead, the results of the probability analysis of the discharge data will be used to determine the design scale.

3.2 Design Discharge Setting

It was decided to define the design discharge by using the probable discharge that was calculated in Chapter A.3.2, based on the locations of discharge stations.

3.3 Consideration of Future Conditions

After studying the Territorial Regulation Scheme (EOT, acronym in Spanish) of the target areas and Municipal Development Plan (from the municipality of Caparrapi, 2016-2019), it was confirmed that the area for future development is limited, that there are no development plans in the near future, and that no major changes are planned in the land use plan. Therefore, it was decided not to consider future changes in land use in this project.

3.4 Setting Design Scale

Discussions were held with related organizations to set the design scale. As a conclusion of the discussion, it is thought that it is appropriate to use floods in April 2011, which are the maximum floods recorded in recent years, as the target flood for the IFMP-SZ. Upon studying the conditions of population and assets in the target area where measures will likely be implemented, the economic benefits of implementing structural measures for this flood scale are expected to be considerably low. This area also is not an area to be developed in the future. Therefore, in this project, the scale for the floods to be controlled with measures including non-structural measures (so as not to have fatal victims) and the scale of flood to be controlled with structural measures will be set separately. In addition, it was decided the scale of the flood to be controlled with structural measures will be studied separately for each location.

After discussions with the relevant entities in this project, it was decided to define the design scale as follows.

- "Return period of the target flood of the IFMP-SZ": The target return period of the flood will be the return period of the flood of April 2011, since there is enough data and the residents remember it clearly. Based on the results of the flood survey and the simulation, it can be concluded that the return period of the flood flow was equivalent to 100 years. Therefore, the target discharge of the IFMP-SZ will be of return period of 100 years.
- "Return period of the target flood to manage with structural measures": in the Rio Negro basin, there are limited and scattered urban centers or villages. Therefore, flood protection with continuous dikes is not effective or necessary as in most rivers in Japan. Consequently, structural measures will be defined individually taking into account the local conditions of each target area. Also, “Return period of the target flood to manage with structural measures" will be defined individually taking into account the conditions of the target area.

As a concrete example of the above-mentioned scale setting, the scale of the target flood in the preparation of the disaster prevention map and the study of the forecasting and warning plan is the floods in April 2011. The target flood for the structural measures in Córdoba, one of the target areas covered in IFMP-SZ, the design scale will be 50-year return period to protect the maximum area possible, because there are many seniors in the area who are considered vulnerable in disasters, though the economic efficiency is thought to be low and little development is expected in the future.

4. Target Discharge

Based on the studies in the previous section, the target discharge will be defined.

In Japan, the target flood hydrograph of the structural measures in the flood prevention plan is defined as the basic discharge, and if there are no flood regulation structures, the peak discharge of the basic flood is defined as the design discharge without modification. In case there are flood regulation structures, such as dams, retention reservoirs or diversion channel, the design discharge is defined, taking into account the impacts of these structures. If there are no flood regulation structures, the peak discharge of the basic flood is defined as the planned discharge without modification.

In the case of Río Negro, structural plans to "retain" the flood will not be considered, since the urban centers that are targets of flood protection are limited and dispersed, and it will not be effective to regulate the discharge with large-scale structures such as retention reservoirs. Currently, there are no plans for structures such as dams or reservoirs.

On the other hand, there are areas with natural reservoirs with retention capacity in the lowest section of Río Negro. It is observed that these areas are flooded naturally during the peak flood, reducing the peak discharge and consequently the flood that reaches Puerto Libre, downstream.

As confirmed above, this IFMP-SZ will study the design flow in the conditions without the flood regulation structures.

The design flow rate will be calculated using the equivalent flow rate of the 100-year return period based on the results of statistical analysis of existing discharge data, taking into account the limitations of not having the hydrograph and the difficulties of performing analyzes of precipitation-runoff in these areas.

Table 4.1 Target Discharge

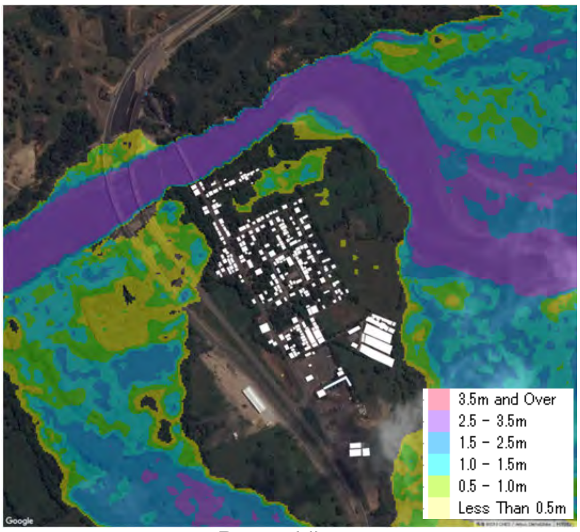
Control Point	Puerto Libre	Colorados	Guaduero
Discharge (m^3/s)	1825	1595	1489

Source: JICA Project Team

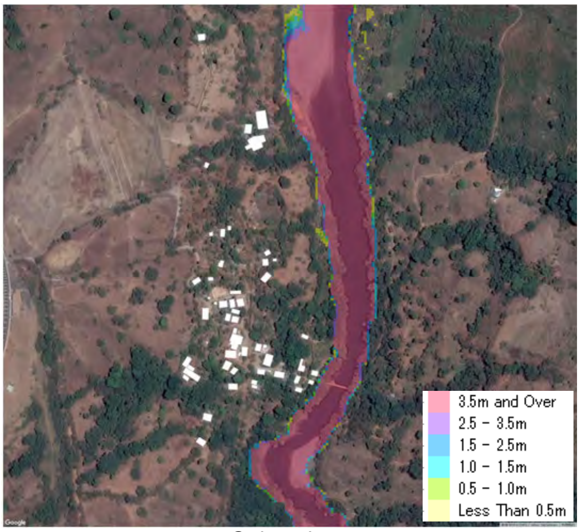
5. Flood Hazard Area Assessment

The hydraulic analysis and the flood analysis of the basin were carried out taking into account the studies in the previous section. The software used for the analysis is HEC-RAS of the US Army Corps of Engineers. After carrying out 1D hydraulic analysis, the flood area was calculated based on the calculated water level. The flood area was evaluated for floods with 4 return periods (2.33 years, 25 years, 50 years and 100 years).

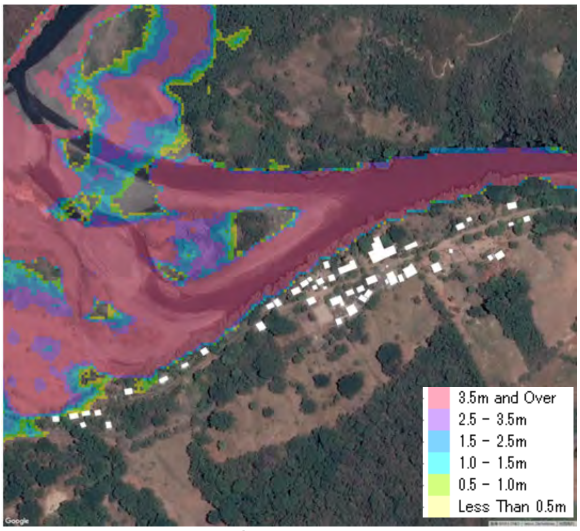
Figures 5.1 and 5.2 show the flood are with 100-year return period in 7 target areas selected and the flood areas with 4 different return periods in Cordoba, where the floor area of the houses affected by flood is the highest. In the figures, buidings and houses are indicated by white parts, which were GIS data with floor area as its property information, and which were prepared by digitizing parts assumed to be buildings in a satellite image in this Project.



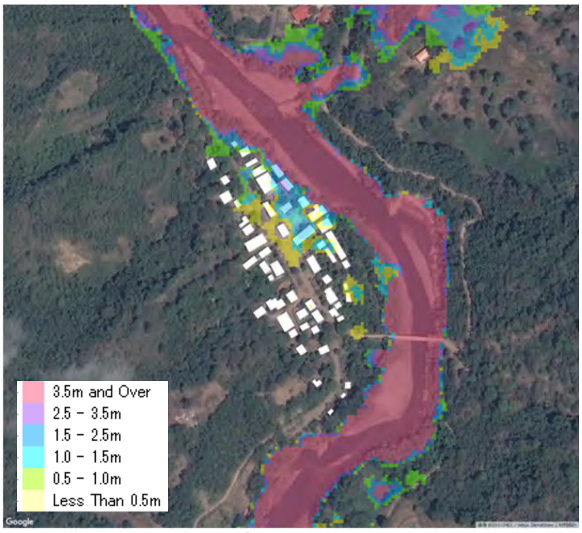
Puerto Libre



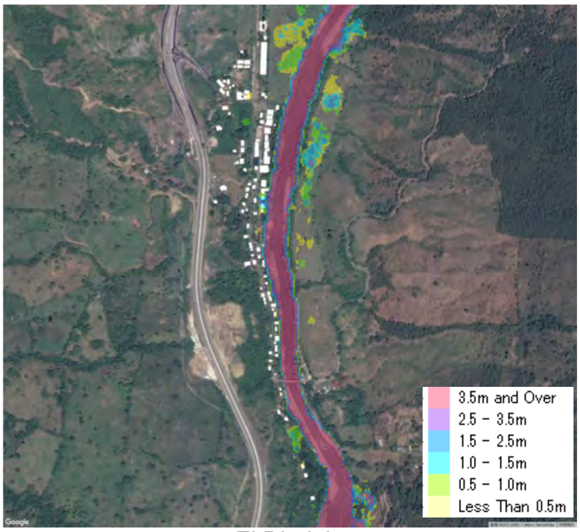
Colorados



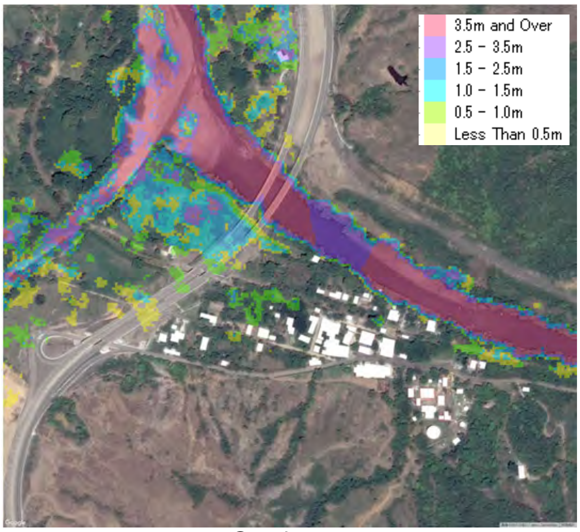
Cambras



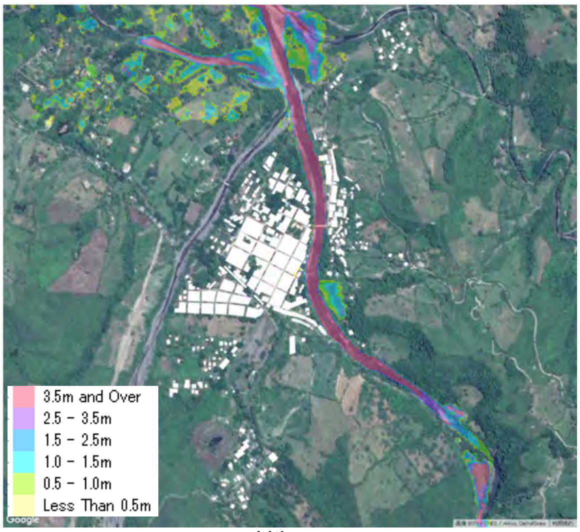
Cordoba



El Dindal



Guaduero



Utica

Figure 5.1 Inundation Maps with 100 years Return Period in 7 Target Areas

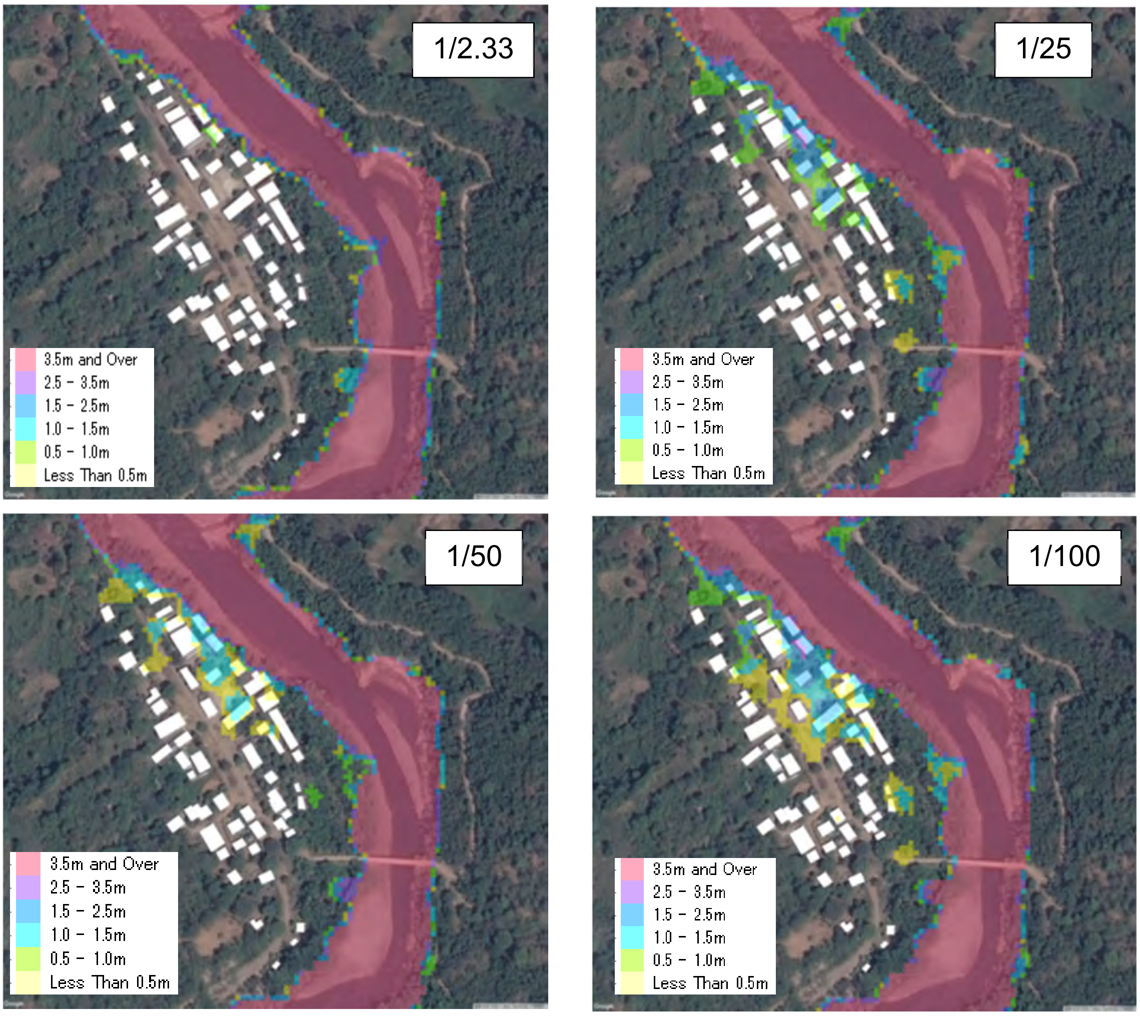


Figure 5.2 Inundation Maps with Various Return Periods in Cordoba

Additionally, the table below shows the simulated affected building area with different return periods in each of the 7 target areas selected.

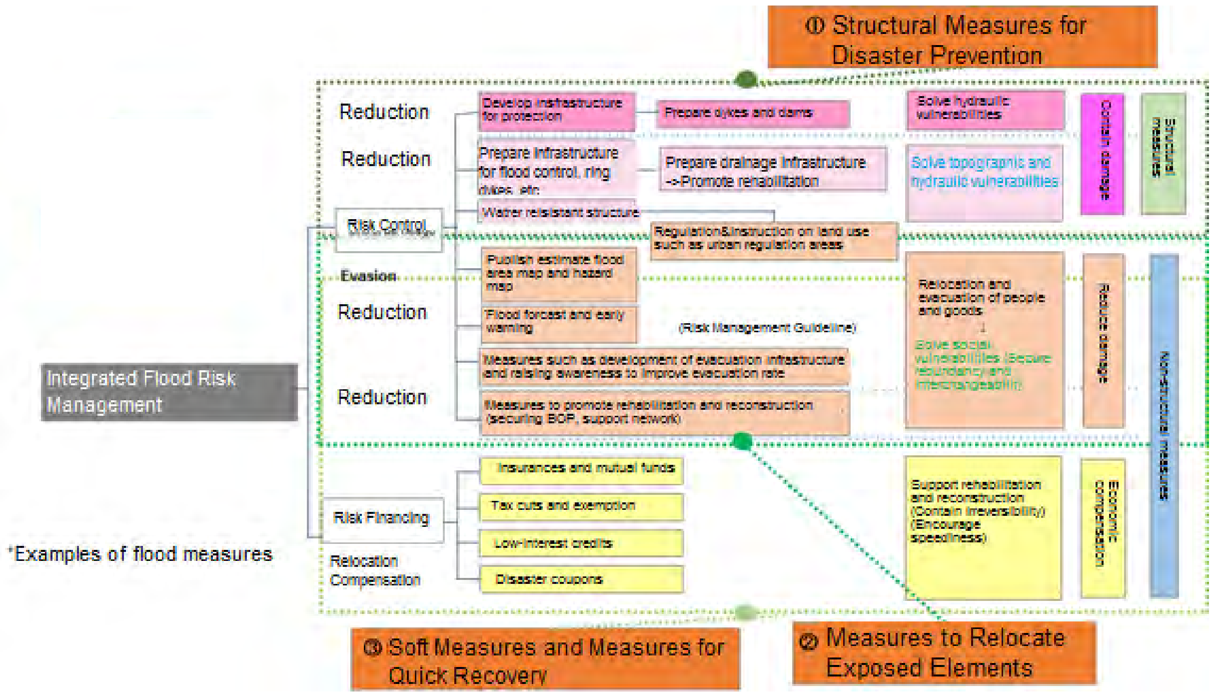
Table 5.1 Simulated Affected Building Area in 7 Target Areas

Target Area	Simulated Affected Buiding Area (m^2)			
	2.33 years	25 years	50 years	100 years
Puerto Libre	0	0	0	0
Colorados	0	0	0	0
Cambras	0	1	2	4
Cordoba	18	224	423	494
El Dindal	11	66	97	117
Guaduero	4	12	12	14
Utica	17	76	80	115

Source: JICA Project Team

6. Flood Control Scheme

En la Figure a continuación se presentan las posibles medidas para la prevención de inundación:



Source: JICA Project Team

Figure 6.1 Posibles medidas contra inundación en el manejo integral de riesgo de inundaciones

The most appropriate and implementable measures for flood prevention plan will be studied by selecting the items in the above figure.

The following measures are the possible structural measures in the Rio Negro basin. However, considering the current disaster situations in the basin and the topographic characteristics, measures in the Section 1 for flood water retention through structures may not be very effective in Rio Negro basin, and they might be excluded from the study.

1. Retaining flood water (Reducing peak flood water)
   - Construction of Reservoir to be installed in the upstream
   - Construction of Dam to be installed in the upstream

2. Enlarging flood carrying capacity
   - Widening of river width
   - Excavation of river bed
   - Construction of Earth Dike
   - Construction of Flood wall (concrete dike)

3. Others such as prevention of erosion
   - Construction of Groins (Spur dikes)
   - Construction of Revetment

The following measures are the possible non-structural measures in Rio Negro basin.

- Preparation and publication/dissemination of hazard map /risk map / disaster risk reduction map
- Establishment of flood early warning (and evacuation) system
- Land use regulation including flood plain management
- Development and Enhancement of Emergency Reponse System during Flood

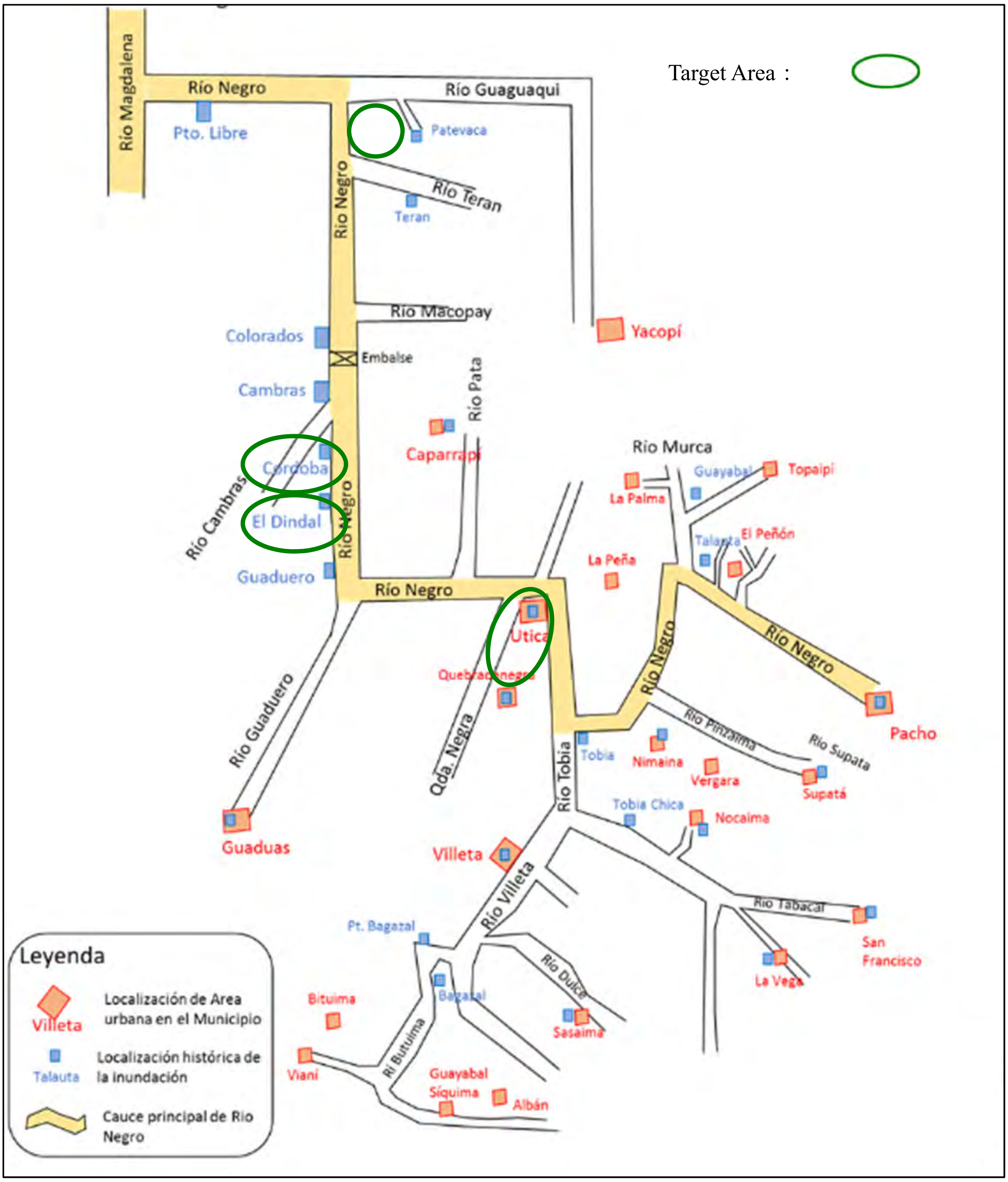
Measures for the target area will be studied in Chapter C by combining above described ítems. Forcast and Warning will be studied with the entire basin area as the target area.

C. Implemantation Program

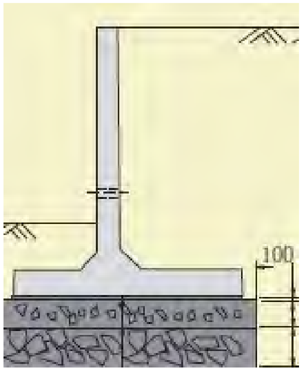
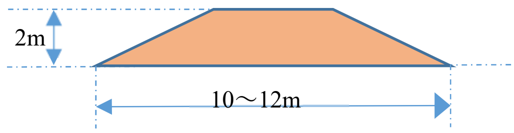
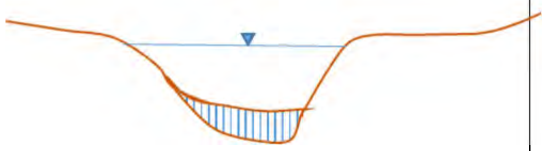
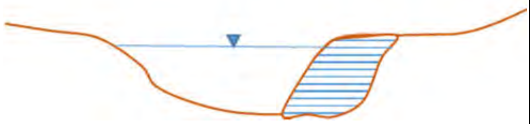
1. Structural Measures

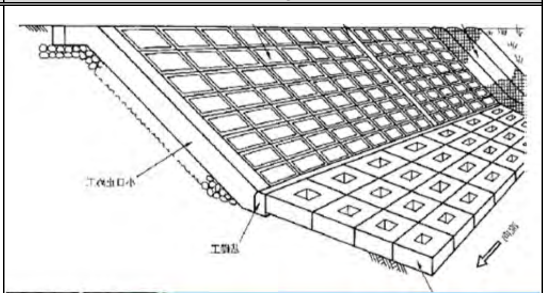
The following are the plans of structural measures and those economic effeciency (cost) in each target area.

Study Area



Flood Characteristics and Effective Measures

Function	Name	Image
Flood prevention Depth reduction	Flood wall - Prevent flood income with a wall. - Structure of metal and concrete ▲ High implementation cost	 ※ In Cordoba only the left bank will be the target area.
	Dike - Prevent the entry of flood with a slope of land. - As a base rule the sediments of the target river are used ▲ Cheaper than a flood wall, but require measures against erosion in steep rivers.	
	Dredging the river bed - Carry out dredging in the channel bed, increase the channel area where water can flow and reduce the level of flooding. ▲ Requires hundreds of meters of dredging in the longitudinal direction. Also, requires periodical monitoring and maintenance works depending on monitoring result.	
	Channel expansion - Expand the channel horizontally, increase the channel area where water can flow and reduce the level of flooding. ▲ Requires hundreds of meters of amplification in the longitudinal direction. Also, requires periodical monitoring and maintenance works depending on monitoring result.	

Function	Name	Image
Prevention bank erosion	Shore protection - Prevent erosion of dikes or banks. - The materials are usually concrete blocks or gabions. - It is important to dig the base of shore protection. ※ The objective is to prevent erosion and does not reduce the water level.	 

1.1 Cordoba

(1) Characteristics of the Disaster ... Flooding in mountainous populated areas

Cordoba is a village located on the left bank of the middle section of Río Negro, with an area of 57,883m^2, 70 homes and a population of 210 people.

Flood damage was reported in 2011 in this village.

Since Cordoba is located on the interior bank of the Río Negro curve, it is unlikely that the water level would rise or that the bank would erode due to the curve.

Therefore, the level calculation was performed with the quasi-two-dimensional non-uniform flow calculation methodology, and the result was superimposed on the elevation data.

The results of the calculation are presented below.

Table1.1.1 Conditions of Non-Uniform Flow Calculation

Items	Contents
Method of calculation	HEC-RAS non-uniform flow
Land elevation Data	DTM with 5m pixel size
Magnitude of the calculation (return period: 1 / year)	1/2.33, 1/25, 1/50, 1/100
Interval of calculation of cross section	1 – 3km
Water level at the lowest point	155.64m (MSL) at confluence with Rio Magdalena
Roughness coefficient of main channel	n = 0.030 – 0.035

The results of the calculation are presented in the Figure 1.1.1.

The figure below shows the results of the calculation of the water level with return period of 25 years and 100 years.

In both cases, the flood occurs in the part of the populated center adjacent to the low section (arrows in the figure). This calculation shows the flood area by elevation, and it is observed that the flood area expands from downstream to medium section to the extent that the magnitude of flooding increases.

In the surveys there was a resident who made comments that prove this, explaining that flooding occurs from downstream.

In Cordoba, the tributary that flows from the right bank of the low stretch is likely to influence the flood, apart from what has been described above. It is natural that the discharge and level of Rio Negro increase as the magnitude of the flood increases. In addition to this, the discharge from the tributary enters the main river and the level is further increased by the backwater effect. In the condition of subcritical flow at normal time, the level upstream increases by the influence of the discharge of the tributary that prevents the flow of water.

In this calculation, the tributary discharge is not included, and the flood mechanism described above is not reflected (due to the flow of the tributary); however, it is projected that this is the real phenomenon that causes the increase inf the flood area.

Also sediments can enter the main channel from the tributary. In case the volume of sediments coming from the tributary is large and this accumulates in the river bed, it is necessary to consider the increase of the level due to the accumulation of the sediment at the same time.

... This was indicated during the workshop as an item to consider at the point of confluence.

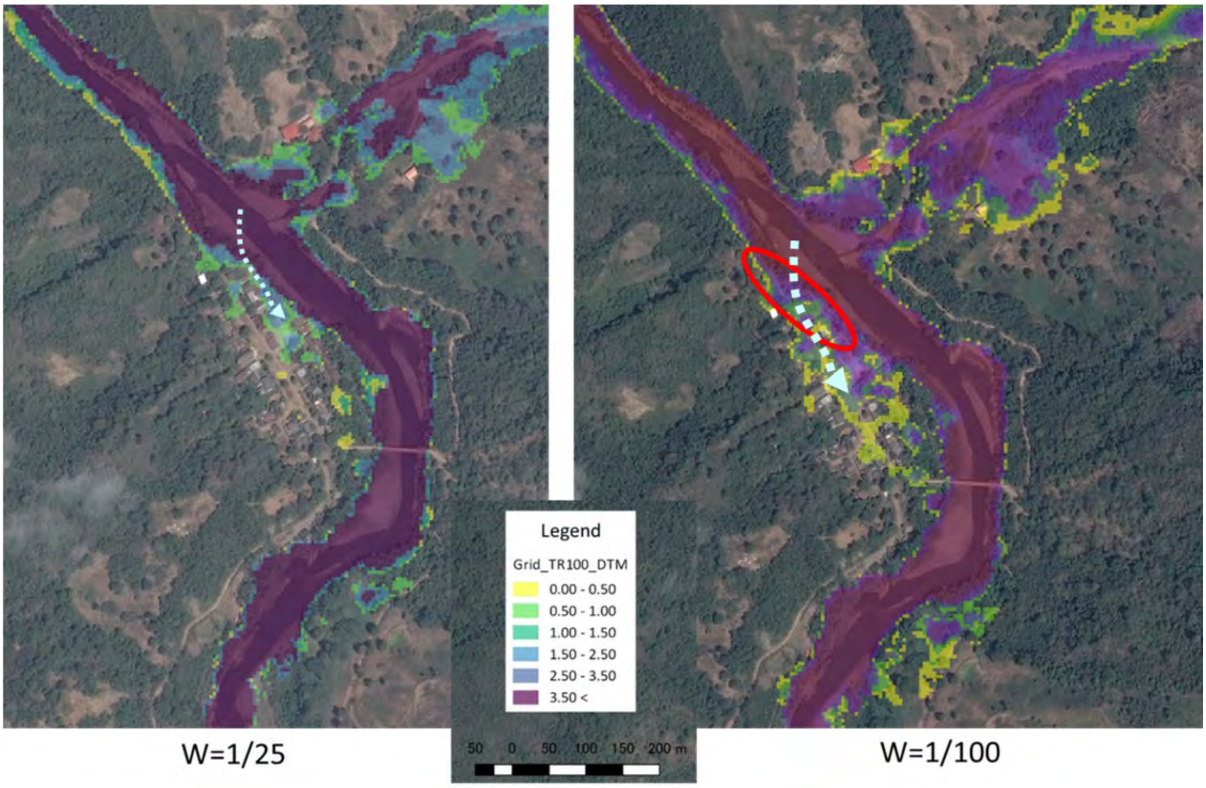


Figure 1.1.1 Flood Area in Cordoba

Reference: Increase in level considering the flow of the tributary

It is necessary to consider the increase in the level caused by the incoming discharge from tributary Q2 in a case such as Cordoba where the infuence of the volume of the discharge that enters from the tributary can not be ignored.

In case a large amount of sediment accumulates that runs off from the tributary, this may influence the upstream level.

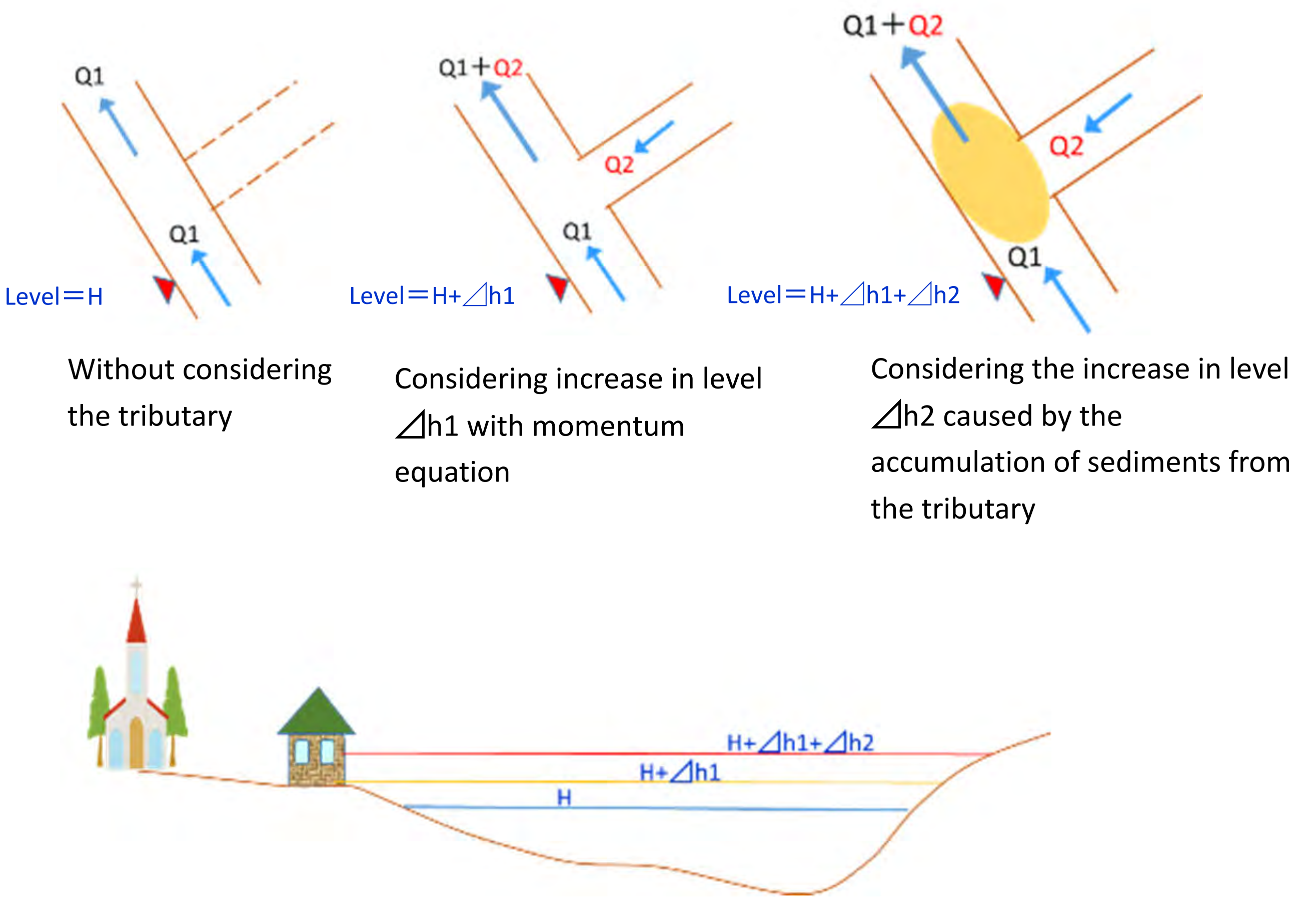


Figure 1.1.2 Influence of the Tributary and the Increase in Water Level

(2) Measures

In Cordoba, the floods smaller than the return period of 50 years will be managed with structural measures, and floods with return periods between 50-100 years will be managed with non-structural measures.

1) Current Situation

In Cordoba it is observed that the flood wall had been installed. However, it is already destroyed, and does not fulfill the function of continuous wall.

Gabions with a concrete layer have been installed at some points; however, they seem to be under construction, and does not protect the entire village.

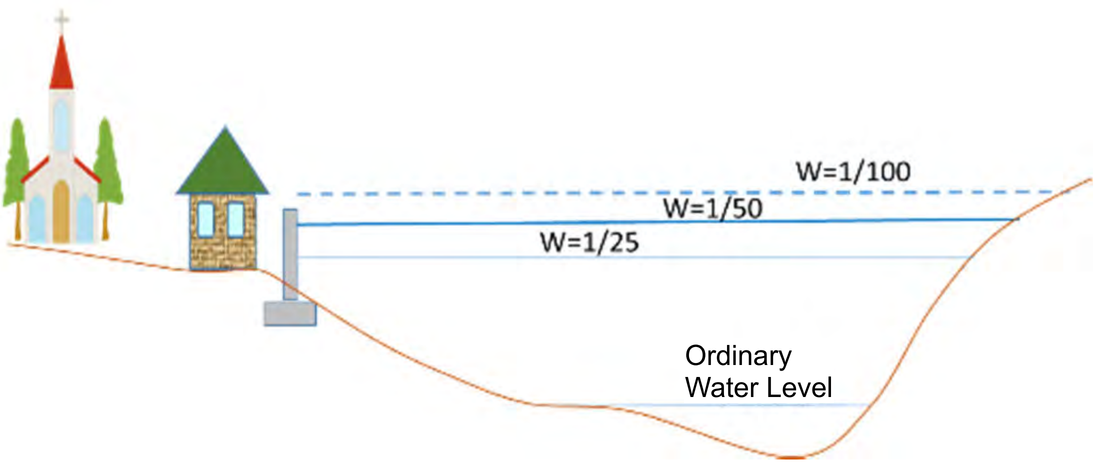
Flood wall (destroyed)

Gabiones＋concrete layer (local)

2) Future Measures

a) Protection Objective (installation height), Method for the works

- The design scale of the entire plan will be the flood level with a 100-year return period.
- For this purpose, structures for flood prevention are installed and non-structural measures will be implemented.
- As a measure of the structure installation for flood prevention, a flood wall will be installed. The flood wall has precedents within the Department of Cundinamarca, such as the municipality of Villeta.
- The design scale of structural measures will be the level of flood with return period of 50 years.
- Non-structural measures such as hazard awareness creation will be implemented using flood threat maps, flood forecast and warning, securement of evacuation route, with 100-year return period design scale.

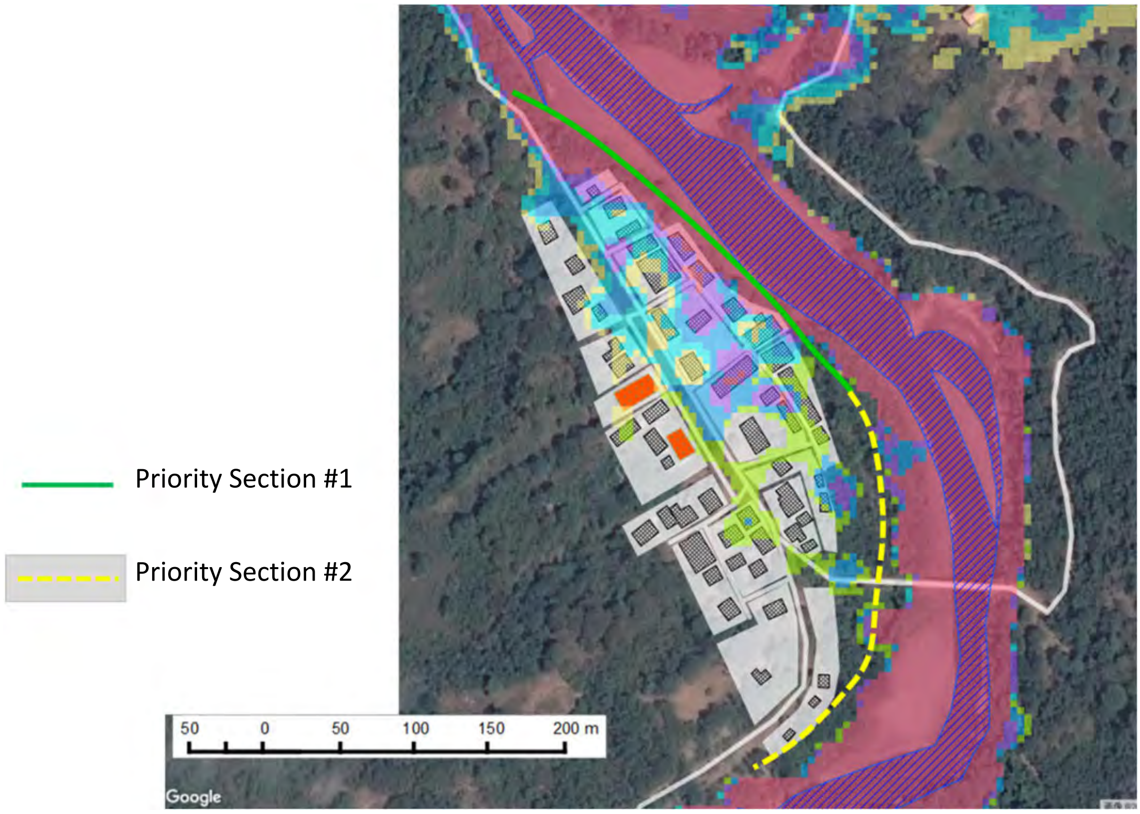


b) Installation Area

As a result of the hydraulic analysis, the cause of the flood is identified to be the increase in water level caused by the confluence with the tributary.

Although it is ideal to install the flood wall in the entire stretch, the priority sections are the sections downstream where flooding must be prevented from entering (indicated in green in the figure below).

... Discussions were held with relevant entities such as CAR in the workshops regarding the definition of priority sections.



c) Estimated Cost

Case-1: Flood Wall

In the municipality of Villeta, in 2011, Villeta River that flows through the urban center presented an increase in level, and caused a 30cm flood. Erosion of the banks in the hospital area near the river occured. The erosion did not affect the hospital fortunately. However, it was decided to build a flood wall as a measure against future erosion.

As a result of discussing whether the hospital should be relocated or flood prevention measures should be implemented after the flood, it was decided to install the flood wall due to the costs. The design of the flood wall, such as the height and structure, was carried out by the Municipality Planning Department (according to the survey with the local fire department chief).

The photos below show the process of building the wall.

Flood Wall in Villeta
- Longitud : 246m
- Por :
  5.4m
- Alto y :
  0.55m

Figure 1.1.3 Flood Wall in Villeta Municipality

Table1.1.2 Approximate Costs of the Installation of the Flood Wall

	Activity	Cost (Peso)		Unit Cost (Peso/m)
	Water Management	18,609,045	1.3%	
	Preliminary, Structure and Filling	1,292,610,527	89.2%	
	Anchorage	135,300,000	9.3%	
	Quality Control for Works	739,600	0.1%	
	Protection Signage Rental	1,154,590	0.1%	
Direct Cost (A)		1,448,413,762	100.0%	5,887,861
Administration		289,682,752	A*20%	
Others		246,230,340	A*17%	
VAT over utility		579,365		
Total Cost		1,984,906,219		8,068,724

Information on costs was obtained from the CAR.

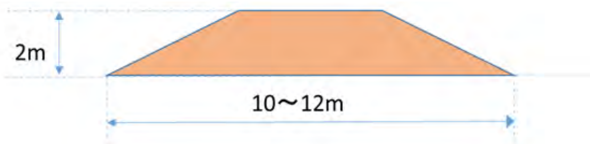
The cost of construction of flood walls per meter based on this structure was calculated:

・Direct Cost : 5,887, 000 pesos

・Administration : 8,068, 000 pesos

Case-2: Dike

The direct cost of the dike shown in the figure was calculated, assuming that the river bed materials were used at the point of installation, based on examples in Japan.



Direct Cost: 800,000 Peso /m

Cf Flood wall: 5,800,000 Peso /m

・30,000 yenes/m ≒Mil peso aproximadamente.

As a result, according to the simple comparison of costs, the dikes are cheaper than the flood wall.

However, in Cordoba, there are houses next to the river. Relocation will be required to guarantee the width required by the dike; however, in reality, this is impossible.

In addition, in a steep river such as Rio Negro, measures for the prevention of erosion on the surface of the dike are necessary. The cost of the shore protection work will be greater than the construction cost of the dike.

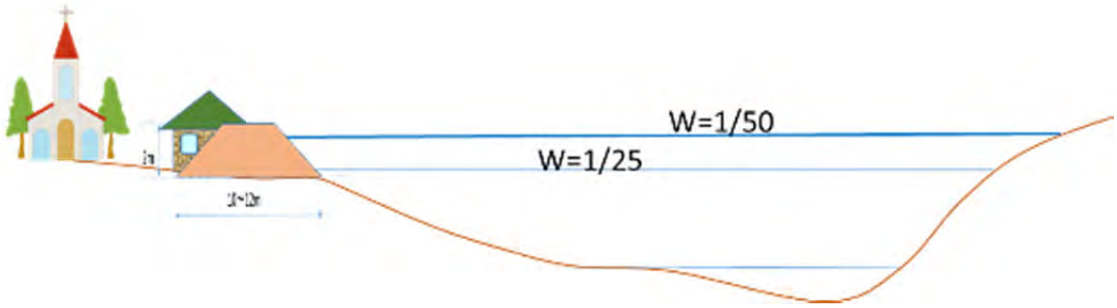


Figure 1.1.4 Location of the Dike and the Houses (Cordoba)

Although in the case of Cordoba the dikes are not a good candidate for measures, they are effective in areas surrounding large rivers where the flood plains are wide and long.

d) Selection of measures

As explained in the previous section, it is difficult to acquire the land for the construction of dikes in Cordoba because the houses that are target of flood protection are located near the left bank of the river. Therefore, in this study, the flood wall was selected as the measure in Cordoba. The main cause of the flood in Cordoba is the increase in the level in the main river due to the flood that enters from the tributary on the right bank. Therefore, it is considered that the flood wall is the most appropriate measure to prevent flood in the residential area when the level of the main river rises. At the point of confluence of the tributary located on the right bank, the residential area is located on the interior bank of the curve of the main river, and therefore has a low probability of the banks near the houses collapsing due to erosion caused by the flood. Thus, it is considered that there is no need to install the shore protection in the lower part of the flood wall. Below is the summary of the measure.

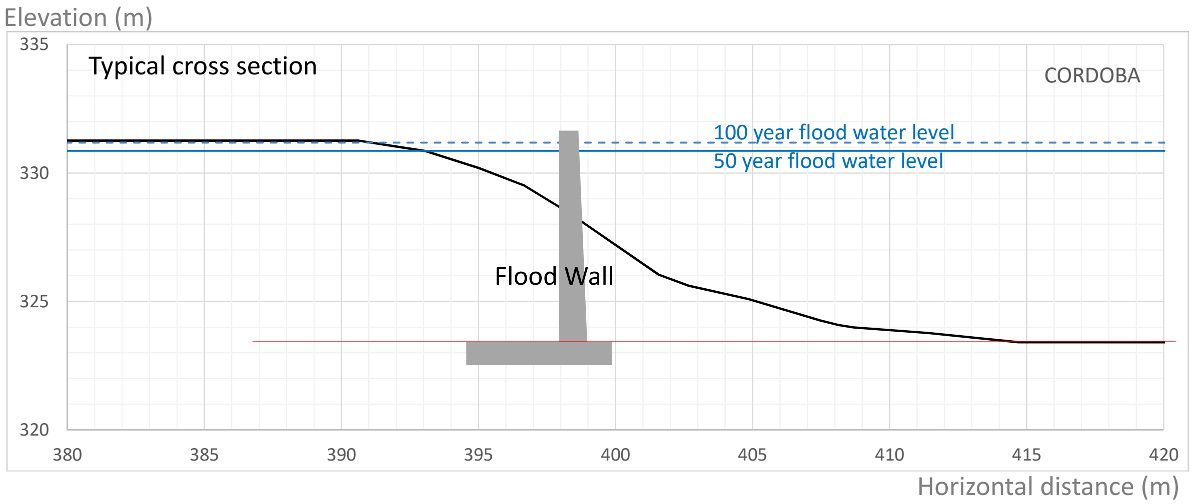


Figure 1.1.5 Figure Summary of the flood measure in Cordoba

e) Cost

The cost of the proposed measure was calculated as follows.

- In Córdoba a flood wall (wall in the shape of an up-side-down T) with a length of 200m will be installed.
- Area of the cross section of the retaining wall is 12.6m^2, as shown in the following figure. Multiplying this value by the length of 200m, the volume of the flood wall is 2,520m^3.
- The cost of the concrete flood wall according to the data from Japan is 43,000 yen / m^3. When comparing the costs of the concrete flood wall in Japan and in Colombia, the unit value in Colombia is 0.68 times more than the unit value in Japan.· Therefore, the direct cost obtained by multiplying the volume by the unit value is 1,989 million pesos.
- The indirect cost of the work according to the existing cases is 37% of the direct cost of the work in Colombia.

The total cost, the sum of the direct cost and the indirect cost, is 2,726 million pesos.

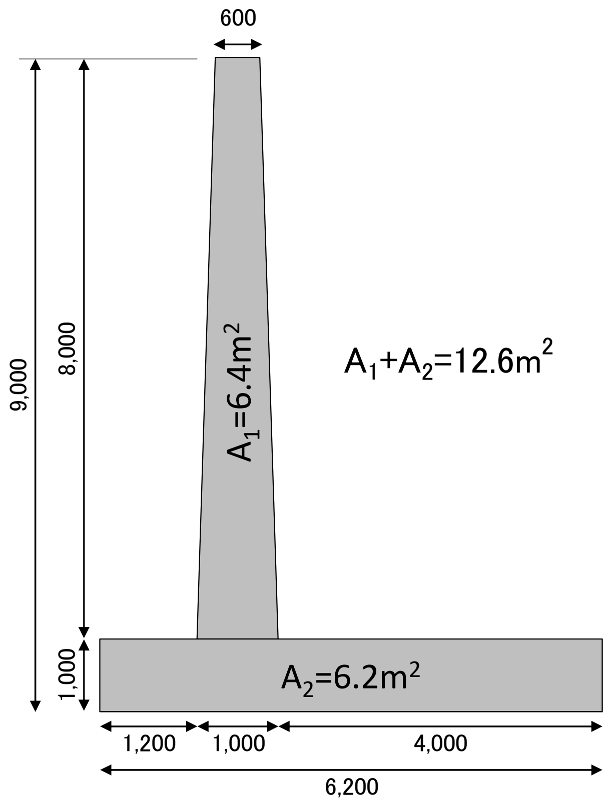
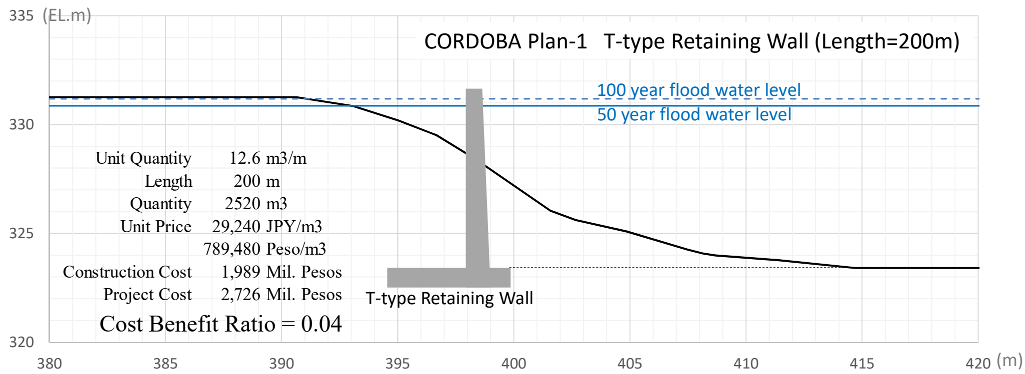
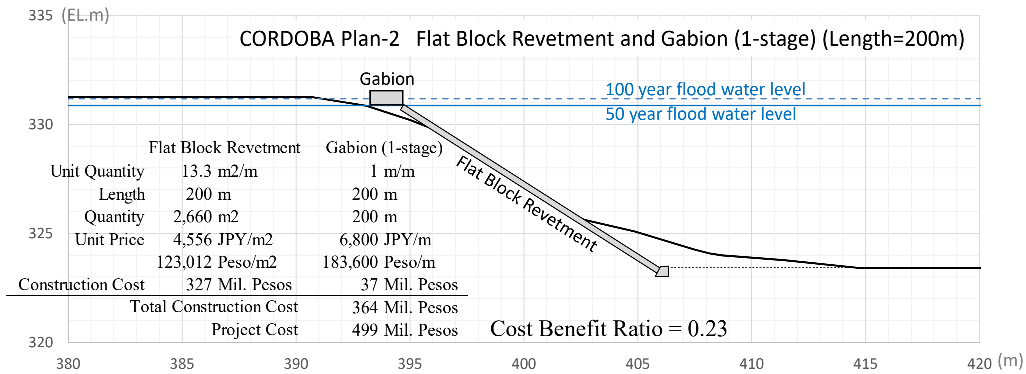


Figure 1.1.6 A Flood Wall (Wall in the shape of an Up-Side-Down T), Transversal Section

(3) Simple Structural Measures appropriate to the Benefit

In the above study, the ideal measure (Plan-1) was assumed as a flood risk reduction measure in Cordoba area, but the cost benefit ratio regarding this measure was 0.04 which is impractical. Therefore, as the lower cost measures, Plan-2 and Plan-3 was studied instead of Plan-1. In case of Plan-2, Flat Block Revetment will be installed at the lower part of 50 year flood water level designated as High Water Level. And at the upper part of High Water Level Gabion (Mattress Bascket) will be installed. In case of Plan-3, in order to lower the cost furthermore, only 2-stage of Gabion will be installed around High Water Level. According to the calculation results of cost benefit ratio regarding Plan-1, Plan-2 and Plan-3, Plan-3 should be adopted to satisfy the condition that the cost benefit ratio is larger than 1.





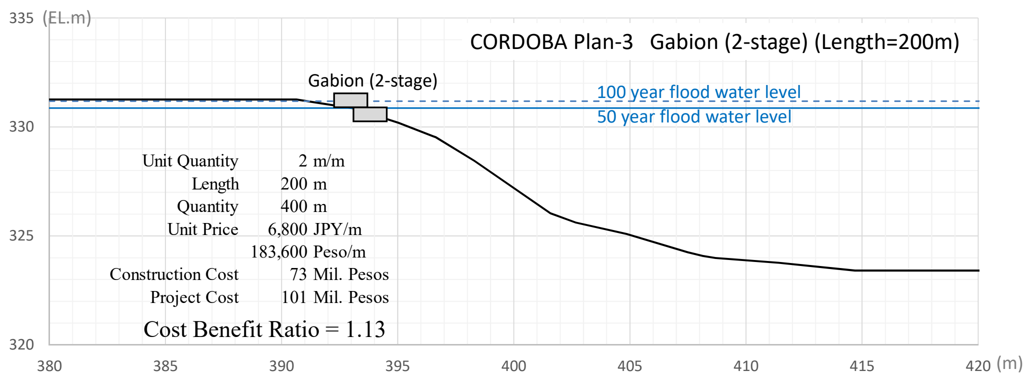


Figure 1.1.7 Flood Risk Reduction Measure in Cordoba area

1.2 El Dindal

(1) Disaster Characteristics

1) Current Situation

El Dindal is a village located on the left bank of the middle section of Rio Negro, with an area of 107,472m^2, 109 homes and a population of 328 people.

In this village, there are some houses scattered along the road parallel to Rio Negro.

In many cases the river is immediately behind the houses. It is an area where there is a concern not onlyfor the flood but also for the damage to the houses caused by the erosion of the banks or runoff. There is no structure against erosion such as shore protection at the moment.

It is reported that the banks in this area suffered an erosion of 1.0-2.5m and threatened the village in the flood of May 2017.

Figure 1.2.1 Proximity of Rio Negro and the Houses in El Dindal

2) Erosion Mecanism

Figure 1.2.2 shows the examples of erosion in rivers in Japan and their processes.

1. The increase in water level due to the increase in flood discharge.
2. Bank side erosion and scouring caused by the increase in velocity near the bank
3. Erosion and destruction of the bank and loss of housing

The speed of the river is greatly increased in steep-slope rivers particularly with a high slope, and erosion is easily generated in banks.

Photo Bank Erosion (Sendai River),1979

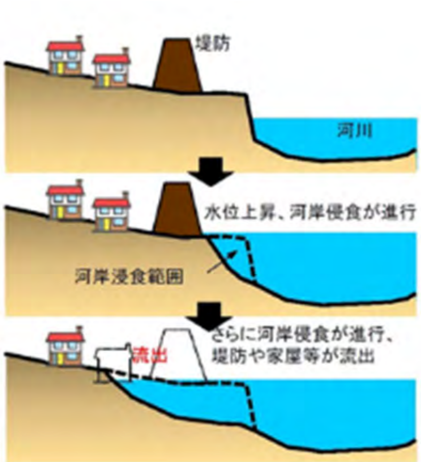


Figura 1.2.2 Bank Erosion Mechanism

(2) Measures

a) Proposed Measures

In El Dindal, the floods smaller than the return period of 50 years will be managed with structural measures, and floods with return periods between 50-100 years will be managed with non-structural measures.

Case-1: River bank protection with concrete

River bank protection is a structure that is installed in order to protect dikes or river banks from erosion. It is necessary to install the river bank protection considering the effectiveness of the structure and the financial effectiveness as well as the ease of maintenance and administration, so that the structure meets its objective and is stable.

The flood causes both erosion in the banks and scouring of the riverbed. It is important to study river bankprotection works and the bases that support them since scouring of the base is the major cause of river bank protection destruction.

Below is the basic structure of river bank protection with concrete.

At El Dindal (the left bank), the slope of the bank is currently approximately 1:30, and the distance between the riverbed and the flood level in the 50-year return period is 3.6m. In case of installing the shore protection with concrete on the slope of the bank, the length of the surface to be protected is 11.4m. The unit value of the shore protection installation is approximately 20,000 yen / m^3 (approximately 540,000 pesos / m^2), and the installation cost in the longitudinal direction per meter will be approximately 228,000 yen / m (approximately 6,516,000 pesos / m^2).

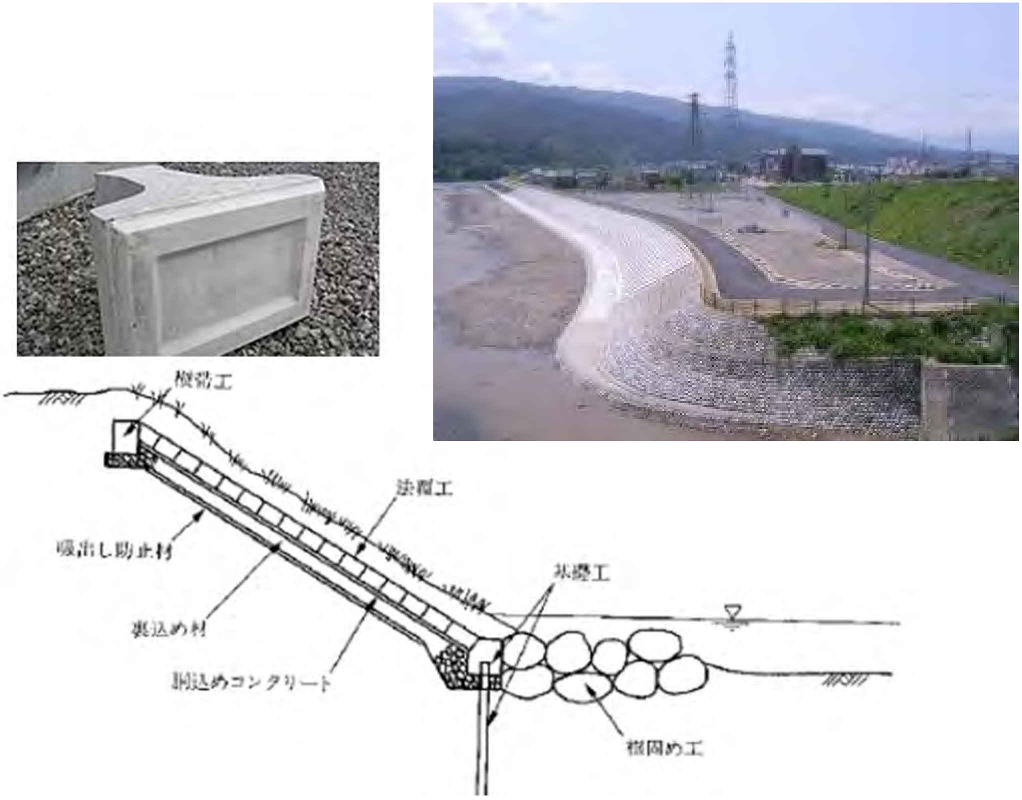


Figure 1.2.3 River bank Protection Structure with Concrete

Case-2: Gabiones

The metal wire baskets are filled with stones of relatively large diameter, and are used for shore protection. The materials generated at the installation point can be used to control costs. It is a measure with consideration to the environment since within the basket there are spaces.

This measure is installed in a part of Cordoba for the protection of banks.

In case of installing the gabions, it is necessary to define the size of the stones so that they do not move with the speed of the flood water, modifying the shape of the basket.

At El Dindal (the left bank), the slope of the bank is currently approximately 1:30, and the distance between the riverbed and the flood level in the 50-year return period is 3.6m. In case of installing gabions which are 60cm high and 120cm wide, they will be installed with a slope of 1: 1, in the form of stairs, with 6 steps. The unit value of the gabion installation (cost of the work) is approximately 10,000 yen / m (approximately 270,000 pesos / m), assuming that the stones or rocks collected at the installation site are used in the baskets. Therefore, the installation unit value in the longitudinal direction is approximately 60,000 yen / m (approximately 1,620,000 pesos / m).

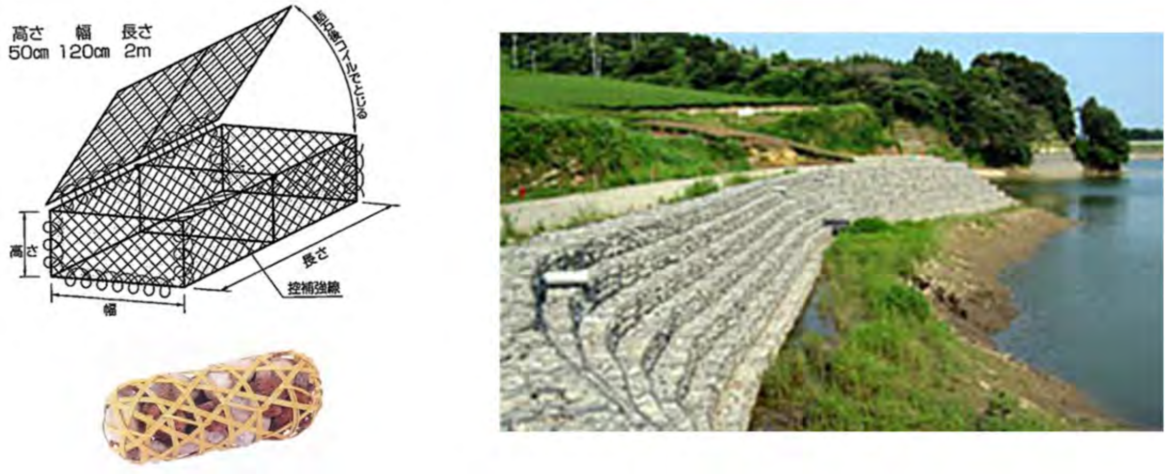


Figure 1.2.4 Structure of Gabions for Shore Protection

b) Selection of the measures

In El Dindal, the homes that are target of flood protection are located near the left bank. Rio Negro does not have large meanders near the urban centers, and the flood flows in a straight line over the river; therefore, the speed is high during the flood and can cause erosion in the banks. Thus, on the left bank it is necessary to install the bank protection. Alternatives to bank protection include bank protection with concrete or gabions. Since gabions are cheaper, and there are several cases of installation in Colombia, the option with gabions is selected. The gabions are installed up to the design flood level (the level of the flood with 50-year return period), and in order to ensure the extra height above the gabions, a parapet will be installed. Below is the summary of the measure.

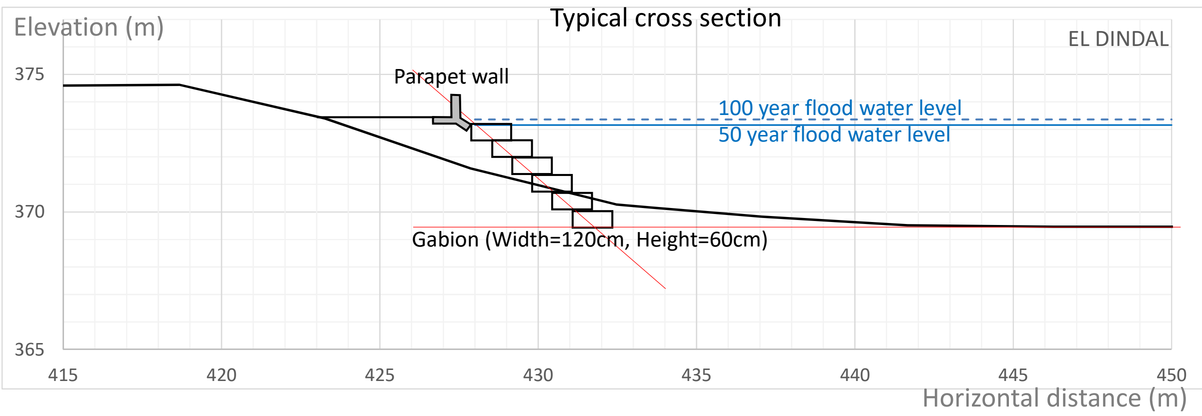


Figure 1.2.5 Summary of Flood Measures in El Dindal

c) Cost

The cost of the proposed measures was calculated as follows.

- 6 steps made of gabions will be installed in an area with a length of 900m. Each gabion is 60cm and 120cm wide.
- The cost of gabions in Japan is 10,000 yen / m; however, the cost in Colombia is assumed to be 0.68 times more than in Japan, in the same way in which the calculation was made for Córdoba. Therefore, the unit value is calculated by multiplying 10,000 yen / m by 0.68, or 6,800 yen / m (183,600 pesos / m).
- The direct cost calculated by multiplying the unit value by the length and by 6 steps is 991 million pesos.
- Above the gabions, parapet wall with height of 80cm will be installed. The area of the cross section of the parapet wall is $0.46m^2$, with a length of 900m, and the unit value is 1,468,800

pesos / m3 (80,000 yen / m^3 x 0.68 = 54.4000 yen / m^3). Using these values, the direct cost of the parapet wall is 608 million pesos.

- The sum of the direct costs of gabions and the parapet wall is 1,600 million pesos
- The indirect cost of the work according to the existing cases is 37% of the direct cost of the work in Colombia.
- The sum of the direct cost and the indirect cost is 2,191 million pesos.

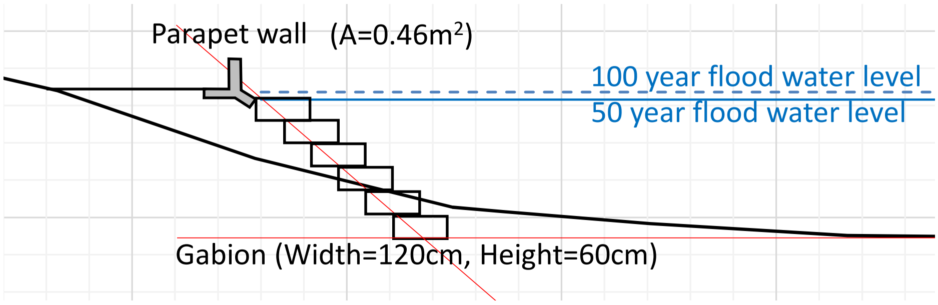
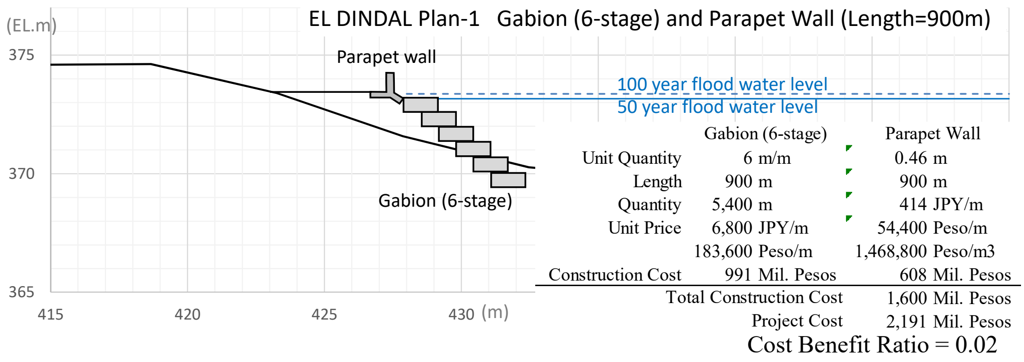
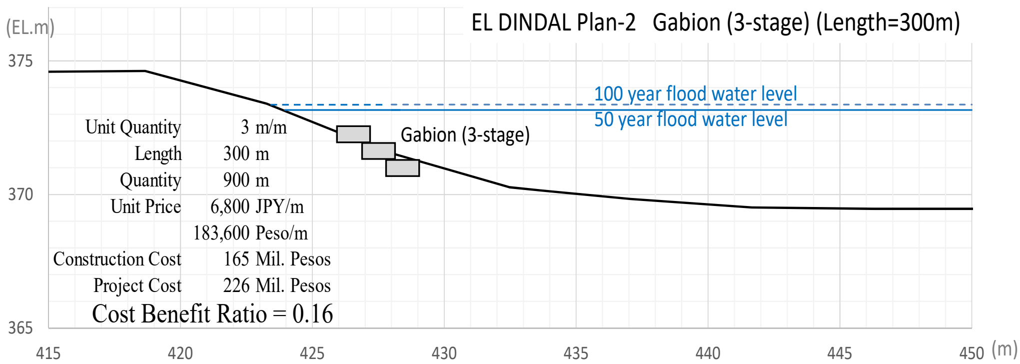


Figure 1.2.6 Gabions and Paratet Wall, Transversal Section

(3) Simple Structural Measures appropriate to the Benefit

In the above study, the ideal measure (Plan-1) was assumed as a flood risk reduction measure in El Dindal area, but the cost benefit ratio regarding this measure was 0.02 which is impractical. Therefore, as the lower cost measures, Plan-2 and Plan-3 was studied instead of Plan-1. In case of Plan-2, 3-stage of Gabion will be installed not to let the bank scoured by the flooding flow. And installed area will be limited 300m where is easy to scoured. In case of Plan-3, in order to lower the cost furthermore, 3-stage Gabion will be installed only at the 45m section where is most vulnerable. According to the calculation results of cost benefit ratio regarding Plan-1, Plan-2 and Plan-3, Plan-3 should be adopted to satisfy the condition that the cost benefit ratio is larger than 1.





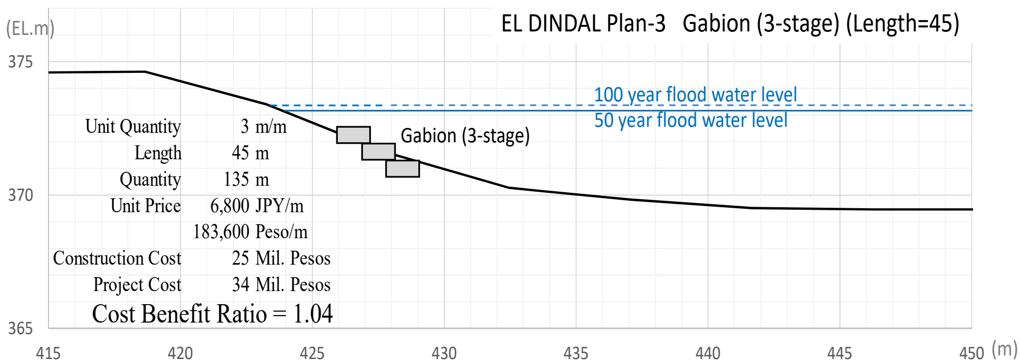


Figure 1.2.7 Flood Risk Reduction Measure in El Dindal area

1.3 Utica

(1) Disaster Characteristics

Utica has frequently suffered from sediment disasters caused by flooding in recent years. The materials on the characteristics of the disaster from the EOT of Utica are presented below.

4 flood disasters have been recorded, all caused by the Quebrada Negra. They occurred in 1963, 1988, 1990 and 2011. In 2011, there were 3 fatal victims, 190 homes lost, 200 buildings destroyed, and damage to crops.

a) Flood of November 17, 1988

Flood in the lower basin of the Quebrada Negra caused by precipitation. Landslide and rupture of the natural dike in the Quebrada Papaya were also reported. The flood flow moved between 1-2m height, leaving behind the accumulated sediments. 3 days after the flood, in the sector of Santa Barbara in Quebradanegra, 5 km upstream from Utica, the 130km point of the railway, a landslide occured and caused damage to the pipeline that extends from Puerto Salgar to Bogota. Due to this landslide, 400m of railway was buried, and Rio Negro was also buried. However, there were no affectations in the urban area of Útica.

b) Floods of 2011

Flood in Quebrada Negra River caused by heavy precipitation affected the sectors of La Cita, Boyaca and Bogota, from 8pm to 9:30 pm on April 18, 2011. In the middle section of the Quebrada Negra, the natural dike of La Quebrada La Chorrera suffered a rupture, flooding the urban and Utica area from the riverbank to Calle 6, with a depth of 2.8m.

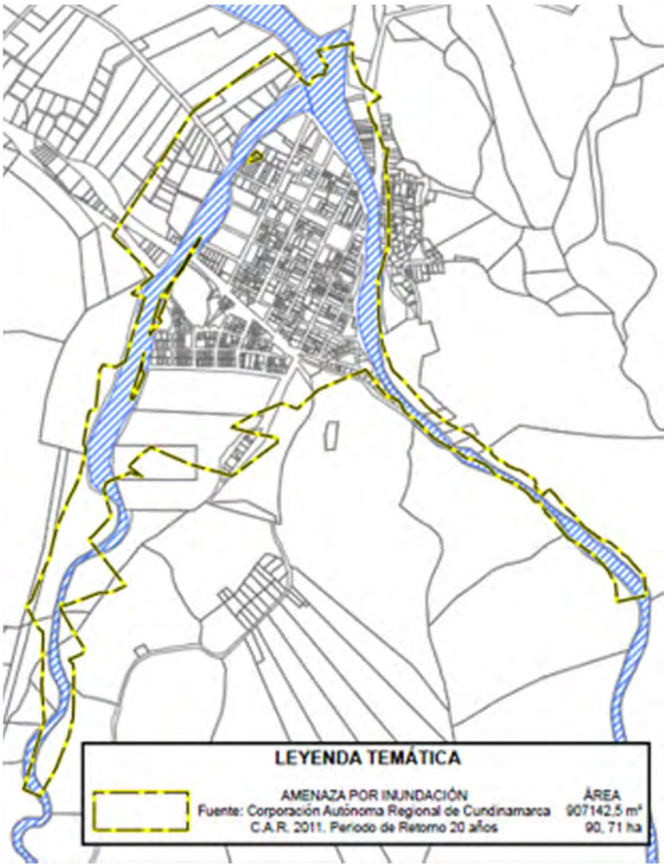
Image No. 2.29. Effects of the hydrogeomorphological event of April 18, 2011: Flood footprint in housing (up to 2.25 m).

Image No. 2.30. Total to partial losses of goods, concentrated from Carrera 5 towards the right bank of the Quebrada Negra.

c) Situation after the Disaster of August 2011

A landslide is under way at Quebrada La Chorrera, carrying sediments, driftwood, and rocks to the ravine. Most of the sediments of this ravine has already drained in Quebrada Negra; however, this does not mean that new threats have disappeared. There are gray to black schists on the slope, pararelos to substrate, from which the soil comes. This type of soil becomes unstable with contact with water, it breaks and falls on the slip surface, creating natural dams downstream. Therefore it is necessary to take precaution.

CAR carried out topographic surveys in 2012, and built a numerical model to recreate the flood conditions of April 18, 2011. The objective was to show the damage to the urban area in a flood with a return period of 100 years without measures. Below is the flood hazard map prepared by CAR (return period of 20 years). The hazard is indicated by a polygon, and the details of the threat are not presented as depth distribution.



(2) Measures

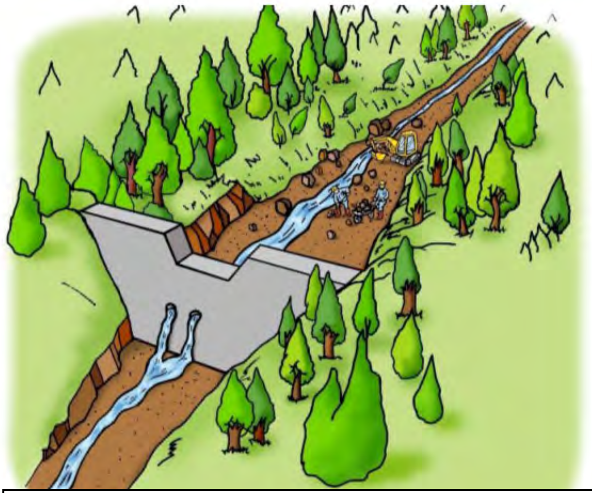
Sabo dam is an effective structural measure to reduce sediment disasters that occur repeatedly in the municipality of Utica.

Below are the functions and examples of Japan..

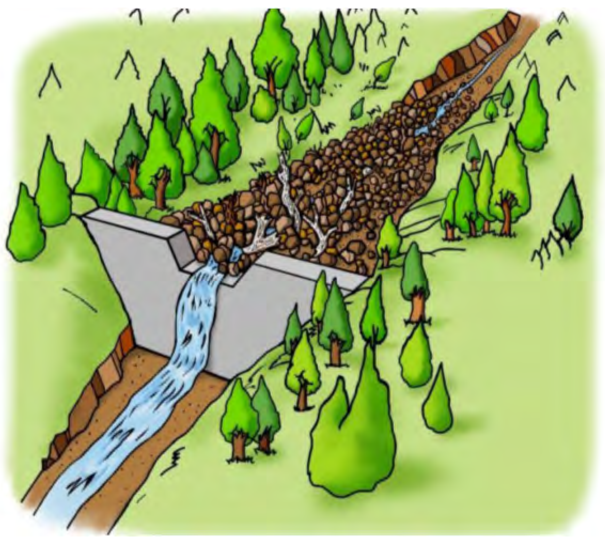
1) Sabo Dam Functions

a) Immediately after construction

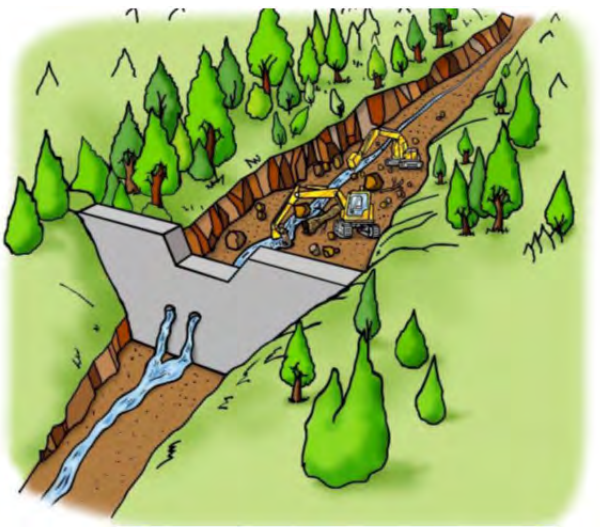
1. The sediments flow accompanied by the water in the river always.



2. With the installation of the sabo dam, on the upstream side of the dam, the sediments begin to accumulate little by little.

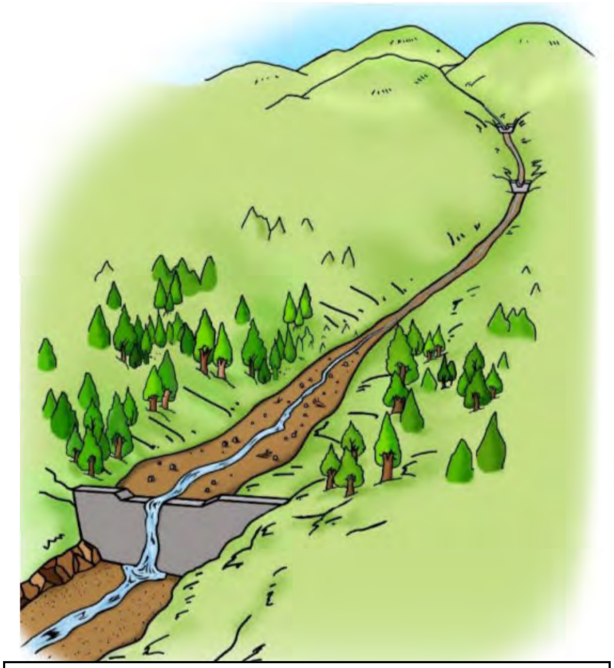


3. In the case of debris flow caused by large precipitation, the dam retains sediments containing large rocks and driftwood, preventing downstream damage.



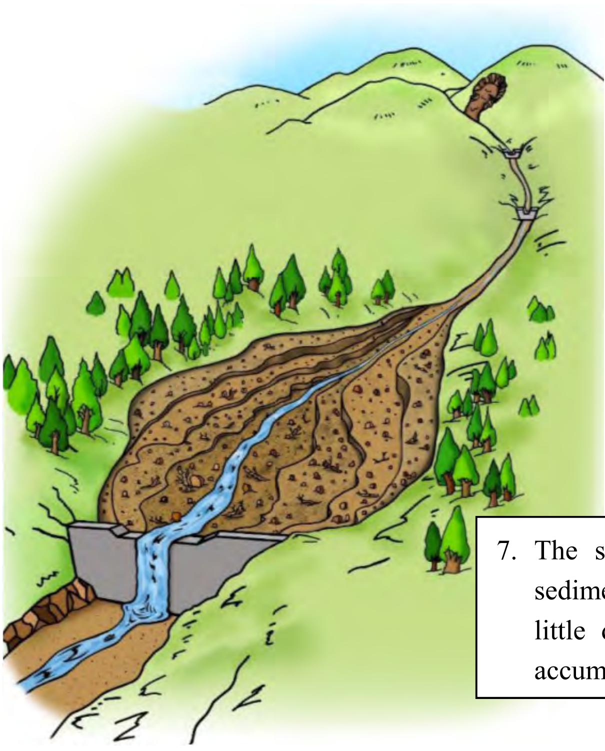
4. The rocks are removed, the sediments and driftwood accumulated in the dam are removed to prepare for the next flow of debris.

b) After the accumulation of sediments



5. The effects of the sabo dam are not lost even when filled with sediment. On the upstream side of the dam, the accumulation of sediments reduces the slope, widening the channel, and reducing speed.

6. If a large amount of sediment floods again, the velocity is reduced on the upstream side of the dam where the slope was reduced, and the sediments accumulate on top of the existing accumulation.



7. The sediments accumulated on top of the existing sediments wear out each time it rains, dripping little by little downstream. Then, if another flood occurs, it accumulates again as in 6.

Source: Sabo Dam Function, National Territory Conservation Office, The Japanese Ministry of Land, Infrastructure, Transport and Tourism (MLIT)

2) Examples of sabo dam in Japan

Case-1: Inari River, tributary of the Kinu River, Hinata Sabo Dam

● Height: 46m, ● Length: 173m,

● Planned accumulation volume：1,500,000m^3 ● Crown height：1,098m

Case-2: Koshibu River,

Tributary of the Tenryu River,

● Height：23m

● Length：33m

● Basin area：82.4km^2

● Original bed slope：1/28.5

●Planned accumulation volume：1,000,000m^3

3) Medidas en Quebradanegra

a) Method to determine the volume of the sabo dam

The volume of sediment runoff that reached the urban center of Utica during the 2011 flood is assumed to have been approximately 2,000,000m^3. In Colombia, the magnitude of this sediment disaster is evaluated as having a 10-year return period. Therefore, the options for capturing approximately 2,000,000cm^3 of sediments with sabo dams were studied.

b) Volume of sediment runoff per flood

The volume of sediment runoff in a flood depends on the magnitude of the flood, the slope of the river, and the geology of the basin. Since in Japan there are studies on the volume of sediment runoff in a flood with a return period of 50 years, this return period is used to take advantage of this knowledge. The volume of sediment runoff changes in the "bed load area" with slope less than 1/30 and in the "debris flow area" with slope greater than 1/30. As can be seen in the following figure, most of the sections in Quebradanegra have slopes less than 1/30, it is considered that this ravine is located in the bed load area.

Table 1.3.1 Types of Sabo Dam

Non-transmission type	Transmission type (made of steel)	Transmission type (made of concrete)
		
Common traditional Sabo dam	Suitable for debris flow area	Suitable for bed load flow area. (Not suitable for debris flow area.) Compared with non-transmission type, the amount of controlled sediment is large and economical

c) The volume of sediments captured by sabo dam, the number of sabo dams required

The volume of sediments that can be captured with the transmission type is 1.11 times more than the volume of stored sediments (F). The volume of stored sediments (F) can be calculated with the slope of the riverbed (N), average sedimentation width (B) and dike height (h).

$$F=NBh^2$$

F: Volume of stored sediments (m^3), N: slope of the river bed (the denominator value of fractions), B: average width of the sedimentation (m).

The volume of sediments that can be captured in case of installing 4 sabo dams calculated with the equation above is 2,150,000 m^3 as shown in the following table, which exceeds 2,100,000m^3, the approximate volume of sediment runoff from the basin in a flood.

Table 1.3.2 Volume of Captured Sediments

	Dam height h (m)	River bed slope N	Sedimentation width B (m)	Sediment storage volume 1.1F (m3)	Sedimentation length L (m)
Sabo dam 1	8	50	100	352,000	800
Sabo dam 2	15	50	100	1,237,500	1500
Sabo dam 3	8	50	100	352,000	800
Sabo dam 4	7	50	80	215,600	700
Total				2,157,100	

d) Locations of Sabo Dams

The proposal for the location of sabo dams in Quebradanegra is presented in the figure below. It was designed for the installation of 4 sabo dams.

- The sabo dam downstream is installed in a point which is as close to the urban center as possible in order to control the sediment runoff in areas near the urban center of Utica, the target for protection.
- To capture the largest volume of sediment runoff from the entire basin, the dams should be installed downstream.
- To guarantee the height of the sabo dam, the points where there is a difference in height between the river bed and the two banks are selected for the installation of sabo dams.
- The points where the width of the channel upstream of the sabo dam is sufficient should be selected (since in the calculation of the captured volume assumes that the width of the sedimentation is 60m, the volume needed in the plan can not be captured even though the sabo dam is installed if the channel width does not exceed this value).

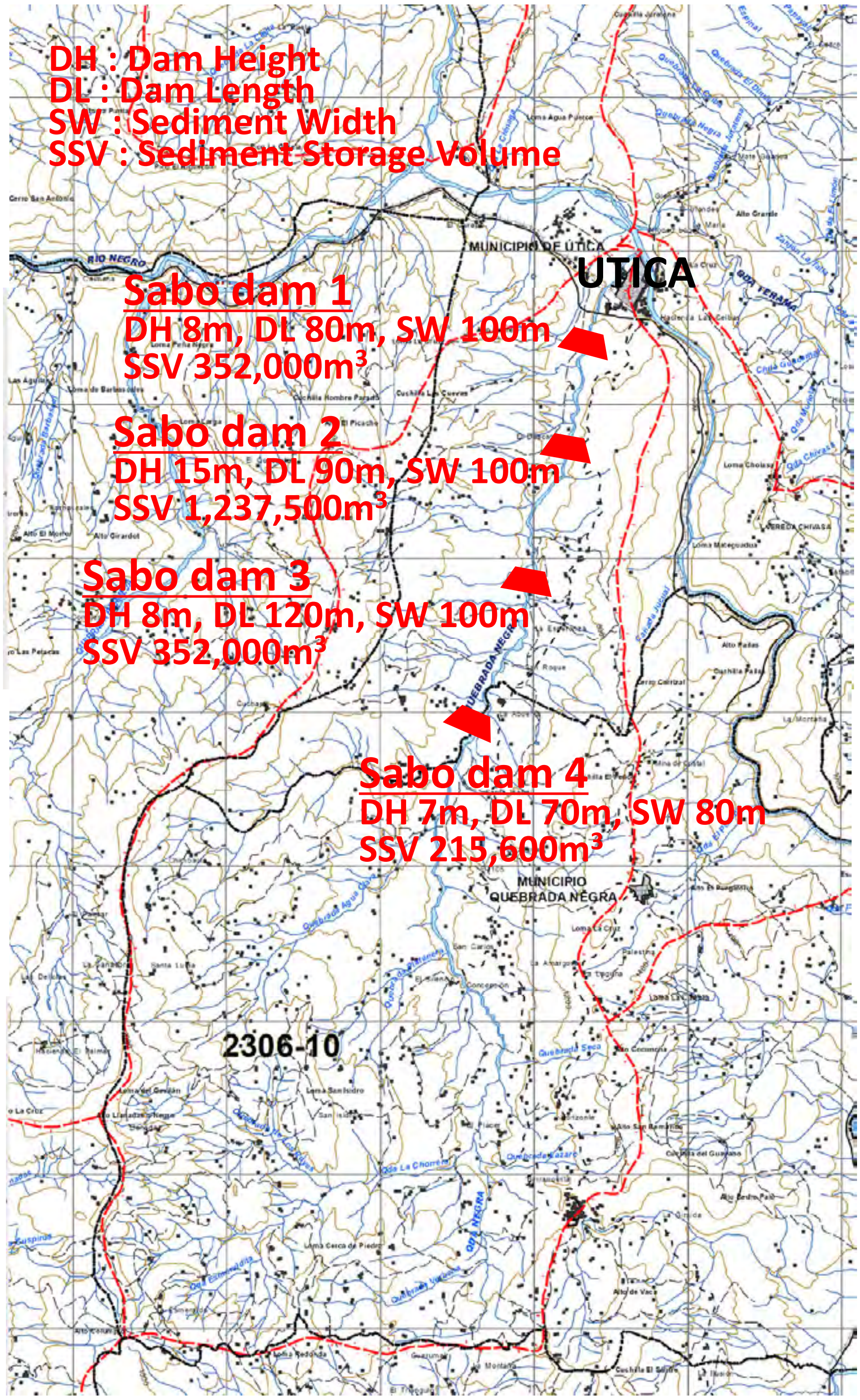


Figure 1.3.1 Proposal for the Location of Sabo Dams in Quebradanegra

e) Costs

The cost of the proposed measure was calculated as follows.

- The width of the crown, the width of the bottom and the height of each of the 4 dams were defined to calculate the area of the cross section of the dam.
- The volume of the dam (volume of concrete) was calculated by multiplying the area of the cross section by the length of the dam.

・ The direct cost of the work was calculated by multiplying the volume of concrete by the unit value of the concrete.

・ The indirect cost of the work according to the existing cases is 37% of the direct cost of the work in Colombia.

・ The total cost is the sum of the direct cost and indirect cost.

The total cost calculated with the above method is 17,124 million pesos as presented in the following table.

Table 1.3.3 Construction costs of the sabo dams in Quebradanegra

		Sabo dam 1	Sabo dam 2	Sabo dam 3	Sabo dam 4	Total construction cost	Indirect expense	Project cost
		a	b	c	d	e=a+b+c+d	f=e×0.37	g=e+f
Cross section area	Crest width (m)	3	3	3	3			
	Bottom width (m)	16.5	16.5	16.5	16.5			
	Dam hight (m)	8	15	8	7			
	Area (m2)	78	146.25	78	68.25			
Length	Dam crest (m)	80	90	120	70			
	Dam bottom (m)	48	54	72	42			
	Left side (m)	16	18	24	14			
	Right side (m)	16	18	24	14			
Concret volume	Left side (m3)	416	878	624	319			
	Right side (m3)	416	878	624	319			
	Center part (m3)	3,744	7,898	5,616	2,867			
	Total (m3)	4,576	9,653	6,864	3,504	24,596		
Cost	Unit price (JPY/m3)	18,920	18,920	18,920	18,920			
	Construction cost (Million JPY)	87	183	130	66	465	172	638
	Rate (pesos/JPY)	27	27	27	27			
	Construction cost (Million pesos)	2,338	4,931	3,506	1,790	12,565	4,649	17,214

Reference: Method of calculating sediment runoff volume (Japanese example)

【Methodology for detemination of capacity of Sabo dam】

There are several methods to control sediment runoff from the basin with the installation of the sabo dam; however, here the method to capture sediment runoff in a flood with sabo dam is presented.

【Volume of sediment runoff per flood 】

The volume of sediment runoff in a flood depends on the magnitude of the flood, the slope of the river, and the geology of the basin. Since in Japan there are studies on the volume of sediment runoff in a flood with a return period of 50 years, this return period is used to take advantage of this knowledge. The volume of sediment runoff changes in the "bed load area" with slope less than 1/30 and in the "debris flow area" with slope greater than 1/30. As can be seen in the following figure, most of the sections in Quebradanegra have slopes less than 1/30, it is considered that this ravine is located in the bed load area.

The volume of sediment runoff in a flood depends on the magnitude of the flood, the slope of the river, and the geology of the basin. In Japan there are studies on the volume of sediment runoff in a flood with 50 year return period. The volume of sediment runoff changes in the "bed load area" with slope less than 1/30 and in the "debris flow area" with slope greater than 1/30. As can be seen in the following figure, most of the sections in Quebradanegra have slopes less than 1/30, it is considered that this ravine is located in the bottom trawl area.

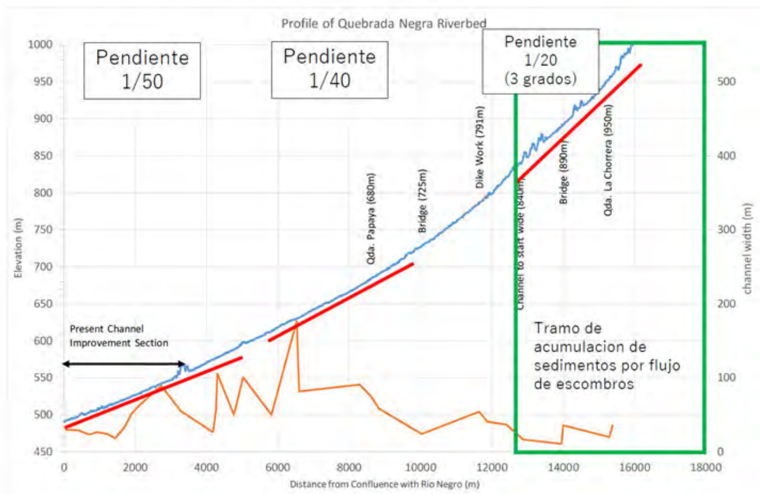


Figure 1.3.2 Longitudinal Riverbed Profile of Quebradanegra

The following table shows the volume of sediment runoff from the basin during the flood, according to the “Technical Criteria for River Works”, MLIT. In this study the average value of this table was used. Here the average value of this table is used.

Table1.3.4 Volume of Sediment Runoff in a Flood in the Bed Load Area (Basin Area of 10km^2, Return period of 50 years)

Geology	Volume of Sediment Runoff (m^3/km^2/1 flood)		
	Average	High	Low
Granite	52,500	45,000	60,000
Volcanic Products	70,000	60,000	80,000
Terciary	45,000	40,000	50,000
Crushing Zone	112,500	100,000	125,000
Others	25,000	20,000	30,000
Average	61,000		

The volume of sediment runoff in a flood according to the table above is 61,000 m^3 / km^2. This value was determined assuming that the basin area is 10km^2, and if the basin area is approximately 10 times larger, the volume of sediments in the table above must be multiplied by 0.5. The Quebradanegra basin area is 70km^2, and is approximately 10 times larger than the assumed basin area, so the drained sediment volume would be 30,000m^3 / km^2, approximately the value obtained by multiplying 61,000m^3 / km^2 by 0.5.

2. Non-Structural Measures

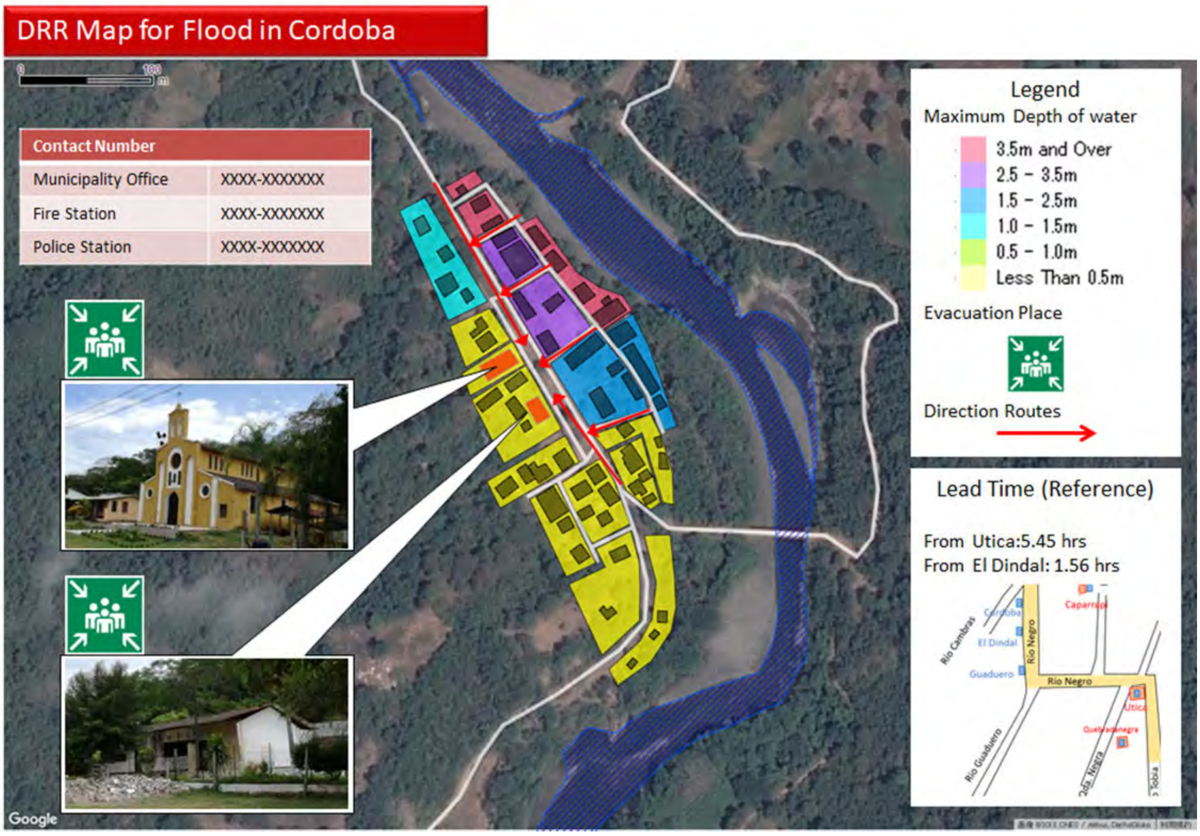
The following are the non-structural measures for the target areas or for the whole basin.

2.1 Disaster Risk Reduction Map (DRR Maps)

Disaster Risk Reduction maps (DRR maps, draft) was created using data on flood area and depth, results of the simulation with the plan's target flood (with 100-year return period discharge) in the target area. DRR map (draft) includes information on the maximum depth in the target flood, shelter, evacuation route, emergency contact information, flood propagation time from upstream for each zone. Regarding the maximum flood depth and flood propagation time, it is necessary to understand that these values are the results calculated with only available data under hypothetical circumstances and that there is always a possibility of a flood greater than the target flood occurring. It is also important to indicate this clearly on the map upon publishing it.

The map should be published and distributed to the residents after the verification process by each municipality.It will be used to raise awareness of flood as well as for evacuation in case of flood.

The DRR map was elaborated in the target area where overflow is major cause as flood damage pattern. The following is an example of DRR map created in this project.



2.2 Early Warning System

2.2.1 Position of the Flood Early Warning System as Measures against Flood in IFMP-SZ

In this chapter, the early warning system, one of the non-structural measures, will be studied as part of the study of structural measures and non-structural measures in this IFMP-SZ. In the figure below, the position that this early warning system occupies in the IFMP-SZ is presented.

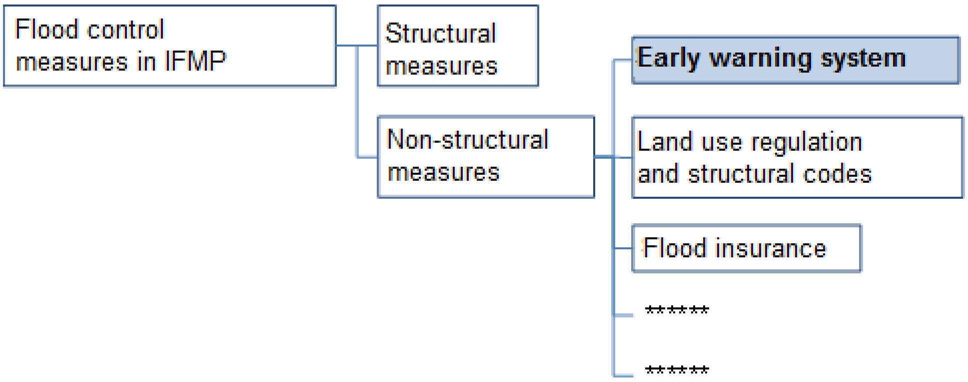


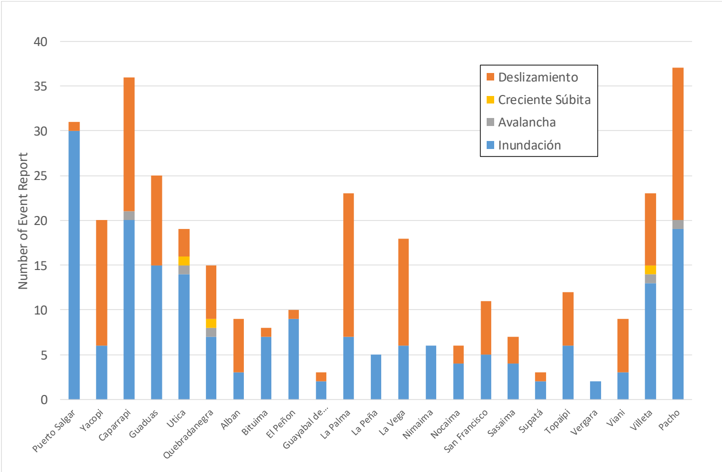
Figure 2.2.1 Position of the Early Warning System

This early warning system is hoped to be a measure for the flood that cannot be managed with the structural measures. Although this measure does not reduce physical damage, it aims to avoid human suffering.

The development of the early warning system has a lower cost compared to the structural measures, and it has the characteristic that it is possible to implement it and see the effects of it in a short time.

2.2.2 Characteristics of Flood Damage in the Rio Negro Basin

Apart from the main river of Rio Negro, there are several tributaries such as Rio Tobia, Rio Guaduero and Rio Guaguaqui in the Río Negro basin. The figure below organizes the municipalities in the Rio Negro basin from upstream to downstream and associated the number of disasters in each municipality. Based on this figure, it is observed that floods occur in all municipalities in the basin, from upstream to downstream.



Source: DNP Data Organized by JICA Project Team

Figure 2.2.2 Data of Past Disasters in the Rio Negro Basin

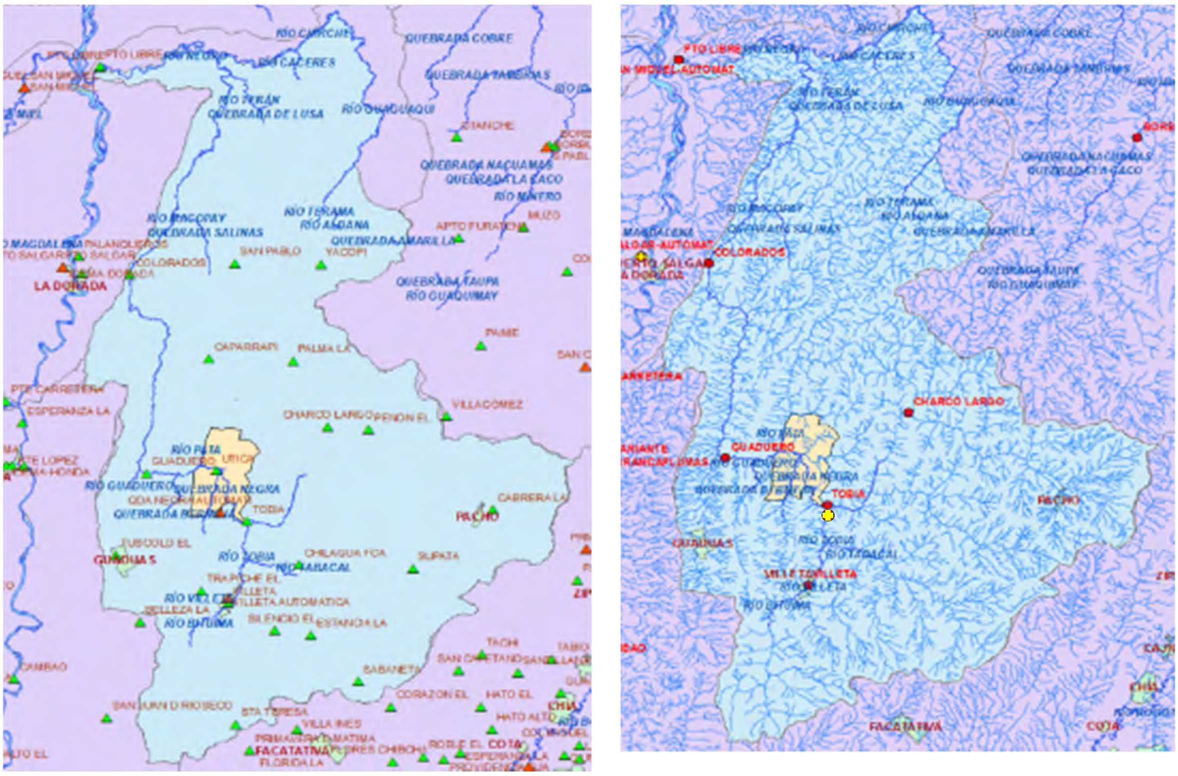
On the other hand, the influence of the tributaries on the flood is not small, and areas near the points of confluence with the main channel suffer frequent flood damage; the development of the early warning system that includes both the main river and the tributaries is expected.

In the flood of 2011, damages occurred in several municipalities simultaneously. At this moment, it is urgent to study the measures that include the entire basin, and not the individual measures by municipality.

2.2.3 Issues Related to the Forecast, Warning and Evacuation

Lack of Precipitation and Level Stations

Although IDEAM and CAR advance the organization of precipitation and level stations in the Rio Negro basin, there are not enough stations to obtain necessary temporal or spatial data for forecasting and issuing warnings. They do not possess enough real-time observation or forecast and alerts with enough lead time.



△Normal Meteorological Stations (precipitation)
▲Real-Time Meteorological Stations (precipitation)

● Normal Level Stations
○ Real-Time Level Stations

Source: IDEAM (october 2014)

Figure 2.2.3 Location of the Stations (IDEAM) in the Rio Negro Basin

Obstacles to Evacuation

Regarding the evacuation at the municipal level, it was stated that there are cases in which residents do not evacuate despite the issuance of the evacuation order because of fear of being victims of looting during the evacuation due to the flood.

Poor Communication System

In the floods of 2011, there was a case where the Department tried to communicate with the municipalities to confirm the evacuation situation without success because the cell phone signals were cut. It is an important challenge to guarantee several communication channels for the dissemination of alert and confirmation of the situation.

Insufficient Existing Guidelines

UNGRD developed "Guide for the Implementation of Early Warning Systems". Since this guide covers all types of disasters, an additional study of specific specialized measures for flood is necessary. In this guide, it focuses on community-level work for early warning as the response at the national level has a limit. From now on, it is necessary to build a system in which the central government entities support the communities (municipalities) and the communities (the municipalities) collaborate.

Source: UNGRD

Figure 2.2.4 Guide for the Implementation of Early Warning Systems

2.2.4 The Objective and Concept of the Development of the Early Warning System

Taking into account the challenges mentioned in the previous section, two points are defined as presented below, in the development of the early warning system: the objective and the concept of this IFMP-SZ.

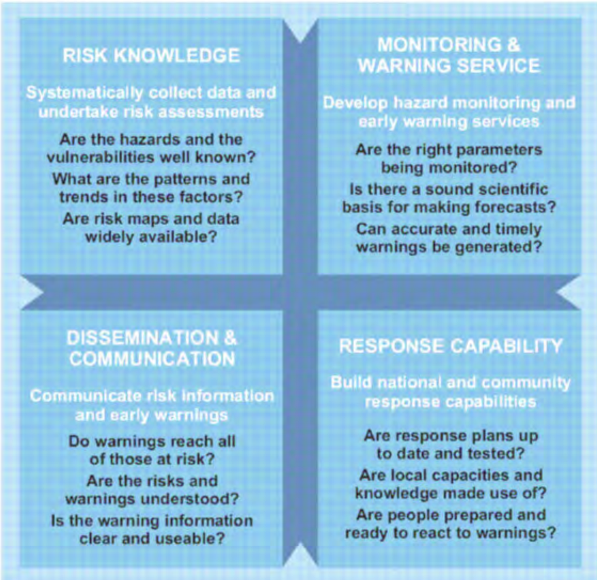
> "Guarantee enough lead time to save not only human life but also some belongings"
> "Promote not only the individual response of the municipalities but also a measure for the entire basin (especially collaboration between upstream and downstream municipalities)"

In the interview conducted in this project, it was clarified that residents in the Río Negro basin want to take their belongings and livestock at the time of evacuation. The early warning, a non-structural measure, can save human life, but cannot reduce physical damage. However, it is imperative to alleviate the problem whereby the residents' quality of life worsens each time they suffer from flood. Also, cases of looting during the evacuation have been reported, and it is necessary to reduce the losses for the residents caused by the evacuation as much as possible, allowing the residents to take some belongings along. Therefore, it is important to build a system that increases the lead time as much as possible in order to ensure sufficient time for preparation to take the belongings.

Taking the above into account, studies were conducted as part of the activities of this project. As a result, it was confirmed that it is possible to guarantee sufficient lead time for the evacuation if, apart from the individual measures of the municipalities, a measure is promoted for the entire basin that includes collaboration between the upstream and downstream municipalities. It was also clarified that it is important for the entities of higher level such as UNGRD, IDEAM, CAR and the Government of Cundinamarca to take leadership for the measure for the entire basin.

2.2.5 Formulation of the Plan Based on the 4 Elements of the Early Warning System

As a standard (norm) of the early warning system, "Development of Early Warning System: a Checklist" (hereinafter "checklist") was developed at the International Congress of early warning system, held in Bonn, Germany, between March 27 and 29, 2006. The checklist is composed of common items and 3 main elements, and it is used as a reference when government entities or communities construct or evaluate the early warning system. Specifically, apart from the common item "allocation of responsibilities", there are 4 elements: 1) Risk Knowledge, 2) Monitoring and Alert Service, 3) Dissemination and Communication, and 4) Response Capacity, which are presented in the figure below.



Source UN / ISDR Platform for the Promotion of Early Warning

Figure 2.2.5 4 Elements of Early Warning System

In this project, a plan was elaborated for these 4 elements, taking into account the situations discovered through the project activities and through the discussions with the C / P, in order to improve the flood forecast and warning in the Rio Negro basin.

Table2.2.1 Development Plan for the Early Warning System in the Rio Negro Basin

Key Elements	Contents	Target Municipality	Entity in Charge	Period
Risk knowledge	Interview to understand the time required for the dissemination of warning and evacuation in each municipality	Along the main channel(Pto Libre, Colorados, Cambras, Cordoba, El Dindal, Guaduero, Utica, Tobia, Charco Largo, Pacho) Along the tributaries(Yacopi, Guaduas, Villeta)	Department, CAR	Short term (within 2 years)
	Distribution of flood map in each municipality	Municipalities for which they are already created	Department, CAR	Short term (within 3 years)
	Installation of signs of the projected depth of flood	Municipalities for which they are already created	Department, CAR	Short term (within 2 years)
Monitoring & Warning service	Increase the number of automatic real-time water level observation station	Along the main channel(Cambras, Cordoba, El Dindal, Pacho) Along the tributaries(Yacopi, Guaduas)	IDEAM, CAR	Short term (within 3 years)
	Study of the standard values for alert communication and start of evacuation through the definition of the danger level (yellow, orange and red) and review thereof	Along the main channel(Pto Libre, Colorados, Cambras, Cordoba, El Dindal, Guaduero, Utica, Pacho) Along the tributaries(Yacopi, Guaduas)	IDEAM	Continuous implementation
	Installation of meteorological radars and dissemination of data		IDEAM	Short term(within 3 years)
	Densification of alerts of heavy rains and flood (increase in emission frequency and resolution)		IDEAM, UNGRD	Long-term (within 10 years)
Dissemination & Comunication	Share the results of the interval time analysis in the Basin Committee.	Along the main channel(Pto Libre, Colorados, Cambras, Cordoba, El Dindal, Guaduero, Utica, Tobia, Charco Largo, Pacho)	Department, CAR, UNGRD	Short term (within 3 years)
	Signing of a document on commitment for collaboration between upstream and downstream municipalities, study of the content of the collaboration	Along the main channel(Pto Libre, Colorados, Cambras, Cordoba, El Dindal, Guaduero, Utica, Tobia, Charco Largo, Pacho) Along the tributaries(Yacopi, Guaduas, Villeta)	Department, CAR, UNGRD	Short term(within 3 years)
	Proposal for the installation of inter-municipal communication (radio) devices and their administration	Along the main channel(Pto Libre, Colorados, Cambras, Cordoba, El Dindal, Guaduero, Utica, Tobia, Charco Largo, Pacho) Along the tributaries(Yacopi, Guaduas, Villeta)	Department (Disaster Risk Management Committee), UNGRD, Municipalities	Short term(within 3 years)
	Installation and administration of equipment for the dissemination of evacuation order (speakers, bells)	Along the main channel(Pto Libre, Colorados, Cambras, Cordoba, El Dindal, Utica, Tobia, Charco Largo, Pacho) Along the tributaries(Yacopi, Guaduas, Villeta)	Department (Disaster Risk Management Committee), UNGRD, Municipalities	Short term(within 3 years)
	Application of EWS between Utica and Qda. Negra to other tributaries	Along the tributaries(Yacopi, Guaduas, Villeta)	Department (Disaster Risk Management Committee), UNGRD, Municipalities	Long-term (within 10 years)
Response Capability	Resident education (flood risk reduction map, information on the upstream and downstream communication system)	Along the main channel(Pto Libre, Colorados, Cambras, Cordoba, El Dindal, Utica, Tobia, Charco Largo, Pacho) Along the tributaries(Yacopi, Guaduas, Villeta)	Municipalities	Continuous implementation
	Support in evacuation drills and collaboration between municipalities upstream and downstream.		Department, UNGRD, Municipalities	Continuous implementation
	Administration and maintenance of the evacuation route and shelters		Municipalities	Continuous implementation

In the sections that follow, content related to the current status of the content of the plan for each element, the challenges, and the implementation of improvement measures will be developed.

(1) Risk Knowledge

In the table below the plan for risk knowledge is presented.

Table2.2.2 Risk Knowledge Plan

Contents	Target Municipality	Entity in Charge	Period
a. Interview to understand the time required for the dissemination of warning and evacuation in each municipality	Along the main channel(Pto Libre, Colorados, Cambras, Cordoba, El Dindal, Guaduero, Utica, Tobia, Charco Largo, Pacho) Along the tributaries(Yacopi, Guaduas, Villeta)	Department, CAR	Short term (within 2 years)
b. Distribution of flood map in each municipality	Municipalities for which they are already created	Department, CAR	Short term (within 3 years)
c. Installation of signs of the projected depth of flood	Municipalities for which they are already created	Department, CAR	Short term (within 2 years)

a. Interview to understand the time required for the dissemination of warning and evacuation in each municipality

Current Situation

Although the people in charge in each municipality do have a concept of the time required for the dissemination of warning and evacuation, this information is not organized in such a way that a third party can consult it.

Issues

It is necessary to understand the current situation of the time required for the dissemination of warning and evacuation in each municipality in order to ensure sufficient lead time from the issuance of flood warning to evacuation

Implementation for Improvement

Carry out surveys in each municipality in order to understand the current situation of the time required for the dissemination of warning and evacuation.

b. Distribution of flood map in each municipality

Current Situation

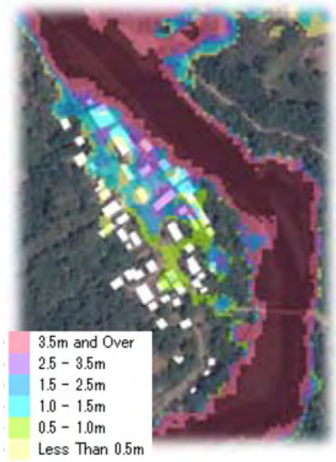
In this project, sufficiently detailed flood maps in which blocks can be identified were elaborated in 7 residential areas next to the main channel of Rio Negro where there is great flood damage.

Issues

It is necessary to share the flood maps prepared in this project to be used in disaster prevention activities.

Implementation for Improvement

Contribute to risk knowledge with the distribution of the flood map in each municipality.



Source: created in this project

Figure 2.2.6 Example of Flood Map

c. Installation of signs of the projected depth of flood

<u>Current Situation</u>

Although the people in charge recognized the need for signs of the projected flood depth, it had not been implemented due to the lack of the flood map.

<u>Issues</u>

It is necessary to provide information that is easy to understand for the residents of each municipality.

<u>Implementation for Improvement</u>

Use the flood map in section b above and implement the projected flood depth signage in each municipality as in the example in the Figure below. In municipalities that do not have the flood hazard map, study the possibility of implementing signage after confirming the data of past floods through the surveys.

Figure 2.2.7 Example of Signage of the Projected Depth in Japan

(2) Monitoring and warning service

The monitoring and warning service plan is presented in the table below.

Table2.2.3 Monitoring and Warning Service Plan

Contents	Target Municipality	Entity in Charge	Period
d. Increase the number of automatic real-time water level observation station	Along the main channel(Cambras, Cordoba, El Dindal, Pacho) Along the tributaries(Yacopi, Guaduas)	IDEAM, CAR	Short term (within 3 years)
e. Study of the standard values for alert communication and start of evacuation through the definition of the danger level (yellow, orange and red) and review thereof	Along the main channel(Pto Libre, Colorados, Cambras, Cordoba, El Dindal, Guaduero, Utica, Pacho) Along the tributaries(Yacopi, Guaduas)	IDEAM	Continuous implementation
f. Installation of meteorological radars and dissemination of data		IDEAM	Short term(within 3 years)
g. Densification of alerts of heavy rains and flood (increase in emission frequency and resolution)		IDEAM, UNGRD	Long-term (within 10 years)

d. Increase the number of automatic real-time water level observation station

<u>Current Situation</u>

Automatic real-time level observation stations in the Rio Negro basin are limited. There is a plan install 1 or 2 real-time level observation stations with Adaptation Fund.

<u>Issues</u>

Although visual measurements are taken in several places, they are only done 2 or 3 times a day, and the hourly data of the level necessary for flood forecasting and warning are limited. There are some automatic real-time observation stations; however, they are not sufficient for the observation of the Rio Negro basin in its entirety.

<u>Implementation for Improvement</u>

Install real-time observation level stations on the main river and tributaries and accumulate more level data.

Source: JICA Proejct Team

Figure 2.2.8 Example of Automatic Level Station

e. Study of the standard values for alert communication and start of evacuation through the definition of the danger level (yellow, orange and red) and review thereof

<u>Current Situation</u>

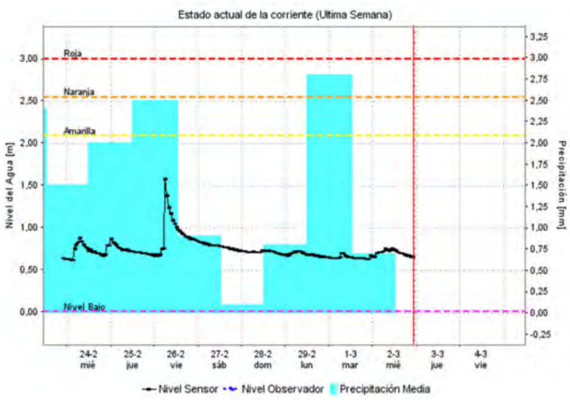
IDEAM is carrying out a study of the standard values for alert issuance and initiation of evacuation by defining the danger level (yellow, orange and red) and its review.

<u>Issues</u>

The new or revised danger level is not being used directly for disaster prevention actions such as the dissemination of alerts or initiation of evacuation. Therefore, it is necessary to study what kind of disaster prevention actions should be taken at each danger level.

<u>Implementation for Improvement</u>

When defining or revising the danger level (yellow, orange and red), study the disaster prevention actions to be taken at each level, taking into account the lead time for evacuation in each municipality.



Source: FEWS Platform -Colombia

Figure 2.2.9 Example of Danger Level and Observation Data

f. Installation of Meteorological Radars and Dissemination of Data

Current Situation

IDEAM plans to install 3 meteorological C-band radars, and within 2-3 years the data is thought to be available to the public. The study of the possible installation of an X-band weather radar is under way.

Issues

It is necessary to study how to use observation data as warning information and how to disseminate them widely to the public when installing weather radars.

Implementation for Improvement

Continuously study the use of weather radar observation data so that they can be converted into usable information for flood forecasting and warning.

g. Densification of heavy rain and flood warnings (increase in frequency of emission and resolution)

Current Situation

In the Rio Negro basin, heavy rain or flood warnings with sufficient spatial resolution or frequencyare are not currently used to allow for an effective evacuation. Therefore, the main methodology of the flood warning and evacuation is through the confirmation of the level carried out by officials in charge in each municipality.

Issues

It is feared that enough time for the evacuation cannot be guaranteed since the main methodology is for the person in charge in each municipality to take measures. Therefore, flood warning information at the national level is necessary.

Implementation for Improvement

Densify heavy rainfall or flood warnings (improve frequency and spatial resolution) based on the data and standards obtained in the activities of sections d, e, and f.

(3) Dissemination and Communication

The dissemination and communication plan is presented in the table below.

Table 2.2.4 Communication and Dissemination Plan

Contents	Target Municipality	Entity in Charge	Period
h. Share the results of the interval time analysis in the Basin Committee.	Along the main channel(Pto Libre, Colorados, Cambras, Cordoba, El Dindal, Guaduero, Utica, Tobia, Charco Largo, Pacho)	Department, CAR, UNGRD	Short term (within 3 years)
i. Signing of a document on commitment for collaboration between upstream and downstream municipalities, study of the content of the collaboration	Along the main channel(Pto Libre, Colorados, Cambras, Cordoba, El Dindal, Guaduero, Utica, Tobia, Charco Largo, Pacho) Along the tributaries(Yacopi, Guaduas, Villeta)	Department, CAR, UNGRD	Short term(within 3 years)
j. Proposal for the installation of inter-municipal communication (radio) devices and their administration	Along the main channel(Pto Libre, Colorados, Cambras, Cordoba, El Dindal, Guaduero, Utica, Tobia, Charco Largo, Pacho) Along the tributaries(Yacopi, Guaduas, Villeta)	Department (Disaster Risk Management Committee), UNGRD, Municipalities	Short term(within 3 years)
k. Installation and administration of equipment for the dissemination of evacuation order (speakers, bells)	Along the main channel(Pto Libre, Colorados, Cambras, Cordoba, El Dindal, Utica, Tobia, Charco Largo, Pacho) Along the tributaries(Yacopi, Guaduas, Villeta)	Department (Disaster Risk Management Committee), UNGRD, Municipalities	Short term(within 3 years)
l. Application of EWS between Utica and Qda. Negra to other tributaries	Along the tributaries(Yacopi, Guaduas, Villeta)	Department (Disaster Risk Management Committee), UNGRD, Municipalities	Long-term (within 10 years)

h. Share the results of the interval time analysis in the Basin Committee.

Current Situation

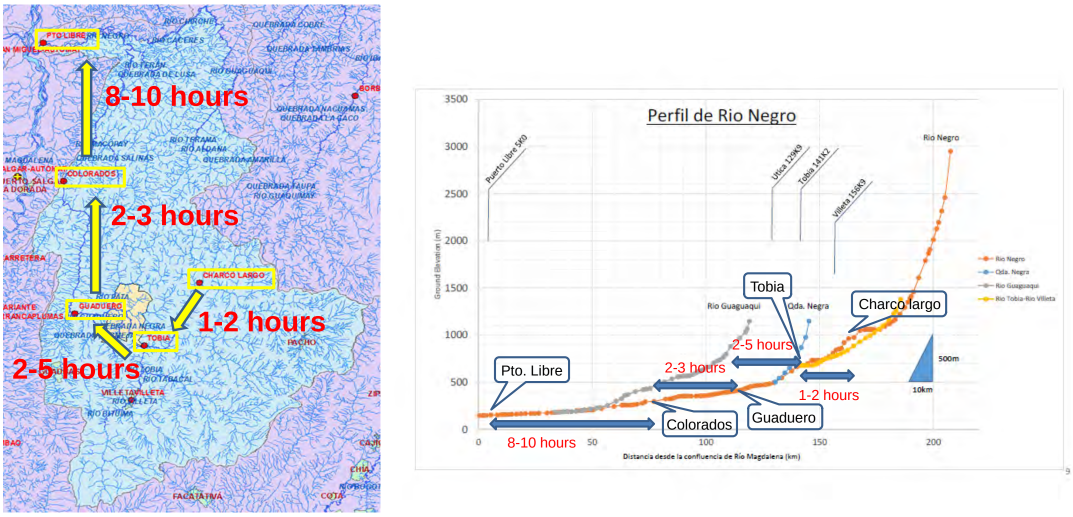
In this project, the interval time of flood propagation was analyzed in order to improve forecast and alert through collaboration between upstream and downstream municipalities.

Issues

Although the results of the interval time analysis were shared with the counterpart of the project and with some municipalities, they have not yet been shared with all the relevant municipalities.

Implementation for Improvement

Share the results of the interval time analysis in an event where all municipalities are invited, such as the Basin Committee. Use the workshop held on February 17, 2017 in the municipality of Guaduas with the presence of 11 municipalities, under the leadership of the Government as reference. In this workshop, the results of the analysis were shared.



Source: JICA Project Team

Figure 2.2.10 Result of the Calculation of the Propagation Time between Water Level Stations in the Rio Negro Basin

i. Signing of a document on commitment for collaboration between upstream and downstream municipalities, study of the content of the collaboration (there is a format developed in this project)

<u>Current Situation</u>

In some municipalities upstream and downstream in the Rio Negro basin, they already collaborate in flood forecasting and warning. The collaboration between municipalities is stipulated in Article 29 of Decree 1523.

<u>Issues</u>

There is not necessarily collaboration between all the municipalities, and in the municipalities that do collaborate they have not signed a document on commitment for collaboration.

<u>Implementation for Improvement</u>

Refer to the results of the analysis in section h above, select upstream and downstream municipalities that should collaborate, and sign a document on commitment for collaboration. Select several triggers for the warning communication process from upstream to downstream municipalities, and define the disaster prevention actions to be taken in the downstream municipalities in advance. Ideally organize lists of contact information of the person in charge in each municipality.

j. Proposal for the installation of inter-municipal communication (radio) devices and their administration

Current Situation

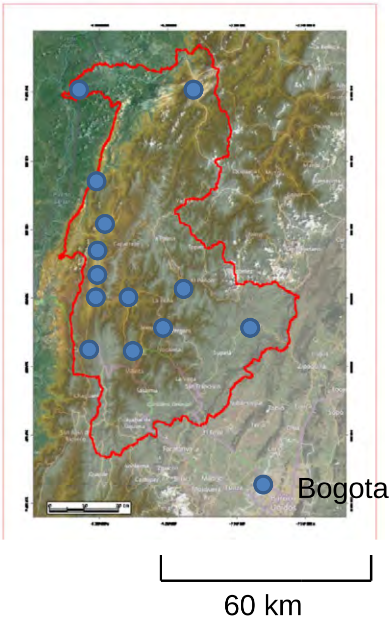
In some municipalities in the Rio Negro basin, there is collaboration between upstream and downstream for early warning. According to the survey conducted in the present project, there were points where the cell phone signal was cut and could not communicate in the 2011 flood.

Issues

Cell phone communication is not fast enough as it can not communicate with several municipalities downstream at the same time.

Implementation for Improvement

Ensure faster communication of the alert with the introduction of radios in the municipalities as a means of communication. Obtain the same type of radios for both the municipalities and the Cundinamarca Department to build the communication system. Guarantee several communication channels using the radio, not only by cell phone.



Source: JICA Project Team

Figure 2.2.11 Image of the Installation Points of the Radio in the Rio Negro Basin

k. Installation and administration of equipment for the dissemination of evacuation order (speakers, bells)

Current Situation

In the majority of the Rio Negro basin, the equipment for the dissemination of evacuation order have not been installed.

Issues

In municipalities where loudspeakers or bells have not been installed to disseminate the evacuation order, this information is disseminated from door to door, with the person in charge of the municipality, which means that the dissemination of the alert takes a long time.

Implementation for Improvement

Confirm the residential area where it is necessary to disseminate the alert in each municipality, select appropriate equipment for this purpose and buy them.

Prepare the guides under the leadership of the Departmen (the Disaster Risk Management Committee) with the support of UNGRD. Explore alternatives for financing as necessary, although as a basic rule the budget should come from the municipalities (from the Disaster Risk Management Committee).

l. Application of EWS between Utica and Qda. Negra to other tributaries

Current Situation

Between Utica and Qda. Negra, an EWS has been introduced with the support of UNGRD.

Issues

In other tributaries that greatly influence the magnitude of the flood damage, apart from Utica-Qda. Negra, there is no EWS.

Implementation for Improvement

Refer to the Utica-Qda. Negra EWS and introduce EWS in other tributaries.

Prepare guides under the leadership of the Department (Risk Management Committee) with the support of UNGRD. Explore alternatives for financing as necessary, although in principle the budget must come from the municipalities (from the Disaster Risk Management Committee).

(4) Response Capacity

The response capacity plan is presented in the table below.

Table2.2.5 Response Capacity Plan

Contents	Target Municipality	Entity in Charge	Period
m. Resident education (flood risk reduction map, information on the upstream and downstream communication system)	Along the main channel(Pto Libre, Colorados, Cambras, Cordoba, El Dindal, Utica, Tobia, Charco Largo, Pacho) Along the tributaries(Yacopi, Guaduas, Villeta)	Municipalities	Continuous implementation
n. Support in evacuation drills and collaboration between municipalities upstream and downstream.		Department, UNGRD, Municipalities	Continuous implementation
o. Administration and maintenance of the evacuation route and shelters		Municipalities	Continuous implementation

m. Resident education (flood risk reduction map, information on the upstream and downstream communication system)

<u>Current Situation</u>

Regarding the activities of section b and i, hazard map and communication system upstream and downstream have not been elaborated.

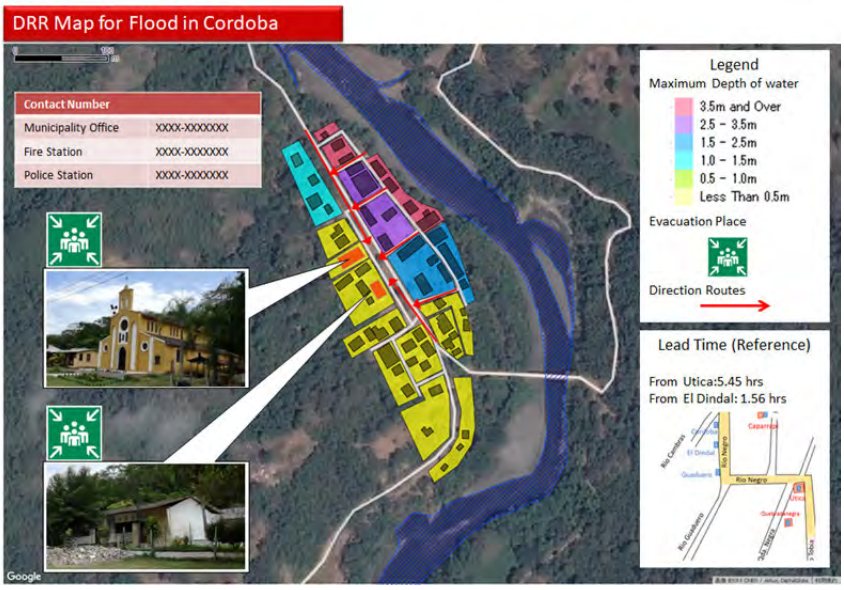
<u>Issues</u>

At the municipality level, it is necessary to educate not only the people in charge of the disaster response but also the residents.

<u>Implementation for Improvement</u>

Conduct orientation workshops for residents and share knowledge in order to educate not only the people in charge of disaster response but also residents about the activities stipulated in section b and i.

Based on the flood disaster risk reduction map prepared in this project in the figure below, confirm the flood area, the depth, the shelter, the evacuation route, the contact persons in charge, and the time of flood propagation from upstream to downstream to create flood disaster risk reduction map in each municipality.



Source: JICA Project Team

Figure 2.2.12 Example of the Flood Disaster Risk Redution Map

n. Support in evacuation drills and collaboration between municipalities upstream and downstream.

Current Situation

There are municipalities where evacuation drills are held several times a year at the municipal level.

Although efforts are being made to collaborate between upstream and downstream municipalities in the event of disasters, collaborative drills are usually not conducted between upstream and downstream municipalities.

Issues

There is a difference in the municipal efforts for the drills depending on the budget and the policy.

It is necessary to understand the time required for the dissemination of the alert through the drills for collaboration between upstream and downstream municipalities.

Implementation for Improvement

Ensure the continuous realization of municipal drills through the workshops related to the incident of command of the Department and the existing national simulations carried out by UNGRD.

Conduct the drills for collaboration between upstream and downstream municipalities under the leadership of the Department.

o. Support in administration and maintenance of the evacuation route and shelters

Current Situation

As for the shelters, they are usually schools or churches that are of habitual use, and ideal for administration and maintenance.

Issues

A system of routine maintenance of the evacuation route and the shelters has not been created so that they can be used in the disaster events.

Implementation for Improvement

Perform periodic maintenance of the evacuation route and the shelters so that they can be used without problems in the disaster events.

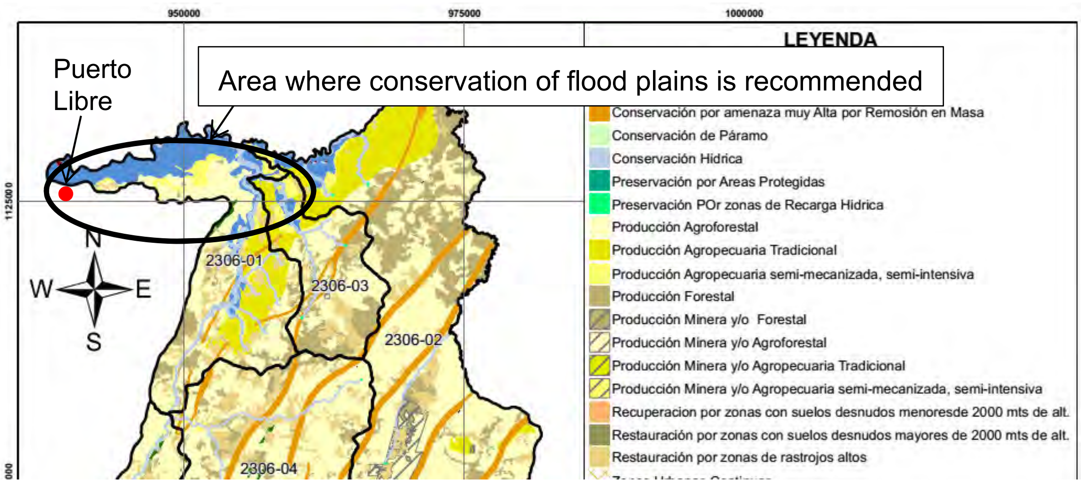
2.3 Land Use Control Including Flood Plain Management

(1) Significance of the Floodplain Conservation

Land use condition in the basin influences the flood runoff greatly. For example, the time from rainfall to runoff is shorter and the peak discharge is greater in paved urban areas or bare lands tan in forests or grass in many cases. Lans use also influences the occurence of sediment desaster and sediment production volumen significantly.

In Rio Negro Basin, there are flood plains in the areas extending from the confluence of Rio Negro River and Guaguaqui River to the confluence of Rio Negro and Magdalena River. These flood plains possess capacity to retain and store flood discharge as a natural retention basin, reducing the discharge in Puerto Libre, located near the confluence of Rui Negro River and Magdalena River. In order to control future flood damage in Puerto Libre, development in these flood plains should be regulated. In POMCA's environmental zoning, this area is classified as a conservation zone for being flood hazard zone, as observed in the figure below.

It is necessary to conserve flood plains like these or forests appropriately with land use control from the point of view of flood and sediment disaster control.



Source: Figure for Environmental Zoning from POMCA with addition by JICA Project Team

Figure 2.3.1 Flood Plain Conservation Area

Figure 2.3.2 Rio Negro near Puerto Libre

(2) Effects of the Floodplain Conservaction

According to the results of the Rio Negro flood analysis carried out by CAR, the data on the floodplains are as follows:

Table2.3.1 Impacts of Retention of Floodplains

Location	Length	Area	Storage Volume
Upstream Puerto Libre	10km	10km^2	20km^3

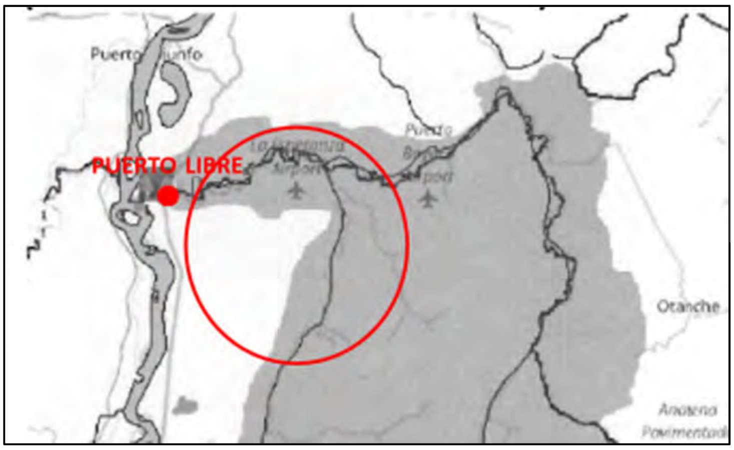


Figure 2.3.3 Location of the Floodplains Upstream of Puerto Libre

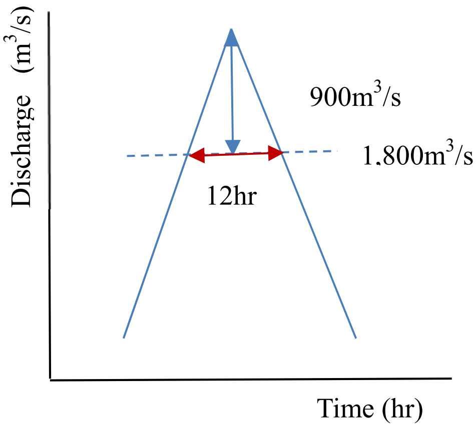


Figure 2.3.4 Image of the Impact of Flood Retention

The impact of flood retention on floodplains is projected based on the results of the calculation described above.

The calculation below is hypothetical since there is no flood hydrograph for Rio Negro.

These floodplains store approximately 1/3 of the peak discharge of the flood with return period of 1/100. Assuming it has flood normalization effect,

- Peak flood discharge that enters Puerto Libre : 2,700 m^3/s aprox.

- Actual peak flood discharge in Puerto Libre : 1,800 m^3/s aprox.(Projected value of flood with return period 1/100)
- Maximum discharge reduced by the floodplains : 900 m^3/s
- Stored flood volume : 20,000,000m^3
- Reduced flood time : Aprox.12hr

As seen in the examples of flood phenomena in the Magdalena River, in the rivers without dams where the river expands horizontally, the floodplains have enough impact to reduce flood damage.

Specifically, the flood retention in the floodplains below the Rio Negro reduces the peak flood flow and flood damage downstream in Puerto Libre. Additionally, it has normalizing effecti on runoff to the Magdalena River, reducing the discharge on the Magdalena River. Therefore, the conservation of floodplains for the reduction of flood damage is important in Rio Negro as well, and the administration of floodplains is expected through the regulation and instruction of land use.

2.4 Development and Enhancement of Emergency Response System during Flood

(1) Support of the Departments (prefectures) and UNGRD for the flood response of municipalities

It is stipulated in Law No. 1523 of 2012 “Law of establishment of national disaster risk management system” that the understanding of flood damage situations and emergency response like rescue of victims etc. are the responsibility of municipalities. However, in the actual situation, because of the poor capability of municipalities for the response to the flood disaster, the Departments and UNGRD support municipalities by providing human resources and equipment during flood according to the scale of floods. Municipalities have a guideline for the emergency response to the disaster and they request support to the Department according to this guideline. The heads of municipalities convey their will of support request to the “Risk Management Division” of the Department. In case of support request from department to UNGRD, there are two ways to convey it. One way is from “Risk Management Division” of the department to the “Crisis Room” of UNGRD and other is from the Department governor to Director General of UNGRD. As mentioned above, the way of support request is already established at a certain level based on the past experiences. However, it is necessary to improve the way of support requests from municipalities to the Department or UNGRD for more smooth and efficient response to the flood disaster as well as to formulate the activities guidelines.

(2) The activities to make municipalities recognize responsibilities and roles about flood risk management

In the workshops of this Project, the concensus has been formed that municipalities have responsibility regarding understanding flood damage situations and improvement of flood response activities. However the representative of municipalities did not join these workshops, it is necessary to make municipalities to recognize these responsibilities and roles and improve flood response capabilities of municipalities. In particular, it is necessary to describe the responsibilities and roles of municipalities on the documents like IFMP-SZ etc. or to raise awareness of municipalities through the disaster response trainings that will be held with UNGRD, CAR, Departments and municipalities seven times in every year.

(3) Procurement of the equipment during flood response period

During emergency response just after flooding the works with equipment are necessary. In Cundinamarca Department, ICCU (Institute de Infraestructura y Concesiones Cundinamarca) that is a public sector belong to the Department manages equipment that is required during flooding period. Through the past flood experiences the way of procuring equipment has been developed, however for the more smooth and effective management of equipment it is necessary to enhance preparing in advance to the flood event. For example deploying equipment in nearest site to the high risk area and preparing shortest route to the devastated site.

3. Comprehensive Evaluation

Within the measures discussed in the last chapter, the structural measures will be evaluated with 3 criteria in each target area for comprehensive evaluation. As the structural measures in this IFMP-SZ are provisional versions created with a study of limited information, please take into account that the evaluation will also be provisional.

- Feasibility according to natural and social constraints
- Social benefits of the structure
- Economic efficiency

(1) Evaluation of Feasibility according to Natural and Social Constraints (Socio-Environmental Evaluation)

1) Cordoba

The planned structural measure is a flood wall. The following are the natural and social limitations that may be posed by the construction and operation of the infrastructure and the degree of its impact.

Possible Impact		Degree of Impact		Comments（Justification）
Main Category	Constraints	Construct ion	Operation	
Socio-En vironment al	Involuntary resettlement	Minor	Almost none	Although there is a possibility that a temporary relocation may be necessary at the time of construction work, permanent relocation is not expected in this project.
	Local economy	Some impact	Almost none	The construction work is expected to create short-term employment opportunities.

	Land use and utilization of local resources	Almost none	Some impact	Overall, beneficial effects such as increased land value in protection areas can be expected.
	Existing infrastructures and services	Almost none	Almost none	The structure will be built on public land along rivers, and it will not cause significant negative impact on existing infrastructure and services.
	Water usage, water rights, communal rights	Almost none	Almost none	Access to the river by neighboring residents may be hindered by construction of the structure, but the impact is considered to be minor if measures such as maintenance of aisles and stairs are taken.
Natural-Environmental	River discharge, flow regime, water temperature	Almost none	Almost none	No impact is thought to exist on river flow rate, flow regime, and water temperature due to installation of facilities.
	Flora, fauna, biodiversity	Minor	Minor	The installation site of the structure is small, and access to the river of small animals may be hindered by construction of the structure, but there is no serious negative impact on Flora, fauna and biodiversity.
	Aesthetic landscape	Minor	Minor	The installation site of the structure is small, and no serious negative impact on the surrounding landscape is thought to exist.
Pollution	Air pollution / water pollution / soil contamination, increase of noise and vibration	Minor	Almost none	Temporary increase of noise and vibration and temporary impact on the air and water pollution are expected during construction work. However, the construction is small scale, and the impact is considered to be minor.

Source: JICA Project Team

As described in the table above, the impact is either minor or can be minimized by implementing countermeasures, and the feasibility according to natural and social constraints is evaluated to be sufficiently high.

2) El Dindal

The planned structural measure is shore protection. The following are the natural and social limitations that may be posed by the construction and operation of the infrastructure and the degree of its impact.

Possible impact		Degree of Impact		Comments (Justifications)
Main Category	Constraints	Construction	Operation	
Socio-Environmental	Involuntary Resettlement	Minor	Minor	Several relocation along river banks are expected to be required.
	Local economy	Some impact	Almost none	The construction work is expected to create short-term employment opportunities.
	Land use and utilization of local resources	Almost none	Some impact	Overall, beneficial effects such as increased land value in protection areas can be expected.
	Existing infrastructures and services	Almost none	Almost none	No important infrastructure is thought to exist in the site where this structure will be located, and no serious negative impact on existing infrastructure and services will be caused.
	Water usage, water rights, communal rights	Almost none	Almost none	Access to the river by neighboring residents may be hindered by construction of the structure, but the impact is considered to be minor if measures such as maintenance of aisles and stairs are taken.

Natural-Environmental	River discharge, flow regime, water temperature	Almost none	Almost none	No impact is thought to exist on river flow rate, flow regime, and water temperature due to installation of facilities.
	Flora, fauna, biodiversity	Almost none	Almost none	The installation site of the structure is small, and there is no serious negative impact on Flora, fauna and biodiversity.
	Aesthetic landscape	Minor	Minor	The installation site of the structure is small, and no serious negative impact on the surrounding landscape is thought to exist.。
Pollution	Air pollution / water pollution / soil contamination, increase of noise and vibration	Minor	Almost none	Temporary increase of noise and vibration and temporary impact on the air and water pollution are expected during construction work. However, the construction is small scale, and the impact is considered to be minor.

Source: JICA Project Team

As described in the table above, the impact is either minor or can be minimized by implementing countermeasures, and the feasibility according to natural and social constraints is evaluated to be sufficiently high.

3) Utica

The planned structural measure is a small-scale sabo dam (infrastructure). The following are the natural and social limitations that may be posed by the construction and operation of the small-scale sabo dam (infrastructure) and the degree of its impact.

Possible impact		Degree of Impact		Comments (Justifications)
Main Category	Constraints	Construction	Operation	
Socio-Environmental	Involuntary Resettlement	Almost none	Almost none	Permanent relocation is not expected to occur in this project.
	Local economy	Some impact	Almost none	The construction work is expected to create short-term employment opportunities.
	Land use and utilization of local resources	Almost none	Some impact	Overall, beneficial effects such as increased land value in protection areas can be expected.
	Existing infrastructures and services	Almost none	Almost none	The structure will be built on public land along rivers, and it will not cause significant negative impact on existing infrastructure and services.
	Water usage, water rights, communal rights	Almost none	Almost none	The impact of the structure is considered to be almost none, or minor even if it occurs along the way.
Natural-Environmental	River discharge, flow regime, water temperature	Almost none	Almost none	No impact is thought to exist on river flow rate, flow regime, and water temperature due to installation of facilities.
	Flora, fauna, biodiversity	Minor	Minor	The installation site of the structure is small, and there is no serious negative impact on Flora, fauna and biodiversity.
	Aesthetic landscape	Minor	Minor	The installation site of the structure is small, and no serious negative impact on the surrounding landscape is thought to exist.
Pollution	Air pollution / water pollution / soil contamination, increase of noise and vibration	Minor	Almost none	Temporary increase of noise and vibration and temporary impact on the air and water pollution are expected during construction work. However, the construction is small scale, and the impact is considered to be minor.

Source: JICA Project Team

As described in the table above, the impact is either minor or can be minimized by implementing countermeasures, and the feasibility according to natural and social constraints is evaluated to be sufficiently high.

(2) Evaluation of Social Benefits of the Structure

1) Cordoba

Building this structure can eliminate flood damage up to the 50-year return period and reduce flood damage caused by excessive flooding compared to the conditions without the structure. Prevention and reduction of flood damage can stabilize the lives of local residents. However, this area is an area where the access from the main road is poor, and even the municipal development plan does not include the future development of this area. Therefore, it is hard to think that the effectiveness will increase greatly in the future.。

2) El Dindal

Building this structure can control river erosion in the area concerned. This can prevent damage to houses caused by the decrease of urbanized areas along river banks and by river bank erosion. It can also stabilize the lives of local residents. In addition, the area is located along the highway, the development plan of the municipality includes future development in the area such as improvement of waterworks facilities. Therefore, the effectiveness of the structure is expected to increase in the future.

3) Utica

Building this facility can considerably suppress the impact of sediment-related disasters to Utica City in the downstream of Quebrada Negra. This can also stabilize the lives of residents within the areas in Utica City with the possibility of sediment-related disaster. In addition, this area is the center of Utica City (urban area), where the population has only increased slightly. Therefore, the effectiveness can increase in the future.

(3) Evaluation of Economic Efficiency

1) Cordoba

Economic efficiency of the measures is evaluated by benefit - cost (B - C) and cost - benefit (B / C). The efficiency is expressed by benefit of the project, which is required in the comparison of the economic benefits between the "with project (structural measures)" and "without project" conditions. The project benefit is calculated based on the benefit of flood damage mitigation generated by the project. In this project,the benefit of mitigating flood damage was evaluated by assessing only the benefit of flood damage mitigation on houses due to the implementation of the project. The cost is the sum of the project cost calculated in the above-mentioned plan of structural measures, and the maintenance cost calculated hypothetically by the following assumption. In addition, the conditions set for calculation are shown below.

- Project evaluation period: 50 years after completion
- Base year: 2018
- Discount rate: 10%
- The cost of the project is calculated based on calculation examples in Japan or past constructions in Colombia, and it is assumed that the period necessary for the completion of the project is one year and that no benefit is generated during the work.
- Maintenance and administration expenses shall be 1% of the cost of construction, and will occur during the service period after the completion of project
- Benefits are calculated from the expected rate of reduction of damage to houses by installing facilities, and are generated during the service period after the completion of project
- Since the design scale is 50 years, the monetary value of the reduced damages is the total value of the damages projected in a flood with a return period of less than 50 years. The measure is expected to reduce the monetary value of the damage projected in a flood with a return period of 50 years in the case of floods with a return period of greater than 50 years.
- Benefits are not assumed to increase

The calculated benefit-cost (BC) and cost-benefic (B / C) are as follows.

- Benefit-Cost (B-C) : 12 million Pesos
- Cost-Benefit (B/C) : 1.13

From the above, it can be concluded that this project has low economic efficiency

2) El Dindal

Economic efficiency of the measures is evaluated by benefit - cost (B - C) and cost - benefit (B / C). Calculation method of each value and assumption for calculation are the same as for Cordoba except the period necessary for the completion of the project, which is two years.

The calculated benefit-cost (BC) and cost-benefic (B / C) are as follows.

- Benefit-Cost (B-C) : 1 million Pesos
- Cost-Benefit (B/C) : 1.04

From the above, it can be concluded that this project has low economic efficiency.

3) Utica

Economic efficiency of the measures is evaluated by benefit - cost (B - C) and cost - benefit (B / C). The efficiency is expressed by benefit of the project, which is required in the comparison of the economic benefits between the "with project (structural measures)" and "without project" conditions. The project benefit is calculated based on the benefit of sediment disaster mitigation generated by the project. In this project,the benefit of mitigating sediment disaster was evaluated by assessing only the benefitof sediment disaster mitigation on houses due to the implementation of the project. The cost is the sum of the project cost calculated in the above-mentioned plan of structural measures, and the maintenance cost calculated hypothetically by the following assumption. In addition, the conditions set for calculation are shown below.

- Project evaluation period: 50 years after completion
- Base year: 2018
- Discount rate: 10%
- The cost of the project is calculated based on calculation examples in Japan or past constructions in Colombia, and it is assumed that the period necessary for the completion of the project (construction of 4 sabo dams) is five years and that the project generates ¼ of benefits at the end of the construction of one sabo dam.
- Maintenance and administration expenses shall be 1% of the cost of construction, and will occur during the service period after the completion of project
- Benefits are calculated from the expected rate of reduction of damage to houses by installing facilities, and are generated during the service period after the completion of project
- Since the design scale is 10 years, the monetary value of the reduced damages is the total value of the damages projected in a sediment disaster with a return period of less than 10 years. The measure is expected to reduce the monetary value of the damage projected in a sediment disaster with a return period of 10 years in the event of a sediment disaster with a return period of more than 10 years.
- Benefits are not assumed to increase

The calculated benefit-cost (BC) and cost-benefic (B / C) are as follows.

- Benefit-Cost (B-C) : 12,150 million Pesos
- Cost-Benefit (B/C) : 1.95

From the above, it can be concluded that this project has some economic efficiency.

(4) Comprehensive Assessment

1) Cordoba

As for the feasibility of this measure according to natural and social constraints, the impact of the measure is considered to be minor. Therfore, the evaluation concluds that there is no problem. While social benefit is obvious, it can must be stated that economic efficiency is low. From a comprehensive point of view, when comparing and evaluating three target areas, the benefit of implementing measures is not high.

2) El Dindal

As for the feasibility of this measure according to natural and social constraints, the impact of the measure is considered to be minor. Therfore, the evaluation concluds that there is no problem. While social benefit is obvious, it can must be stated that economic efficiency is low. From a comprehensive point of view, when comparing and evaluating three target areas, the benefit of implementing measures is not high.

3) Utica

As for the feasibility of this measure according to natural and social constraints, the impact of the measure is considered to be minor. Therfore, the evaluation concluds that there is no problem. Besides the obvious social benefit, there is a degree of economic efficiency. From a comprehensive point of view, when comparing and evaluating three target areas, the benefit of implementing measures is high.

4. Monitoring Plan

Since a IFMP-SZ deals with natural phenomena, there are limits to the conditions that can be grasped at the planning stage. In addition, in the current state of data development in the Rio Negro basin, necessary information is not sufficiently prepared for planning. Therefore, continued monitoring after the project is implemented is essential so as to provide feedback for future IFMP-SZ.

Monitoring can be broadly divided into regular periodic monitoring and monitoring after inundation (including when large discharge is observed without causing flood). Items to be monitored, their methods and objectives are shown in the table below.

Mornitoring Item	Objective	Method	Frequency
＜Periodic Monitoring＞			
Observation, collection and organization of rainfall and water level data	Understanding run-off characteristics and improving accuracy of prediction model	Continually observe rainfall and water level. Work to increase the data observation frequency and accuracy, such as hourly data and 10-minute data besides the daily data. Work to increase the stations. Implement these initiatives concurrently.	Continuous
Discharge observation	Understanding run-off characteristics, updating the HQ curve, and improving accuracy of prediction model	Periodically perform flow rate observation. Work to increase the observation frequency / accuracy. Work to increase the stations. Ideally, these efforts should be made concurrently.	More than once every several months

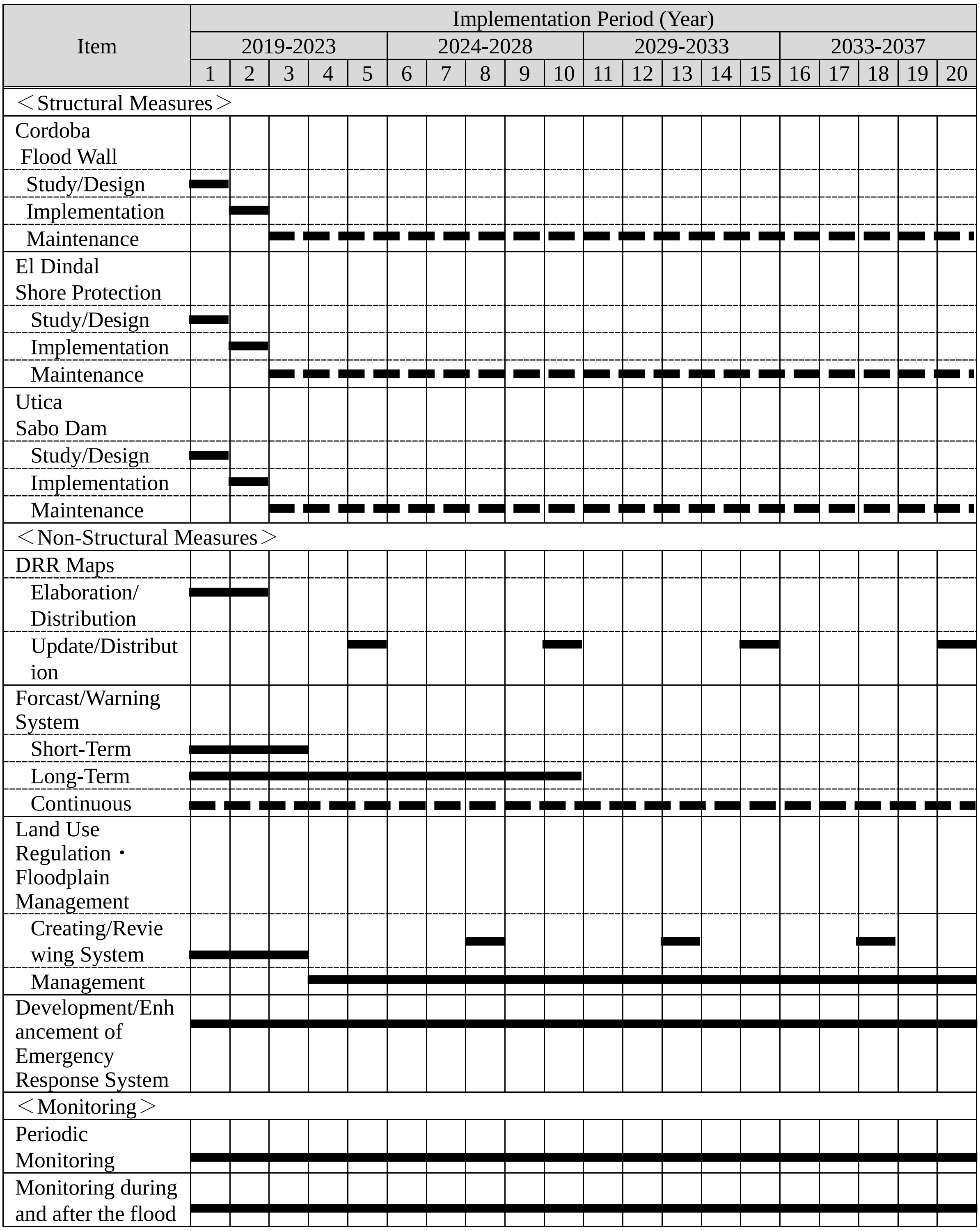
Study of riverbed changes	Evaluating the stability of river channels after project implementation and confirming the safety of river structures	Regularly conduct river patrols, compare it with the previous year by photographing it etc. and investigate the changes in river bed. Also investigate the degree of localized erosion around the structure and check whether safety is ensured. Ideally, conduct longitudinal cross-sectional surveys of important reaches such as the confluence point of the main branch in order to compare the before and after and to evaluate the long-term trend of the river bed changes and the flow capacity.	River patrol about once a year Transversal section survay once every few years
Study of river use and ecosystem	Setting and reviewing policies on river use and conservation of the natural environment	Regarding the river use, continue the interviews with residents and surveys for the ecosystems, considering the optimal timing and the target species.	Interview with the residents once every few years Survey for ecosystems about once a year
Study of conservation situation of floodplain	Adequately preserving important floodplains with a water-retaining effect such as reducing peak flow rate. They have potential for significant downstream flood damage reduction	Periodically patrol the floodplains and inspect whether or not inappropriate use is present or, and whether or not local governments properly regulate them.	About once a year
＜Monitoring during and after inundation (large discharge)＞			
Observation, collection and organization of rainfall and water level data	Understanding the run-off characteristics during the flood and to improving the accuracy of the prediction model	Measure the water level and discharge data during flood. Investigate the flood marks after flood.	During and after the large discharge
Discharge observation	Confirming the degree of river bed changes due to flood and confirming safety of river structures after flood	Survey the river bed changes after flood, damages to the river structure, safety of the structure that may be affected by erosion, etc.Confirm the extent of river bed changes due to the flood and the necessity of renovation of the structure.	After a large discharge
Study of riverbed changes	Confirming the impact of river use and the impact of flood on the ecosystem	Investigate the impact of flood on structure for river use and on ecosystem.	After a large discharge
Study of conservation situation of floodplain	Confirming the water retention effect of the floodplain	Investigate the flood conditions (flood area, flood depth, duration, etc.) of the floodplain during the flood through flood marks and interview with residents.	After a large discharge

Source: JICA Project Team

Since it is difficult to implement these monitoring actions only with the entity responsible for them (CAR), it is necessary to cooperate with the local governments as well as riverside communities and residents.

5. Implementation Schedule

Implementation schedule for the structural measures, non-structural measures and monitoring described in the previous chapter are shown in the table below.



D. Allocation of Responsibility for Planning of IFMP-SZ

1. Current Situation and Issues

(1) Organization of the Flood Risk Management System in Public Entities Related to the River

Regarding the administration of rivers and flood control in Colombia, CARs (Regional Autonomous Corporations) are responsible for the activities in small basins. However, the distribution of responsibilities between the central government (UNGRD, IDEAM) and the regional government (CAR, Departments, Municipalities) is not clear in terms of the concrete activities and the contents of the plans. It is necessary to improve this situation since there are no comprehensive laws on the allocation of responsibilities.

POMCA is formulated mainly by CAR using the guideline prepared by the Ministry of Environment and Sustainable Development, as an existing plan where it is possible to include items related to flood risk management. However, since POMCA addresses the risk of numerous types of disasters and includes many issues related to the basin such as water resource and environment, it is necessary to develop specific contents related to flood risk management in POMCA. In addition, it is necessary to clarify the distribution of responsibilities for coordination with the National Disaster Risk Management Plan (PNGRD) that occupies the position of the upper level plan in the component of risk management and the adjustment of the items that must be reflected in IFMP-SZ that occupies position of a lower level plan.

(2) Study of plan for activities related to flood risk management adjusted to existing laws

After the floods that occurred in 2010-2011, laws related to flood control were created in Colombia.

- Decree 4147 of 2011 on "Creation and Legal Nature of the National Unit for Disaster Risk Management"
- Law 1523 of 2012 by which "the National System of Management of Disaster Risk is established and other provisions are issued"
- Decree 1640 of 2012 by means of which "the instruments for the planning, management and management of watersheds and aquifers are regulated": This decree is now contained in decree 1076 of 2015
- Resolution 1907 of the Ministry of Environment, December 2013 "Technical Guide for the Formulation of Management Plans and Management of Hydrographic Basins (POMCA)"
- Decree 1807 of September 2014 by which "items related to the incorporation of the management of the risk in the plans of territorial ordinance" are regulated

2. Discussion in the Workshops

2.1 Workshops in 2015-2016

Workshops were held regarding the role sharing between the central government and the regional government in 2015 and 2016, as presented below. In these workshops, the information collected and cataloged in this study was presented (the entities, laws and the current situation of distribution of responsibilities related to flood risk management), and the discussion was held in order to make a proposal on the creation of the implementation of flood risk management system.

Table 2.1.1 Workshops on the Role Sharing between the Central Government and the Regional Government for Flood Risk Management

Date	Contents
2015/10/23	Relavant entities for the River Management Plan in Japan and the Magdalena River Basin
2015/11/03	Process of formulating the plan for the Magdalena River basin and Rio Negro basin, role sharing among relevant entities
2015/11/10	Role sharing among relevant entities
2016/02/16	Discussion on Role sharing among relevant entities (Magdalena River basin)
2016/03/02	Discussion on Role sharing among relevant entities (Rio Negro basin)
2016/10/05	Discussion on the participation of CORMAGDALENA and CIRMAG in the present project as C / P.
2016/10/28	Discussion on the participation of CORMAGDALENA and CIRMAG in the present project as C/P.

As a result of the discussion, it was clarified that CORMAGDALENA and MADS are the main entities that should assume the management of Río Magdalena since at the moment the expert team interpreted that CORMAGDALENA was given the responsibility of administering the Magdalena River basin in the Constitution of 1991 and since MADS is in charge of of the formulation of the Strategy Plan for Macrobasin. Regarding the formulation of the IFMP-SZ for the Rio Negro basin, it was clarified that IDEAM and CAR would be the main entities. In addition, it was confirmed that the entities that participated in the workshops understood role sharing for flood risk management in the following manner.

Table 2.1.2 Ideas on Role Sharing for Flood Risk Management

	Magdalena River Basin	Rio Negro Basin
UNGRD	Activities for flood risk management (organize the disaster record)	
CORMAGDALENA	Formulation of the River Management Plan for the tributary basin	
IDEAM	Hydrological and meteorological observation of the basin, hydrological and hydraulic modeling, flood forecast and warning	
MADS	Formulation of strategies	Formulation of basic guidelines for flood control
Cundinamarca Department	Activities in accordance with the policy of CORMAGDALENA and MADS Support for the municipalities	Support for the municipalities

	Magdalena River Basin	Rio Negro Basin
CAR		Hydrological and meteorological observation of the basin, hydrological and hydraulic modeling, study of structural measures, activities to incorporate flood risk in POMCA
Municipio	Final decision on the implementation of measures, implementation, maintenance and administration	

2.2 Workshop on October 12, 2017

(1) Contents of Study

In this workshop, the allocation of responsibilities for the formulation of IFMP-SZ for Rio Negro basin and for the implementation of works related to flood risk management stipulated in IFMP-SZ were studied. Workshop participants came to share a common understanding about these items.

In August 2016, "Proposal on the Effective and Efficient Allocation of Responsibilities" was elaborated through the discussions in the workshops held between 2015 and 2016. In this workshop, it was confirmed that the allocation of responsibilities based on this would be studied.

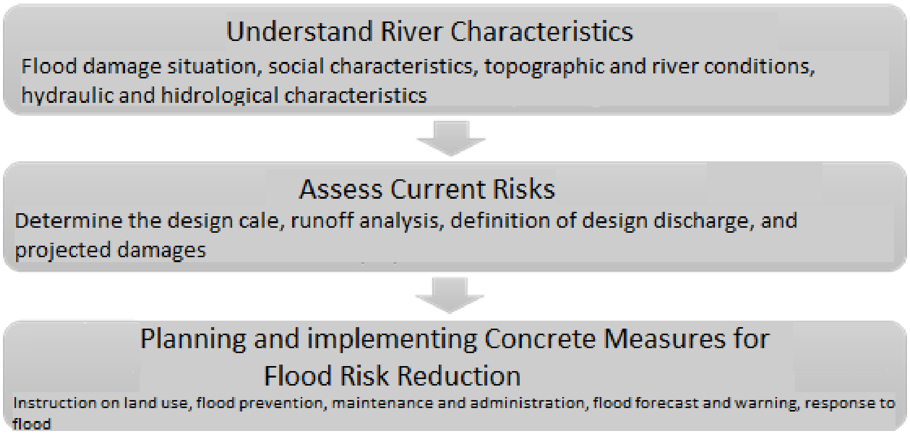


Figure 2.2.1 Flood Risk Management Process

The content presented in the table below was presented as the concrete measures to reduce the risk of flooding in the Rio Negro basin, in order to study the distribution of responsibilities based on this. The content of the table below is the result of the study within the project team.

Table 2.2.1 Measures for the Reduction of Flood Risk in the Rio Negro Basin (draft)

Meaures		Main Content
Instruction on land use	Non-structural measures	Hazard map creation Land use regulation in floodplains Conservation of forests etc. (runoff control)
Installation of flood prevention structure	Structural measures	River channel improvement Installation of dams and retention reservoirs Construction of diversion channel
Maintenance and administration	Structural measures	Checking existing structures Repair and modify the flood prevention structure
Flood forecast and warning	Non-structural measures	Improvement of the flood forecast and warning sistem Organization of measures to provide information for the residents Raise awareness among residents
Response to flood	Non-structural measures	Construction of structures for the response to flood Use of structures to prevend flood Issuance of evacuation order Response activities and insallation of shelter

(2) Result of the Study

The following items were confirmed as reference information to study the allocation of responsibilities.

1) Measures to Reduce Risks

a) Land Use Regulation in Floodplains (Conservation of Flood Retention Functions of Wetlands)

- They must be implemented based on the regulation stipulated in the environmental zoning plan in POMCA in order to conserve the wetlands downstream of Rio Negro.
- POMCA has legal force over POT (Territorial Ordinance Plan) or EOT (Territorial Ordinance Scheme), and CAR, which formulates POMCA, can stop the development of residential area etc. for the prevention of floods through the means of land management in POMCA based on environmental determinants.

b) Works on structures for flood prevention (works of the river)

- There is dike construction, dredging and construction of retaining reservoir as options for river works. In Rio Negro there is one dam. However, in Colombia there are no dams with the purpose of regulating floods.
- River works are carried out with the purpose of post-disaster recovery, and works are not carried out to reduce the risk. National subsidies are obtained for post-disaster recovery; however, it is difficult to obtain financing for works to reduce risk. The budget of the river works comes from the funds of the municipalities or the nation.

- It is difficult to identify who implements the river works for post-disaster recovery since it varies from case to case.

c) Response to Flood

There are three stages in response to the flood, depending on the magnitude of the event.

Stage-1: Response by municipalities

The municipalities declare the public calamity and study the emergency measures and the recovery and reconstruction plan. As the municipalities generally ask for the support of the Department within a few hours after the declaration of public calamity, this stage ends in a short time. The municipalities have little human resources that have the technical ability to respond to the disaster, and the response capacity is low.

Stage-2: Response by Departments

The Department responds to the flood after receiving the municipality's request. In this stage, the department also requires the permission of the municipality in case the Department wants to implement works. (However, the decision on the response to the flood is made by the Department, and the Department is designated as the entity in charge of the response to flood. In this regard, the municipality remains in the attention of the event even if the Department decide to respond to the event). In the event of a major disaster that exceeds the Department's response capacity, the Department requests the support of the nation.

Stage-3: Response by the central government

The central government receives the request of the Department and becomes responsible for the response to flood. This happens in a major disaster such as the sediment disaster in Mocoa, in April 2017. At this stage (when the request for support reaches the central government) the response methodology is defined by the UNGRD. In the recovery phase, the Government supports the elaboration of the action plan specific to the municipality or the Department. In this plan the implementers of the works to be carried out are defined; these are assigned according to the corresponding sector. In the case of Mocoa, the President of the Republic defined a Manager for Reconstruction, and it was the Minister of Defense in this case, which in some way was identified as unclear given that there is UNGRD (the coordinator of DRG in Colombia), and this can create coordination problems. For the entities, there are still coordination problems in the recovery stage. Especially in the normative and competency issues in terms of jurisdictions, each entity carries out what it considers appropriate.

In the floods caused by La Niña in 2010-2011, this system was implemented (responses are required in several sectors such as wastewater and hydroelectric generation, and it is difficult to create a response with only one sector. Therefore this system was implemented). In this case, en entity called Humanitarian Colombia was created; for the response and for the recovery, the Adaptation Fund was created and given the budget as well as the technical capacity.

2.3 Workshop on 25 of October, 2017

(1) Contents of Study

In this workshop, the flood risk management process presented below was confirmed and the allocation of responsibilities related to the items below was studied. Workshop participants shared a common understanding about these items.

- Identify problems in flood risk management through understanding the characteristics of the river in the Magdalena River and Rio Negro basins
- Formulation and implementation of concrete measures for the reduction of flood risk in the Rio Negro basin.

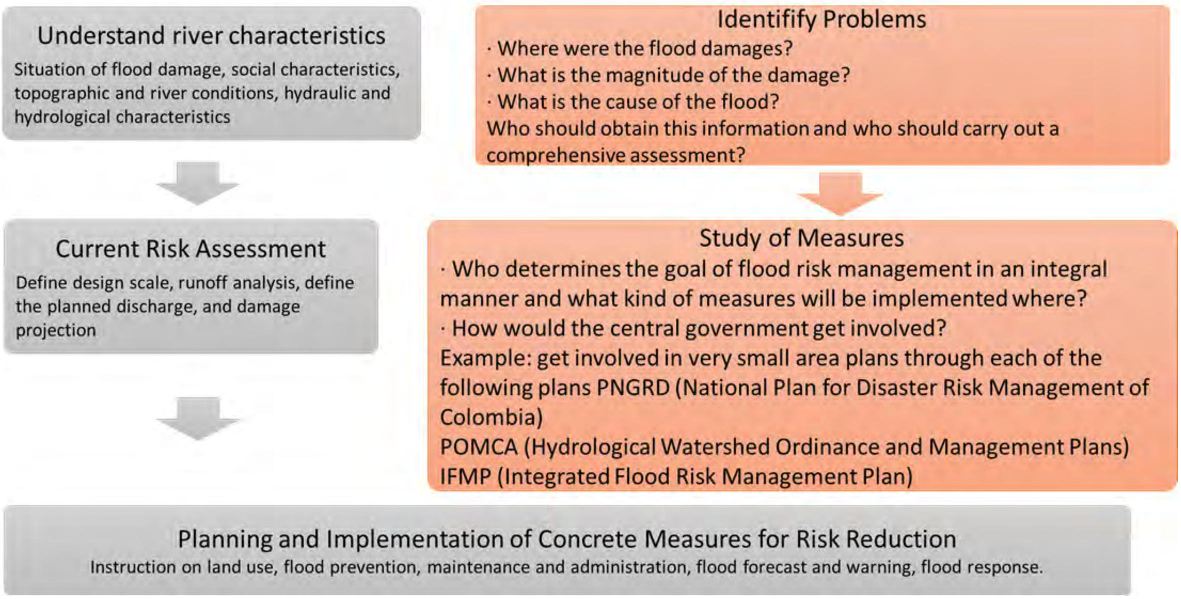


Figure 2.3.1 Process of Flood Risk Management

(2) Result of the Study

1) Allocation of Responsibilities for the Study of Measures for Flood Risk Reduction

a) Study of the Measures for the Reduction of Flood Risk in the Magdalena River Basin.

The allocation of responsibilities related to the measures for the flood risk reduction in the Magdalena River basin was studied, and the draft presented below was elaborated.

Table 2.3.1 Allocation of Responsibilities Related to Measures to Reduce Flood Risk in the Magdalena River Basin (draft)

Items to implement			Responsible Entity							Note
			UNGRD	CORMAG DALENA	IDEAM	Departments	CAR	MADS	Municipality	
Recognition of problems	Understand flood damage situations	Where did the flood occur?	3		1-3 o 3'	2	2'		1	*1
		The magnitude of the damage?	3			2	2'		1	*1
		The cause of the flood?			3		△			*1 *2
	Comprehensive assessment and organization of problems (current situation)						△			*3
	Comprehensive assessment and organization of problems (ideal)		3			2			1	
Study measures	Determine the goal of flood risk management (current situation)				○'			○		
	Determine the goal of flood risk management (ideal)		○	○'	○'			○'		
Study measures	Where will these measures be implemented? (current situation)		Consejo Ambiental Regionales							
	Where will these measures be implemented? (ideal)		○	○'	○'			○'		

* 1 The responsible entity depends on the magnitude of the flood. In the table, the number indicates the magnitude (1: small, 2: medium: 3: large)
* 2 No one conducts study on the cause of flooding for small floods
* 3 There are no rules, however if it is to be implemented, CAR will be the responsible entity. In the sediment disaster of Mocoa, SGC and all the
The black letter is the current situation and the red letter is ideal in the future

b) Study of Measures to Reduce Flood Risk in the Rio Negro Basin

The allocation of responsibilities related to the measures for the flood risk reduction in the Rio Negro basin was studied, and the draft presented below was elaborated.

Table 2.3.2 Allocation of responsibilities Related to Measures for Flood Risk Reduction in the Rio Negro Basin (draft)

Items to implement			Responsible Entity							Note
			UNGRD	CORMAG DALENA	IDEAM	CUNDINA	CAR	MADS	Municipality	
Recognition of problems	Understand flood damage situations	Where did the flood occur?	3		1-3 o 3'	2	2'		1	*1
		The magnitude of the	3			2	2'		1	*1
		The cause of the flood?			3		1 y 2			*1
	Comprehensive assessment and organization of						△			
	Comprehensive assessment and organization of		3			2	2'		1	*1
Study measures	Determine the goal of flood risk management (current situation)						○'		○	
	Determine the goal of flood risk management (ideal)		○'		○'		○	○'		
Study measures	Where will these measures be implemented? (current situation)						○'		○	
	Where will these measures be implemented? (ideal)		○'		○'		○	○'		

* 1 The responsible entity depends on the magnitude of the flood. In the table, the number indicates the magnitude (1: small, 2: medium: 3: large)
The black letter is the current situation and the red letter is ideal in the future

2) Allocation of Responsibilities for the Implementation of Measures for Flood Risk Reduction in the Rio Negro Basin

The allocation of responsibilities related to the implementation of measures for flood risk reduction in the Rio Negro basin was studied, and the draft presented below was elaborated.

Table 2.3.3 Allocation of Responsibilities Related to the Implementation of Measures to Reduce the Risk of Flooding in the Rio Negro Basin (draft)

Items to implement				Responsible Entity						
				UNGRD	CORMAG DALENA	IDEAM	CUNDINA MARCA	CAR	MADS	Municipality
Structural Measures	Planning of flood prevention structures	Flood wall, bank protection, etc	Study and design			○'		○		
			Works				○			○
			Maintenance and administration				○			○
	Sediment control	Dredging in the confluence with the tributary Works for sediment retention dams (sabo)	Study and design			○'		○		
			Works (dredging etc.)				○			○
			Maintenance and administration				○			○
			Monitoring				○	○		○
Non-Structural Measures	Land Use Regulation	Creation of hazard map	Collect information and identify flood areas			○		○		○
			Runoff and flood analysis			○'		○		
			Creation and distribution of hazard map					○		○
		Land use regulation in floodplains (conservation of wetlands)	Policy and guideline						○	
			Study and planning			○		○		○
			Regulation					○		○
			Monitoring					○		
	Flood Forecast and Warning	Improvement of the flood forecast and warning system	Observation of precipitation and water level			○		○		
			Water level forecast			○		○		
			Organization of the system (communication of information)	○		○	○	○		○
		Raise awareness among residents	Preparation of brochures and carrying out orientations				○			○
	Response to Flood	Improvement of the flood response system		○			○			○
		Improvement of the issuance of the evacuation order		○			○			○
		Improvement of flood response activities and establishment of shelter		○			○			○

◎ Principal entity ○ Supporting entity

2.4 Workshop on 14 of February, 2018

(1) Contents of Study

In this workshop, following flood risk management process was confirmed. After understanding flood damage situations and studying measures against flood, IFMP-SZ (More concrete version) for Rio Negro Basin should be formulated and flood risk reduction measures should be implemented based on this IFMP-SZ. Base on this understanding, the allocation of responsibilities related to the recognition of problems and study of measures against flood was studied. These items were already studied in the workshop held on 25 of October, 2017. Therefore, in this workshop, more details were discussed assuming concrete implementation items based on the result of previous study.

(2) Result of the Study

Based on the study in this workshop, the allocation of responsibilities was determined as following table. The result of workshop held on 25 of October, 2017 was revised considering following items;

- In principle, understanding flood damage situations (flood damage sites and damage level etc.) is responsible to municipalities although it may receive support from the Department or UNGRD.

- It is ideal that CAR is responsible for the comprehensive assessment and organization of problems because for this responsibility the perspective of balancing whole river basin is required and CAR will be responsible for the study of measures against floods.

- IDEAM should contribute to the recognition of problems and studying measures by providing meteorological and hydrological information.

Table 2.4.1 Allocation of Responsibilities Related to Measures for Flood Risk Reduction in the Rio Negro Basin (draft)

Items to implement			Central Governmanet			Regional Government		
			UNGRD	MADS	IDEAM	CUNDINAMARCA (Departamento)	CAR	Municipio
Recognition of problems	Understand flood damage situations	Where did the flood occur? The magnitude of the damage (response just after disaster)	Support during large scale flood		Information providing	Support during mid scale flood		○
		The magnitude of the damage?						
		The cause of the flood?			○		○	○
	Comprehensive assessment and organization of problem (current situation)						△	
	Comprehensive assessment and organization of problem (ideal)		Support			Support	○	Support
Study measures	Determine the goal of flood risk management (current situation)						Support	○
	Determine the goal of flood risk management (ideal)			○	Information providing		○	○
	Where will these measures be implemented? (current situation)						Support	○
	Where will these measures be implemented? (ideal)			○	Information providing		○	○

○ : Principle entity

2.5 Workshop on 23 of February, 2018

(1) Contents of Study

In this workshop, the allocation of responsibilities for the recognition of problems, study of measures against flood and implementation of measures was studied. Regarding the recognition of problems and study of measures, allocation of responsibility was already studied in the workshop held on 25 of October, 2017. Therefore, in this workshop, more details were discussed assuming concrete implementation items based on the result of previous study.

(2) Result of the Study

Based on the study in this workshop, the allocation of responsibilities was determined as following table. The result of workshop held on 25 of October, 2017 was revised considering following items;

- In principle, understanding flood damage situations (flood damage sites and damage level etc.) is responsible to municipalities although it may receive support from the Department or UNGRD.

- Since the jurisdictions of multiple CARs are included in Magdalena river system, it is necessary to evaluate the intent of each CAR comprehensively. Therefore MADS and CORMAGDALENA are the candidate of responsible organization for the comprehensive assessment and organization of problems. However to make CORMAGDALENA responsible for this role, it is necessary to amend current law. Therefore MADS is qualified for the responsible organization regarding this role.

- In the current situation, planning etc. of Magdalena river system is studied in CARMAC (River basin committee) that is consisted with MADS, IDEAM, CAR, related government offices and Department. Therefore the allocation of responsibilities for the comprehensive assessment and organization of problems and studying of measures should be studied considering this situation.

The allocation of responsibilities for the implementation of measures was studied in this workshop for the first time and determined as shown in the following table.

Table 2.5.1 Allocation of Responsibilities Related to Measures for Flood Risk Reduction in the Magdalena River Basin (draft)

Items to implement				Central Governmanet				Regional Government			
				UNGRD	CARMAC	MADS	IDEAM	COR MAGDALENA	Departamento	CAR	Municipio
Recognition of problems	Understand flood damage situations	Where did the flood occur? The magnitude of the damage (response just after disaster)	current situation	Support during large scale flood			information providing		Support during mid scale flood		○
			ideal	Support during large scale flood			information providing		Support during mid scale flood		○
		The cause of the flood?	current situation				Implement against large scale flood			Implement agaisnt middle scale flood	△
			ideal				○	Support	Support	Support	Support
	Comprehensive assessment and organization of problems		current situation							△	
			ideal	○	○	○	Support (only for hazard)	Support	Support	Support	Support
Study measures	Determine the goal of flood risk management - Determine target area and design scale		current situation				information providing		○		○
			ideal	○	Support	Support	○	Support			
	Where will these measures be implemented? - Determine design flood discharge and inundation area - Study of cost benefit ratio		current situation				information providing		○		○
			ideal	○	Support	Support	○	Support			
Impliment structural measure (Levee development)		Study and design	ideal	○			information providing	Support	Support	Support	Support
		Works	ideal	Support			information providing	Support	Support	○	Support
		Maintenancee and administration / Monitoring	ideal	Support			information providing	Support	○	○	○
Implement non-structural measure (Land use regulation in floodplains)		Policy and guideline	ideal			○					
		Study and planning / Regulation / Monitoring	ideal							○ Land use management	

○: Principal entity

2.6 Workshop on 1 of March, 2018

(1) Contents of Study

In this workshop, the allocation of responsibilities for the implementation of measures in Rio Negro Basin was studied. Regarding this issue, allocation of responsibility was already studied in the workshop held on 25 of October, 2017. Therefore, in this workshop, more details were discussed assuming concrete implementation items based on the result of previous study.

(2) Result of the Study

Based on the study in this workshop, the allocation of responsibilities was determined as following table. The result of workshop held on 25 of October, 2017 was revised considering following items;

- CAR and the Department should be responsible for the study, design and construction work. And IDEAM should support principle entities by providing meteorological and hydrological information.

- Regarding sediment dredging in the river, following items should be considered;

    - In the current situation, in Cundinamarca Department, ICCU (Institute de Infrastructura y Concesiones Cundinamarca) that is a public sector belong to the Department manages equipment that is required during flooding period.

    - ICCU and CAR implement sediment dredging in the river cooperating with each other.

    - UNGRD supports the Department by providing equipment.

Table 2.6.1 Allocation of Responsibilities Related to Measures for Flood Risk Reduction in the Rio Negro Basin (draft)

Items to implement				Central Governmanet			Regional Government		
				UNGRD	MADS	IDEAM	CUNDINAMARCA (Departamento)	CAR	Municipio
Implement structural measures	Planning of flood prevention structure	Flood wall / Bank protection etc	Study and design			Information providing		○	
			Works			Information providing	○	○	Support
			Maintenance and administration / Monitoring			Information providing	○	○	○
	Sediment control	Sediment retention dams (SABO dams)	Study and design			Information providing		○	
			Works			Information providing	○	○	Support
			Maintenance and administration / Monitoring			Information providing	○	○	○
		Dredging in the confluence with the tributary	Study			Information providing		○	
			Works (dredging etc)	Support			○	○	Support
			Maintenance and administration / Monitoring				○	○	○
Implement non-structural measure	Land use regulation	Disaster Rrisk Reduction Map (DRR Map)	Collect information and identify flood areas			○		○	○
			Runoff and flood analysis			Support		○	
			Creation and distribution of DRR Map			○		○	○
		Land use regulation in floodplains (Conservation of wetland)	Policy and guideline		○				
			Study and planning			Information providing		○	○
			Regulation / Monitoring					○	○
	Flood forecast and warning	Improvement of the flood forecast and warning system	Observation oof precipitation and water level			○	○	○	
			Water level forecast			○	○	○	
			Organization of the system (communication of information)	○		○	○	○	○
		Raise awareness among residents	Preparation of brochures and carrying out orientations				○		○
	Response to flood	Improvement of the flood response system		○			○		○
		Improvement of the issuance of evacuation order					○		○
		Improvement of flood response activities and establishment of shelter		○			○		○

○ : Principle entity

3. Allocation of Responsibility for Planning of IFMP-SZ

3.1 Allocation of Responsibilities for the Study of Measures for Flood Risk Reduction in the Magdalena River Basin

3.1.1 Study of Measures for Flood Risk Reduction

(1) Identification of Problems

1) Understanding the Situation of Flood Damage

For the understanding of the flood damage situation, the responsibilities will be allocated to the municipalities in principle although municipalities will be supported by the Departments or UNGRD according to the magnitude of the flood. The municipalities are responsible for small floods without support. For the medium magnitude floods that exceed the response capacity of the municipalities, the Departments support municipalities. And for the great magnitude that exceeds the response capacity of the Departments, UNGRD support the Departments and municipalities. IDEAM, an entity that carries out meteorological and hydrological observation and hydrological modeling, will support entities that are responsible for understanding the flood damage situations parcticularly in major rivers, providing observation data, thematic cartography, available studies, etc.

2) Study of the Cause of Flood

IDEAM and CAR will collaborate to carry out the study of the flood cause, with the result of understanding the flood damage situation. Currently, this type of study is not carried out for small floods; however, in the future the cause of all floods should be studied. The definition of the flood in the target river will be studied. It will be defined later based on the level, flow, precipitation and other indicators.

3) Integral Evaluation and Identification of Issues

The responsibility to understanding the flood damage situation, study the cause of flood, and identify the challenges with technical knowledge will be for UNGRD and MADS. Because it is necessary to evaluate the intent of each CAR comprehensively, since the jurisdictions of multiple CARs are included in Magdalena river system And in the current situation, planning etc. of Magdalena river system is studied in CARMAC (River basin committee) that is consisted with MADS, IDEAM, CAR, related government offices and Department. Therefore considering above situation, CARMAC will also be responsible for this role.

(2) Study of Measures

The responsibility to define the goal of flood risk management with technical knowledge and to study the concrete measures for flood risk reduction will be mainly for UNGRD and IDEAM. In the current situation, UNGRD has no power on the flood risk management. However UNGRD will be made responsible for this entity based on the concept that the power of UNGRD related to the flood risk management should be enhanced. MADS and CORMAGDALENA will support UNGRD and IDEAM base on the current situation that MADS formulates the “Strategic Plan for the Macrobasin” and CORMAGDALENA formulates the “Master Plan of Exploitation”. As it is necessary to define the goal of flood risk management and study the measures for flood risk reduction taking into account the social, economic, meteorological, hydrological and environmental conditions in the basin, these 4 entities will collaborate in the process.

3.1.2 Implementation of Measures for Flood Risk Reduction

As the measures for flood risk reduction in the Magdalena river system, two methods can be assumed. One is levee development as structural measure and the other is land use regulation in floodplains. The allocation of responsibilities is shown below.

(1) Structural Measure (Levee Development)

UNGRD will be responsible for the study and design of this measure considering the convenience of securing budget. CAR will be responsible for construction works because sometimes it is difficult to secure budget for the Departments or municipalities. The Departments, CAR and municipalities are responsible for the maintenance and administration and monitoring. IDEAM should provide information in all phases of study, design, maintenance and administration and monitoring. And in all phases, UNGRD, IDEAM, CORMAGDALENA, CAR and municipalities should cooperate with each other although if they are not mainly responsible for each role.

(2) Non-structural Measure (Land Use Regulation in Floodplains)

Regarding policy decision and preparing guideline, MADS will be responsible because MADS has been in charge of formulating “Basin Management Strategy”. Regarding study, planning, regulation and monitoring, multiple CARs will be responsible in each jurisdiction because it is practical to divide large scale river system into some sections.

3.1.3 The Table of Responsibilities Allocation related to the Flood Risk Reduction

The result of study for the allocation of responsibilities related to the flood risk reduction in the Magdalena river system is shown in the following table.

Table 3.1.1 Allocation of Responsibilities Related to Measures for Flood Risk Reduction in the Magdalena River System

Items to implement				Central Governmanet				Regional Government			
				UNGRD	CARMAC	MADS	IDEAM	COR MAGDALENA	Departamento	CAR	Municipio
Recognition of problems	Understand flood damage situations	Where did the flood occur? The magnitude of the damage (response just after disaster)	current situation	Support during large scale flood			information providing		Support during mid scale flood		○
			ideal	Support during large scale flood			information providing		Support during mid scale flood		○
		The cause of the flood?	current situation				Implement against large scale flood			Implement agaisnt middle scale flood	△
			ideal				○	Support	Support	Support	Support
	Comprehensive assessment and organization of problems		current situation							△	
			ideal	○	○	○	Support (only for hazard)	Support	Support	Support	Support
Study measures	Determine the goal of flood risk management - Determine target area and design scale		current situation				information providing		○		○
			ideal	○	Support	Support	○	Support			
	Where will these measures be implemented? - Determine design flood discharge and inundation area - Study of cost benefit ratio		current situation				information providing		○		○
			ideal	○	Support	Support	○	Support			
Impliment structural measure (Levee development)	Study and design		ideal	○			information providing	Support	Support	Support	Support
	Works		ideal	Support			information providing	Support	Support	○	Support
	Maintenancee and administration / Monitoring		ideal	Support			information providing	Support	○	○	○
Implement non-structural measure (Land use regulation in floodplains)	Policy and guideline		ideal			○					
	Study and planning / Regulation / Monitoring		ideal							○ Land use management	

○ : Principal entity

3.2 Allocation of Responsibilities Related to the Reduction of Flood Risk in the Rio Negro Basin

3.2.1 Study of Measures for Flood Risk Reduction

(1) Identification of Problems

1) Understanding the Situation of Flood Damage

(Same as Rio Magdalena): For the understanding of the flood damage situation, the responsibilities will be allocated to the municipalities in principle although municipalities will be supported by the Departments or UNGRD according to the magnitude of the flood. The municipalities are responsible for small floods without support. For the medium magnitude floods that exceed the response capacity of the municipalities, the Departments support municipalities. And for the great magnitude that exceeds the response capacity of the Departments, UNGRD support the Departments and municipalities. IDEAM, an entity that performs meteorological and hydrological observation, supports the all entities in floods of all magnitudes, providing observation data, etc.

2) Study of the Cause of Flood

IDEAM, CAR and municipalities will collaborate to carry out the study of the flood cause, with the result of understanding the flood damage situation. Currently, this type of study is not carried out for small floods; however, in the future the cause of all floods should be studied. The definition of the flood in the target river will be studied. It will be defined later based on the level, flow, precipitation and other indicators.

3) Integral Evaluation and Identification of Issues

The responsibility to understand the situation of flood damage, to study the cause of flooding, and to identify the issues with technical knowledge will be for CAR considering that the perspective of balancing whole river basin is required for this responsibility and CAR will be responsible for the study of measures against floods. Municipalities who face with disaster directly will support CAR as well as UNGRD and the Departments who will be responsible for the implementation of measures.

(2) Study of Measures

1) Definition of the Goal of Flood Risk Management

The responsibility to define the goal of flood risk management with technical knowledge and study the concrete measures for flood risk reduction will be for MADS, CAR and municipalities. IDEAM will provide necessary information such as meteorological and hydrological observation data. As it is necessary to define the goal of flood risk management and study the measures for flood risk reduction taking into account the social, economic, meteorological, hydrological and environmental conditions in the basin, these 4 entities will collaborate in the process.

2) Study of Concrete Measures for Flood Risk Reduction

The responsibility to study the concrete measures for flood risk reduction taking into account the goal of risk management in the Rio Negro basin will be for MADS, CAR and municipalities. IDEAM will provide necessary information such as meteorological and hydrological observation data. As it is necessary to coordinate with the flood risk management and study the measures for the reduction of flood risk taking into account the social, economic, meteorological, hydrological and environmental conditions in the basin, these 4 entities will collaborate in the process.

3.2.2 Implementation of Measures for Flood Risk Reduction

(1) Structural Measures

In the Rio Negro basin, possible measures include the installation of the floodwall at the points with flood hazard, installation of bank protection to conserve the bases of the bridges, dredging at the point of confluence, and installation of SABO dams. CAR will assume the study and design of the measures as it has experience in the installation of bank protection and dredging, and has the highest technical capacity at present. As it is necessary to use meteorological and hydrological observation data for the study and design, IDEAM must support CAR. Apart from CAR, which is responsible for the study and design, the Department of Cundinamarca and the municipalities located near the implementation points of the works will be responsible for the work, maintenance and administration. Regarding sediment dredging in the river, the support of UNGRD will be added considering following items;

- In the current situation, in Cundinamarca Department, ICCU (Institute de Infrastructura y Concesiones Cundinamarca) that is a public sector belong to the Department manages equipment that is required during flooding period.
- ICCU and CAR implement sediment dredging in the river cooperating with each other.
- UNGRD supports the Department by providing equipment.

(2) Land Use Regulation

1) Preparation of Disaster Risk Reduction map (DRR Maps)

The preparation of the disaster risk reduction map for the area where villages exist scattered along Rio Negro, such as Puerto Libre, Colorados, Córdoba, El Dindal, Guaduero, and Utica can be considered. IDEAM and CAR will be responsible for this measure. IDEAM will be in charge of providing data required for the collection, and organization of observation data of the level and analysis of runoff and flooding in the objective areas. CAR is in charge of using the IDEAM data to carry out the runoff and flood analysis and develop hazard maps. The municipalities will provide data from the flood area to CAR and will be responsible for preparing the DDR maps together with the residents.

2) Regulation of Land Use in Floodplains (conservation of wetlands)

In the Rio Negro basin, it is thought that the wetlands located upstream of Puerto Libre, in the lowest section of Rio Negro, control the increase in level in Puerto Libre. A measure to regulate development in these areas to conserve this water retention capacity can be considered. CAR, MADS and the municipalities will be responsible for this measure. MADS is responsible for formulating the basic policy on the conservation of water retention capacity of wetlands throughout the Colombian territory and developing guidelines for this effect. CAR, which formulates POMCA, an upper level plan of IFMP-SZ, should be involved in the conservation of wetlands through IFMP-SZ based on POMCA. In addition, what is stipulated in POMCA has legal force over the municipalities; therefore, it is necessary for CAR to also be in charge of the study, planning, regulation and monitoring. IDEAM will provide meteorological and hydrological information and evaluate the effectiveness of wetland conservation through study and planning. Municipalities, which are directly responsible for development regulation, should be responsible for the study, planning and regulation.

(3) Flood Forecast and Warning

It is necessary to improve the existing flood forecast and warning system for flood risk reduction. In Colombia, there is already a practice of flood forecasting and warning. The basic information for the forecast and alert are the meteorological and hydrological data from IDEAM. CAR also has its own stations and collects and provides observation data. In recent years, Department of Cundinamarca has been engaging actively in flood forecast and warning as part of disaster risk management. Taking into account this current situation, IDEAM, Department of Cundinamarca and CAR will be responsible for the observation of data and forecast of precipitation and water level. Currently, UNGRD and IDEAM are the entities that officially issue flood forecast and alert, and there are municipalities that issue forecast and alert using their own observation data. Bearing in mind that municipalities, Departments and UNGRD are responsible for flood response according to the magnitude of the flood, and that CAR provides the results of meteorological and hydrological observation, the management of the system (methods of communication) will be the responsibility of UNGRD, IDEAM, the Department of Cundinamarca, CAR and the municipalities. For raising awareness regarding flood response among residents, the Department and municipalities are responsible for the preparation of brochures and carrying out orientations.

(4) Improvement of the Flood Response

It is necessary to improve the response to the flood for flood risk reduction in the Rio Negro basin. Currently, the municipalities are responsible for the response to small floods by themselves, the Departments supports municipalities for the response to medium floods that exceed the response capacity of the municipalities, and UNGRD supports municipalities for the response to large floods that exceed the response capacity of the Department. Therefore, these 3 entities should be mainly responsible for the study regarding improvement of the flood response. It is necessary to create a system of collaboration of each entity taking into account the experience in the response to past floods.

3.2.3 The Table of Responsibilities Allocation related to the Flood Risk Reduction

The result of study for the allocation of responsibilities related to the flood risk reduction in the Rio Negro Basin is shown in the following table.

Table 3.2.1 Allocation of Responsibilities Related to Measures for Flood Risk Reduction in the Rio Negro Basin

Items to implement				Central Governmanet			Regional Government		
				UNGRD	MADS	IDEAM	CUNDINAMARCA (Departamento)	CAR	Municipio
Recognition of problems	Understand flood damage situations	Where did the flood occur? The magnitude of the damage (response just after disaster)		Support during large scale flood		Information providing	Support during mid scale flood		○
Recognition of problems	Understand flood damage situations	The magnitude of the damage?		Support during large scale flood		Information providing	Support during mid scale flood		○
Recognition of problems	Understand flood damage situations	The cause of the flood?				○		○	○
Recognition of problems	Comprehensive assessment and organization of problem (current situation)							△	
Recognition of problems	Comprehensive assessment and organization of problem (ideal)			Support			Support	○	Support
Study measures	Determine the goal of flood risk management (current situation)							Support	○
Study measures	Determine the goal of flood risk management (ideal)				○	Information providing		○	○
Study measures	Where will these measures be implemented? (current situation)							Support	○
Study measures	Where will these measures be implemented? (ideal)				○	Information providing		○	○
Implement structural measures	Planning of flood prevention structure	Flood wall / Bank protection etc	Study and design			Information providing		○	
Implement structural measures	Planning of flood prevention structure	Flood wall / Bank protection etc	Works			Information providing	○	○	Support
Implement structural measures	Planning of flood prevention structure	Flood wall / Bank protection etc	Maintenance and administration / Monitoring			Information providing	○	○	○
Implement structural measures	Sediment control	Sediment retention dams (SABO dams)	Study and design			Information providing		○	
Implement structural measures	Sediment control	Sediment retention dams (SABO dams)	Works			Information providing	○	○	Support
Implement structural measures	Sediment control	Sediment retention dams (SABO dams)	Maintenance and administration / Monitoring			Information providing	○	○	○
Implement structural measures	Sediment control	Dredging in the confluence with the tributary	Study			Information providing		○	
Implement structural measures	Sediment control	Dredging in the confluence with the tributary	Works (dredging etc)	Support			○	○	Support
Implement structural measures	Sediment control	Dredging in the confluence with the tributary	Maintenance and administration / Monitoring				○	○	○
Implement non-structural measure	Land use regulation	Disaster Risk Reduction Map (DRR Map)	Collect information and identify flood areas			○		○	○
Implement non-structural measure	Land use regulation	Disaster Risk Reduction Map (DRR Map)	Runoff and flood analysis			Support		○	
Implement non-structural measure	Land use regulation	Disaster Risk Reduction Map (DRR Map)	Creation and distribution of DRR Map			○		○	○
Implement non-structural measure	Land use regulation	Land use regulation in floodplains (Conservation of wetland)	Policy and guideline		○				
Implement non-structural measure	Land use regulation	Land use regulation in floodplains (Conservation of wetland)	Study and planning			Information providing		○	○
Implement non-structural measure	Land use regulation	Land use regulation in floodplains (Conservation of wetland)	Regulation / Monitoring					○	○
Implement non-structural measure	Flood forecast and warning	Improvement of the flood forecast and warning system	Observation oof precipitation and water level			○	○	○	
Implement non-structural measure	Flood forecast and warning	Improvement of the flood forecast and warning system	Water level forecast			○	○	○	
Implement non-structural measure	Flood forecast and warning	Improvement of the flood forecast and warning system	Organization of the system (communication of information)	○		○	○	○	○
Implement non-structural measure	Flood forecast and warning	Raise awareness among residents	Preparation of brochures and carrying out orientations				○		○
Implement non-structural measure	Response to flood	Improvement of the flood response system		○			○		○
Implement non-structural measure	Response to flood	Improvement of the issuance of evacuation order					○		○
Implement non-structural measure	Response to flood	Improvement of flood response activities and establishment of shelter		○			○		○

○ : Principle entity

E. Revison and Update of IFMP-SZ

1. Development to Current Situation and Issues

As described in Chapter 2.1 of Part 0, this IFMP-SZ is a provisional plan and needs to develop it as a more concrete plan. In this Project, discussions of future necessary activities to develop this provisional plan to the more concrete plan and preparation of a road map of those necessary activities have been carried out as one of activities of the Project. Table 1.1 is the road map for the formulation of a more concrete version of IFMP-SZ in Rio Negro basin, which were prepared in the Project and agreed among C/Ps and other participated organizations.

It is necessary that Colombian relevant agencies will carry out activities to develop this provisional IFMP-SZ to the more concrete IFMP-SZ along the Road Map from now.

2. Revison and Update of IFMP-SZ

Since a IFMP-SZ deals with natural phenomena, there are limits to the conditions that can be grasped at the planning stage. In addition, in the current state of data development in the Rio Negro basin, necessary information is not sufficiently prepared for planning. Also, it has a possibility that quite large-scale flood and/or unexpected phenomena over assumptions in the planning stage happen. Further, structure change of relative organizations also may be performed. In fact, IFMM-SZ is a plan that needs continuous review and update.

This IFMP-SZ in Rio Negro basin is planned to be reviewed and updated in the following timing:

- As a regular review and update, the IFMP-SZ will be reviewed and/or revised once five years confirming and utilizing results of monitoring.
- As an irregular review and update, the IFMP-SZ will be reviewed and/or revised after large-scale discharge or inundation utilizing results of the monitoring and flood survey.
- As an irregular review and update, the IFMP-SZ will be reviewed and/or revised in case that structure change of relative organizations are performed and/or upper level plans are revised.

Table 1.1 Road map for the Formulation of More Concrete Version of IFMP-SZ in Rio Negro Basin

Leading entity : CAR (Cundinamarca)

Supporting entities: UNGRD, IDEAM, Department of Cundinamarca and MADS

No.	Necessary activities	No.	Secondary activities	Explanation / Comments	2018	2019	2020	2021	2022	2023
	<Information>									
1	Collection of accurate disaster information / confirmation on site	1.1	Development of systems that can collect and accumulate accurate disaster information (unified format, preparation of specification to collect various information such as flood mark and flood area, preparation of the manual)	Multi-level studies from the points of view of the national government / local governments, consultants, academics						
		1.2	Start of information collection							
2	Compilation of high precision hydrological information (e.g. peak water level / peak flow during flood)	2.1	Development of a system (human or automatic) that can record accurate hydrological information							
		2.2	Start of information collection							
	<Surveys and studies>									
3	Collection of existing detailed information such as topographic survey results by municipalities	3.1	Confirmation of existing data	Preparation of questionnaire sheet and distribution to relevant organizations including municipalities						
		3.2	Collection of data							
4	Topographic surveys for all rivers (plane / LIDAR, cross-section)									
5	Basic studies to characterize the channels	5.1	Geological survey							
		5.2	Flow measurement							
		5.3	Sediment transport survey							
6	Construction of a more precise hydrological-hydraulic basin model that reflects the results of the topographic surveys									
7	Examination of measures that reflect the results of the hydrological-hydraulic model	7.1	Detailed and concrete study/design of structural measures, calculation of B / C							
		7.2	Detailed and concrete study/design of non-structural measure							
	<Role and Responsibility>									
8	Discussion and documentation of the role sharing involving municipalities									
	<Others>									
9	Feasibility study of IFMP-SZ									

Appendix-9 Road Map for Formulation of IFMP-SZ (principal plan) in Rio Negro Basin

Road map for the formulation of more concrete version of IFMP-SZ in Rio Negro Basin
Leading entity : CAR (Cundinamarca)
Supporting entities: UNGRD, IDEAM, Department of Cundinamarca and MADS

No.	Necessary activities	No.	Secondary activities	Explanation / Comments	2018	2019	2020	2021	2022	2023
	<Information>									
1	Collection of accurate disaster information / confirmation on site	1.1	Development of systems that can collect and accumulate accurate disaster information (unified format, preparation of specification to collect various information such as flood mark and flood area, preparation of the manual)	Multi-level studies from the points of view of the national government / local governments, consultants, academics						
		1.2	Start of information collection							
2	Compilation of high precision hydrological information (e.g. peak water level / peak flow during flood)	2.1	Development of a system (human or automatic) that can record accurate hydrological information							
		2.2	Start of information collection							
	<Surveys and studies>									
3	Collection of existing detailed information such as topographic survey results by municipalities	3.1	Confirmation of existing data	Preparation of questionnaire sheet and distribution to relevant organizations including municipalities						
		3.2	Collection of data							
4	Topographic surveys for all rivers (plane / LIDAR, cross-section)									
5	Basic studies to characterize the channels	5.1	Geological survey							
		5.2	Flow measurement							
		5.3	Sediment transport survey							
6	Construction of a more precise hydrological-hydraulic basin model that reflects the results of the topographic surveys									
7	Examination of measures that reflect the results of the hydrological-hydraulic model	7.1	Detailed and concrete study/design of structural measures, calculation of B / C							
		7.2	Detailed and concrete study/design of non-structural measure							
	<Role and Responsibility>									
8	Discussion and documentation of the role sharing involving municipalities									
	<Others>									
9	Feasibility study of IFMP-SZ									

Appendix-10 Guideline for Formulation of IFMP-RP

Japan International Cooperation Agency (JICA)
National Unit for Disaster Risk Management (UNGRD)
Institute of Hydrology, Meteorology and Environmental Studies (IDEAM)
Autonomous Regional Corporation of Cundinamarca (CAR)
Department of Cundinamarca
Ministry of Environment and Sustainable Development (MADS)

Project for Strengthening Flood Risk Management Capacity in the Republic of Colombia

Guideline for Formulation of IFMP-RP

June 2018

Contents

Preface

For 3 years from July 2015 to June 2018, JICA implemented a technical cooperation project entitled "Project for the Strengthening of Flood Risk Management Capacity in the Republic of Colombia".

The overall goal of the project is “the reduction of flood risk in Colombia” and the project purpose is “to enhance the capacity of Colombian institutions in flood management”. The expected results, for which activities will be carried out, are the following:

<u>Output 1:</u> Capacity on flood risk assessment is improved and concept of integrated flood management planning and river basin management is introduced

<u>Output 2:</u> Capacity on flood forecasting, warning and information dissemination to relevant organizations is improved (mainly IDEAM and UNGRD)

<u>Output 3:</u> Roles and responsibility of the central and local government for flood risk reduction are elucidated and enhanced (mainly UNGRD and IDEAM).

<u>Output 4:</u> Capacity of flood management planning is enhanced through formulation of integrated flood management plan (IFMP) in the pilot river basin

In this project, formulation of IFMP for the pilot basin of Rio Negro was planned (located north of the Department of Cundinamarca with basin area of 4,572km^2) as part of Output 4. However, the Rio Negro is a tributary of the Magdalena River basin, and to formulate IFMP (IFMP for sub-zone (IFMP-SZ)), it was necessary to locate the Rio Negro basin within the basin of the main river, Magdalena River, in order to determine the conditions of the point of confluence with the main river. In the preparatory stage of the project, the formulation of IFMP for the Magdalena River (IFMP for "principal river" (IFMP-RP)) was considered for this purpose. In the project, the content of the existing PMA was studied, prepared by CORMAGDALENA as the equivalent of the master plan for the Magdalena River, and it was decided the additional writings would be studied and elaborated in the project in areas that can be considered insufficient in the plan, and thus IFMP-RP was elaborated for the Magdalena River as a provisional plan, which the part on flood analysis.

Also, through discussions in the project on the items needed for the Magdalena River, the need to formulate a plan in collaboration and in coordination with entities related to execution power was recognized, since the existing PMA was elaborated only by CORMAGDALENA. The need for a specialized plan for the flood sector was recognized as well, in order to create an executable plan.

As a result of the ongoing discussions, the participating entities agreed to create a road map (refer to Table 1.2) that includes the necessary items and target schedule for the formulation of IFMP-RP for the Magdalena River (principal plan).

This guideline was developed as a result of the project activities, and aims to explain the concrete activities and processes for the implementation of activities of this road map and contribute to the formulation of IFMP-RP for other "principal rivers" (the definition is explained later) in Colombia. This guideline is expected to be used along with the guideline for the sub-zones prepared separately and effective IFMP that take into account the balance between the main river (RP) and the tributaries (hydrographic subzones) are expected to be formulated.

Table Definition of Terms

Término	Definición/Expicación
Integrated Flood Risk Management Plan for Principal River (IFMP-RP)	Integrated Flood Risk Management Plan for "principal river"
Integrated Flood Risk Management Plan for Hydrographic Subzone (IFMP-SZ)	Integrated Flood Risk Management Plan for Hydrographic Subzone
"Principal River"	A river that has an outlet to the sea within the national territory, or a river that crosses the border of the national territory, and is made up of several hydrographic subzones. Its basin area exceeds 10,000 km^2 (approximate value in April 2018)
POMCA (Management and Ordination Plan for Basins)	A basin management and ordination plan formulated for subzones. The content was regulated by decree 1640 of 2012.
PMA (Plan Maestro de Aprovechamiento (Master plan of Exploitation)	Master plan formulated by CORMAGDALENA in 2014 for the development of the Magdalena River.
Ronda Hídrica (Water Round)	River or water area defined by the decree in Colombia

1. What is the guideline for the Integrated Flood Risk Management Plan for "Principal River" (IFMP-RP)?

1.1 Definition of the IFMP for "principal rivers" (IFMP-RP)

The IFMP-RP will present the necessary studies, the study methodologies, the effective and feasible measures as future plans, for the "principal rivers" in Colombia in order to learn and manage the effects generated by the floods.

The IFMP-RP is formulated within the framework of the strategic plan of the macrobasins (environmental planning instrument for each macrobasin) of the 5 macrobasins. The formulation of the strategic plan of the 5 macrobasins is the responsibility of the Ministry of Environment and Sustainable Development, and its implementation will be the responsibility of the different entities that make up the regional environmental councils-CARMAC according to their competencies. The 5 macrobasins include the Caribbean, Magdalena-Cauca, Orinoco, Amazon and Pacific macrobasins.

This guideline presents the purpose, the methodology and the processes of elaboration of the IFMP-RP, for the professionals of the MADS and IDEAM, and of the relevant entities at national and regional level that make up the CARMAC (includes CORMAGDALENA in case of the Magdalena River basin), in order to present the purpose, methodology and processes of the formulation of IFMP-RP. CARMAC is an organization established by Article 14 of decree 1640 of 2012[1] adjusted by Decree 50 of 2018 of MADS.

In this guideline, the "principal rivers" are defined. In Colombia, there is a Hydrographic Area (macrobasin), a legally defined term that refers to the 5 macrobasins. However, these macrobasins have different characteristics: the Magdalena River basin concludes within the national territory; the Orinoco and Amazonas basins refer to the group of basins of tributaries of international rivers, and the Caribbean and Pacific basins refer to groups of independent basins. Given this context, in order to avoid confusion, it became necessary to create a new definition of the "principal rivers", regarding the existing framework of the "5 macrobasins".

The "principal river" was defined as the rivers in Colombia that have relatively large basin area, which have the following characteristics:

- A river that has a mouth to the sea in the lowest reach within the national territory or a river that crosses the border of the national territory.
- A river that is comprised of several hydrographic subzones.
- Its basin area exceeds 10,000km^2 (approximate value in April 2018).

In Numeral 2. (2) Definition of the principal river, this definition is explained in detal.

The following is the base rules for the main entities that will elaborate IFMP-RP:

- Determine the leading entity respecting the framework of the strategic plans for the 5 macrobasins defined by law.

[1] Included in Decree 1076 of 2015.

- If several "principal rivers" defined above exist in the 5 macro-basins, the IFMP-RP is prepared for each one.

The "principal river" in this guideline have the characteristics described above.

For the hydrographic subzones, the guideline for the formulation of IFMP-SZ is prepared separately. Both IFMP-RP and IFMP-SZ are formulated so that they do not contradict each other. With the use of both guidelines in the future, a plan is expected to be formulated where there is a balance between the "principal river" (main rivers) and the subzone (tributary).

The "principal rivers" have several key functions such as navigation, hydroelectric generation, agriculture, fishing and the environment, apart from flood protection. Table 1.1 shows several entities that have responsibilities related to the river intervention on a "principal river". In the case of the Magdalena River, several entities work articulately in order to maintain and improve these functions.

Table 1.1 Entities Related to the River Intervention by Sector

	Related Entity	Magdalena River
Navigation	Ministry of Transport	Ministry of Transport/CORMAGDALENA
Hydroelectric Generation	Ministry of Energy and Mines	Ministry of Energy and Mines
Environment	Environmental Authorities	Environmental Authorities
Agriculture	Ministry of Agriculture (Floodplains)	Ministry of Agriculture
Fishing	National Authority of Aquaculture and Fisheries (AUNAP)	Ministry of Agriculture / AUNAP
River Environment	Ministry of Environment and Sustainable Development (MADS)	Ministry of Environment and Sustainable Development (MADS) / Environmental Authorities
Water Level Monitoring	IDEAM	IDEAM / Environmental Authorities

Additionally, the departments in the basin must be related to the intervention of the river. For example, 14 departments exist in the Magdalena River basin.

When formulating the IFMP-RP for "principal rivers", since the institutions related to risk management are several, the adjustment of their interests is difficult. Therefore, it is very important to coordinate between the opinions of the leading entities and the relevant entities in the process from the planning stage.

In the case of the Magdalena River, the road map was prepared for the actions to be taken and the methods to take these actions so that the relevant entities can formulate an IFMP-RP. This result is presented in (Table 1.2).

Table 1.2 Road Map for the Formulation of the IFMP-RP for the Magdalena River

Road Map for the formulation of IFMP-RP for Magdalena River

Leading entity : MADS, CORMAGDALENA and IDEAM

Supporting entities: UNGRD, DNP, CAR (Cundinamarca) and Department of Cundinamarca (and National University)

No.	Necessary Activity	No.	Secondary Activity	Explanation/Comments	2018	2019	2020	2021	2022	2023	Main Responsilble entity(entities)
0	Development of framework among main entities in order to formulate and implement this plan	0		Need to gather all related organizations							
1.1	Review of the existing national regulations and planning tools	1.1.1	Identification of the topics related to the Magdalena River basin in the national development plan								DNP
		1.1.2	Identification of the topics related to the Magdalena River basin in the current regulations								MADS
		1.1.3	Evaluation of the scope of the flood component in planning tools (Macro-Basin Strategic Plan, River Ordination and Integrated Management Plan, Basin Management Plan, Master Plan by CORMAGDALENA, Coastal Environmental Unit Plan (UAC),Municipalities and Departmental Risk Plans, among others)								All
		1.1.4	Revision of existing regulation and formulation of a proposal to correct loopholes and improve institutional coordination	This activity will be carried out based on activities of 1.1.1 to 1.1.3							CORMAGDALENA, MADS, IDEAM
1.2	Review of previous technical studies	1.2.1	Analysis of available information	Gather existing information at various levels from relevant organizations as well as related materials produced by the academy, research centers and institutions							All
		1.2.2	Definition of mechanism for sharing available information	Gathered information will be carefully reviewed and shared among entities to use in next activities							MADS, IDEAM
		1.2.3	Make an inventory of historical extreme hydroclimatic events and historical disaster events								UNGRD, IDEAM
		1.2.4	Create an inventory of information (documents and maps) with their original metadata and wih the possibility of feeding official data bases								MADS
2	Definition of the scope of the IFMP-RP for Magdalena River	2.1	Definition of the objective and expected outcomes of IFMP-RP	To study and clarify what we want to achieve. A possible objective: "Main target is flood, but water related issues such as drought and etc. are also partially included. Upper, middle, lower basin will be investigated separately and in an integrated manner. River flood influenced by marine conditions such as high tide will be also included."							All
3	Analysis of use and impact on the river dynamics from sectors	3.1	Analysis of navigation and transportation								CORMAGDALENA, MADS, IDEAM, DNP
		3.2	Analysis of hydropower generation								CORMAGDALENA, MADS, IDEAM
		3.3	Analysis of the environment and environmental services								CORMAGDALENA, MADS, IDEAM, DNP
		3.4	Analysis of the agriculture sector								CORMAGDALENA, MADS, IDEAM
		3.5	Analysis of other sectors								CORMAGDALENA, MADS, IDEAM, DNP
4	Characterization of the flood in the Magdalena River basin and definition of the flood sector	4.1	General characterization of the flood phenomenon in the main river (and floodplains)	*Organization of flood patterns/mechanisms *Organization of river profile and topographic characteristics *Organization of hydraulic an hydrological characteristics *Organization of geomorphological characteristics and river dynamics *Organization of the inventory of mitigation and regulation structures							IDEAM, CORMAGDALENA
		4.2	General characterization of the tributary basins	*Organization of flood patterns/mechanisms *Organization of river profile and topographic characteristics *Organization of hydraulic an hydrological characteristics *Organization of geomorphological characteristics and river dynamics *Organization of the inventory of mitigation and regulation structures							IDEAM, CORMAGDALENA
		4.3	Identification of benefits and damages from the flood in the main river and tributaries	Consult river-related NGOs, University of Magdalena, University of Atlantico, technical studies for the construction of works by CORMAGDALENA, WWF, AFD							All
		4.4	Definition of "flood risk" for Magdalena River Basin								MADS
		4.5	Identification and characterization of exposed elements	The scale will be defined depending on the prioritization and the scope of the project							UNGRD
		4.6	Analysis and identification of the relationship between flood and each economic sector								MADS and DNP
		4.7	Definition of target area								CORMAGDALENA, MADS, IDEAM, DNP
5	Detailed analysis of flood in identified sections	5.1	Organization of socioeconomic characteristics								MADS and DNP
		5.2	Study of topographic condition	To survey detailed topographic condition including flood plain by LIDAR survey or acquisition of detailed topographic data such as satellite DEM							Leading entity
		5.3	Study of river condition	To carry out topographic survey of longitudinal and cross sectional condition of rivers in key sections							Leading entity
		5.4	Study of hydrological and hydraulic condition	*Study of rainfall condition *Study of water level and discharge *Study of flow regime, etc.							IDEAM (and National University)
		5.5	Study of geomorphology and fluvial dynamics								MADS, IDEAM (and National University)
		5.6	Detailed analysis of past flood phenomena	*Study of time-series variation of basin rainfall *Study of time-series variation of flood area *Study of relationship between observed water levels in stations and flood areas, etc.							IDEAM (and National University)
		5.7	Reproduction and prediction of flood hazard area	*Preparation of model and calculation of flood including flood plain *Preparation of possible inundation area map and hazard map *Setting of the hydrological (floods) area for RONDA							IDEAM (and National University)
6	Land use and disaster risk management for the flood zones	6.1	Definition of "critical flood hazard zone" and identification of critical flood hazard zone in the basin	*To define "critical flood hazard zone" *To identify critical flood hazard zone based on results of "5. Detailed analysis of flood"							All
		6.2	Risk assessment including flood vulnerability analysis inside the flood zone	*Definition of "critical flood risk zone" *Evaluation of risk							All
		6.3	Identification of critical flood risk areas	*Identify critical flood risk areas *Preparation of risk map							All
		6.4	Study of the necessity of response in front of flood risks	*Definition of areas to be protected against floods *Definition of Design Scale							All
		6.5	Study of structural measures	*Study of types and scale of measures (river channel improvement, dikes, dams, reservoirs) *Measures for drought management will be included as part of the activities							All
		6.6	Study of non structural measures	Study of types and scale of measures (organization of early warning system, elaboration and publication of hazard and risk maps, land use regulation, proposal of financial protection measures, etc.)							All UNGRD-SAT & financial protection for early warning only
7	Formulation of the IFMP-RP for the Magdalena River	7.1	Elaboration of IFMP-RP	To summarize results of all the studies To investigate and set ordering of priority of measures To investigate implementation plan							All
		7.2	Clarification of the sharing of responsibilities								All

1.2 The Need and Purpose of the Formulation of the IFMP-RP

In Colombia, floods caused by La Niña have been frequent in recent years. The floods that occurred during 2010-2011 were the most serious, and in 2011 Colombia experienced the longest rainy season since 1974. Of the 32 departments across the country, 28 departments reported damage. There are statistical data that indicate that around 3 million people were left homeless, 570,000 houses were damaged, 813 schools and 15 health service centers were damaged and economic losses exceeded 8.6 billion dollars.

Existing laws and plans related to flood management include the "Strategic Planning Guidelines" of the MADS. And the most concrete content for macro basins is that of the PMA (Master Plan for the Exploitation of the Magdalena River). In the subzones, there is the POMCA, formulation of which is the responsibility of the Regional Autonomous Corporations and Sustainable Development - CAR.

Although existing plans such as PMA contain the flood risk component, specific methods for understanding/analyzing the actual flood conditions and mitigation measures are not mentioned. In the POMCA, the risk component is an important element; however, its effect is not clearly reflected in the "principal rivers" such as the Magdalena River. This is because the flood analysis is not clearly reflected in an integral manner throughout the basin and or its Ronda. The concrete methodology of the flood risk component that must be incorporated in the POMCA is in the initial stage of the application.

The Environmental Authorities in charge of the MADS, who have played an important role in the management of the rivers and the hydrographic basins, focus mainly on the conservation of the water of the river and the environment. In addition, although IDEAM develops hazard maps and evaluates hazards, it does not have jurisdiction over risk assessment.

In other words, it is difficult to take concrete actions because it is not clear who is responsible for flooding in higher-level rivers such as the Magdalena, Cauca, Orinoco, and Amazon rivers, which have different Environmental Authorities, which administer part of the round of the river under its jurisdiction.

The IFMP-RP is formulated in order to help solve the problem described above. The process related to flood risk management is expected to be better articulated as a result of the above.

The objectives of the IFMP-RP are the following:

- Contribute to the reduction of the risk of flood damage, an urgent issue in Colombia.
- Clarify the contents of the flood prevention plan and the river engineering processes.
- Clarify the entity that will lead the formulation of the flood prevention plan, and in turn share information on collaboration and the role sharing with entities related to flood prevention.

IFMP is formulated in 3 stages: "comprehension of river characteristics", "study of basic items in the plan" and "evaluation of measures". The "principal rivers" have different characteristics such as the distribution of rainfall, runoff mechanism, flood mechanism, concentration of population and goods, and situation of flood damage. The first step in the stage "comprehension of the characteristics of the river" is to study and understand these characteristics.

In the "study of basic items" stage, the design flood discharge is defined, the projected level and the projected flood areas are calculated, and the section for which flood protection will be planned is determined.

At the stage of the "evaluation of measures", appropriate options of structural measures such as dams, flood walls and retarding basins and of non-structural measures such as the hazard maps map or flood early warning are selected and comprehensively evaluated. (The concrete content of each process is presented in Chapters 6, 7 and 8).

Characteristics from Rivers

- Social Characteristics
- Topography and River Conditions
- Hydrology and Hydraulics
- Flood Damage

Basic Design of River Planning

- Basic Policy for River Planning
- Target Section
- Target Safety Level and Consequent Discharge
- Flood Control Scheme
- Flood Hazard Area Assessment

Evaluation Integral

- Structure Measures
- Non-structure Measures
- Cost-Benefit Analysis

Figure 1.1 Processes of IFMP Formulation

The objectives of this guideline are the following:

- Improve the knowledge related to the flood and the relevant entities' response capacity through the process of formulating the IFMP-RP.
- It clearly explains the objectives, methods, processes and items that must be taken into account, which are necessary for the formulation of a flood protection plan. The proposed content is designed to complement the strategic plan for each basin and master plans.
- The contents are designed specifically for professionals of the MADS, IDEAM, and other relevant entities in each macro-basin (in the case of the Rio Magdalena basin, CORMAGDALENA) that lead the formulation of the plan as much as possible.
- This guideline is based on the general knowledge acquired so far. On the other hand, each "principal river" has different characteristics, and for the IFMP-RP to reflect these characteristics, it is recommendable to adjust some proposed contents.

1.3 Processes, Items and Contents of the IFMP-RP Formulation Explained in the Guide

Table 1.3 shows the items included in the plan (explained in the guideline)

Table 1.3 Items Included in IFMP-RP (Described in the Guideline)

Chapter	Necessary Activity	Sub Chapter	Secondary Activity
1	What is the guideline for the Integrated Flood Risk Management Plan for "Principal River" (IFMP-RP)?	1.1	Definition of the IFMP for "principal rivers" (IFMP-RP)
		1.2	The Need and Purpose of the Formulation of the IFMP-RP
		1.3	Processes, Items and Contents of the IFMP-RP Formulation Explained in the Guide
2	Development of a Framework among the Main Entities to Formulate and Implement the IFMP-RP	-	—
3	Review of Existing National Regulations, Existing Plans and Existing Studies	3.1	Review of Existing National Regulations and Planning Tools
		3.2	Review of Past Technical Studies
4	Analysis of Use and Other Sectors' Impact on the Dynamics of the Rivers	-	—
5	Defining the Scope of the IFMP-RP	-	—
6	Characterization of the Flood in the Basin and Definition of the Flood Sector	6.1	General Characterization of the Flood Phenomenon in the Main Channel (and Floodplains)
		6.2	General Characterization of Tributary Basins
		6.3	Identification of Benefits and Damages of the Flood in the Main River and Tributaries
		6.4	Definition of "Flood Risk" for the River Basin
		6.5	Identification and Characterization of Exposed Elements
		6.6	Analysis and Identification of the Relationship between Floods and Each Economic Sector
		6.7	Definition of the Target Area
7	Detailed Flood Analysis in Target Area	7.1	Study of Hydrological and Hydraulic Conditions
		7.2	Detailed Analysis of Past Flood Phenomena
		7.3	Recreation and Prediction of the Flood Risk Area
8	Land Use and Disaster Risk Management for Flood Zones	8.1	Definition of "Critical Flood Hazard Zones" and selection of "Critical Flood Hazard Zones" in the Basin
		8.2	Risk Assessment, including Analysis of Flood Vulnerability within the Flood Area
		8.3	Identification of the Critical Flood Risk Zone
		8.4	Study of the Need to Respond to Flood Risk
		8.5	Study of Structural Measures
		8.6	Study of Non-Structural Measures
9	Formulation and Comprehensive Assessment of the IFMP-RP	9.1	Development of the Flood Management Plan (Focused on the Flood Sector)
		9.2	Clarifying the Role Sharing
10	Revision of IFMP-RP	-	—

2. Development of a Framework among the Main Entities to Formulate and Implement the IFMP-RP

The IFMP-RP will be prepared for each "principal river" of Colombia, with the main purpose of defining and designing measures against floods. The target "principal rivers" are determined in an appropriate manner, taking into account the current management system. With respect to the content of the IFMP-RP and the role sharing related to each macrobasin, and a team based on the "Road Map for the Formulation of the IFMP-RP for the Magdalena River" should be created in order to carry out discussions and implement actions.

【Explanation】

(1) Main Entities' Framework

The IFMP-RP will present the elements of necessary studies, the study methodologies, the effective and feasible measures as future plans, for the "principal rivers" in Colombia in order to mitigate the effects of the floods.

The IFMP-RP is for the "principal rivers" in Colombia that have a relatively large basin area. In case there are several rivers within a basin, a separate plan will be formulated for each of these rivers.

The main entities that formulate these plans will be MADS, IDEAM, and the relevant national and local entities that are part of CARMAC, which is planned to be established in each macrobasin.

In rivers where flood damage does not present a serious problem, the relevant entities determine the need for the formulation of IFMP-RP in an appropriate manner.

(2) Definition of the Principal River

A "principal river" is defined as follows: • A river that is comprised of several hydrographic subzones. • A river with basin area greater than 10,000km^2 (approximate value in April 2018).

In Colombia, there is a Hydrographic Area (macro-basin), a legally defined term that refers to the 5 macrobains. Within these 5 macrobasins, there are hydrographi areas and hydrographic subzones which are recognized in administrative terms.

Given this context, in order to avoid confusion, it became necessary to create a new definition of the "principal river", respecting the existing framework of the "5 macrobasins". In addition, there are problems in proposing the formulation of 5 IFMP-RPs for each macrobasin.

These 5 macrobasins possess different characteristics:

- The Orinoco and Amazon basins refer to groups of basins of tributaries of international rivers and do not conclude within the Colombian national territory. For example, the Amazon basin has a basin area of 211,361 km^2, and within it there is a basin of the tributary called "middle basin: Caquetá basin", with the basin area of 99,968km^2.

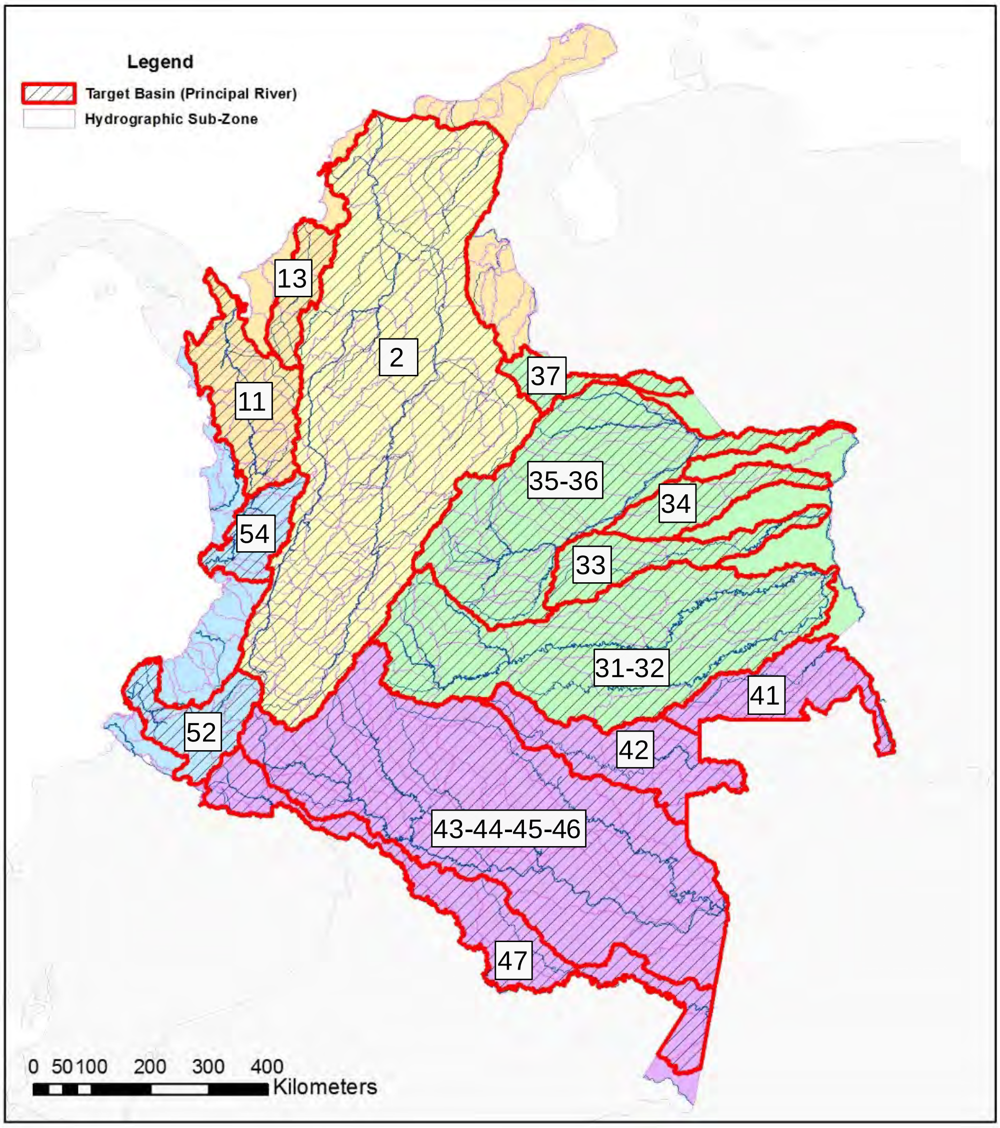
- The Caribbean and Pacific basins refer to groups of independent basins. There are no "principal rivers" called "Pacífico River" or "Caribe River."
- The basin of the Magdalena River is the only basin that concludes within the national territory.

Therefore, from the point of view of flood management, a new definition of the "principal river" was created.

As an initial configuration, it was determined that the basin area of these rivers should be greater than 10,000km^2, taking into account the runoff system.

Figure 2.1 and table 2.1 show the delimitation of basins of the "principal rivers" with the respective names.

Note: The definition of the "Principal River" in this guideline is different from that of the IDEAM ("Principal river is the river which possesses the longest course, from the mouth of its waters to an area, hydrographic zone or lower hierarchy unit to the highest point (head) where surface runoff occurs. ")



Source: elaborated by the JICA Project Team

Figure 2.1 Delimitation of the Basins of "Principal Rivers".

Table 2.1 List of "Principal Rivers"

ID	List of "Principal Rivers"	Macrobasin	ID	"Principal Rivers"	Macrobasin
2	Magdalena Cauca	Magdalena Cauca	41	Guainía	Amazonas
11	Atrato – Darién	Caribe	42	Vaupes	
13	Sinú		43-44-45-46	Apaporis	
31-32	Inírida	Orinoco		Caquetá	
	Guaviare			Yarí	
33	Vichada			Caguán	
34	Tomo		47	Putumayo	
35-36	Meta		52	Patía	Pacífico
	Casanare		54	San Juán	
37	Arauca				

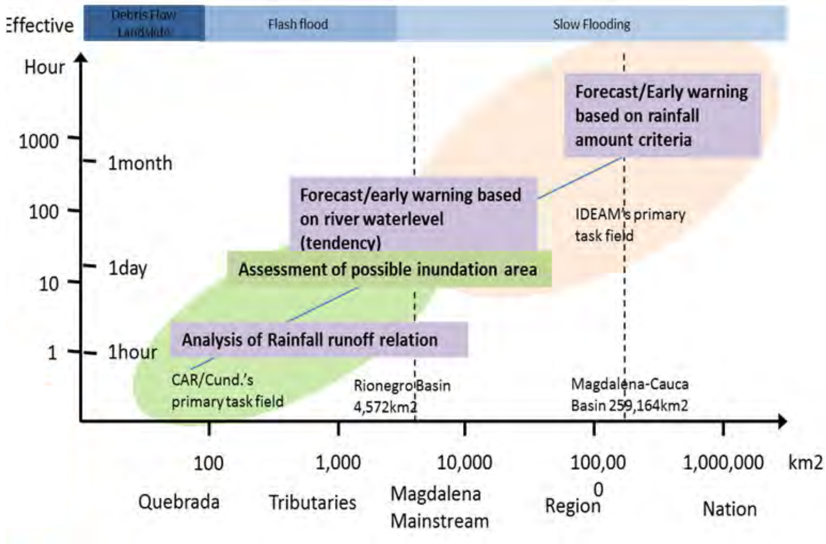
Source: elaborated by the JICA Project Team

Reference:

Figure 2.2 shows the relationship between the basin area and the runoff time after rainfall.

The time between rainfall and flood runoff, the duration of the flood and the relative discharge in the basin downstream of the flood (m^3/s/km) depend on the basin area. It is estimated that the runoff in "principal rivers" in Colombia takes between a few days to a month after the rainfall, for which the basin area of reference for the "principal river" was defined as greater than 1000km^2.

The reference basin area standardized for the "principal rivers" is useful since certain aspects of an IFMP-RP such as the structural measures and the time required for the evacuation can be used as a reference in its formulation in other "principal rivers".



Source: JICA Project Team

Figure 2.2 Relationship between the Basin Area and the Runoff Time

3. Review of Existing National Regulations, Existing Plans and Existing Studies

3.1 Review of Existing National Regulations and Planning Tools

When preparing the IFMP-RP, not only must the necessary contents be established for the measures against the flood, but also the existing legal regulations, related plans and the results of the existing studies must be reviewed and coordinated the same time.

【Explanation】

When preparing the IFMP-RP, review the existing legal regulations at the national level and existing plans. (Policies of macrobasin strategic plans, PMC, the POMCA (Watershed Management and Ordination Plan), master plan, coastal environmental plan, municipal/departmental risk plan, etc.). Current legal framework related to measures against floods must be reviewed

Figure 3.1 shows the relationship between IFMP-RP and existing plans.

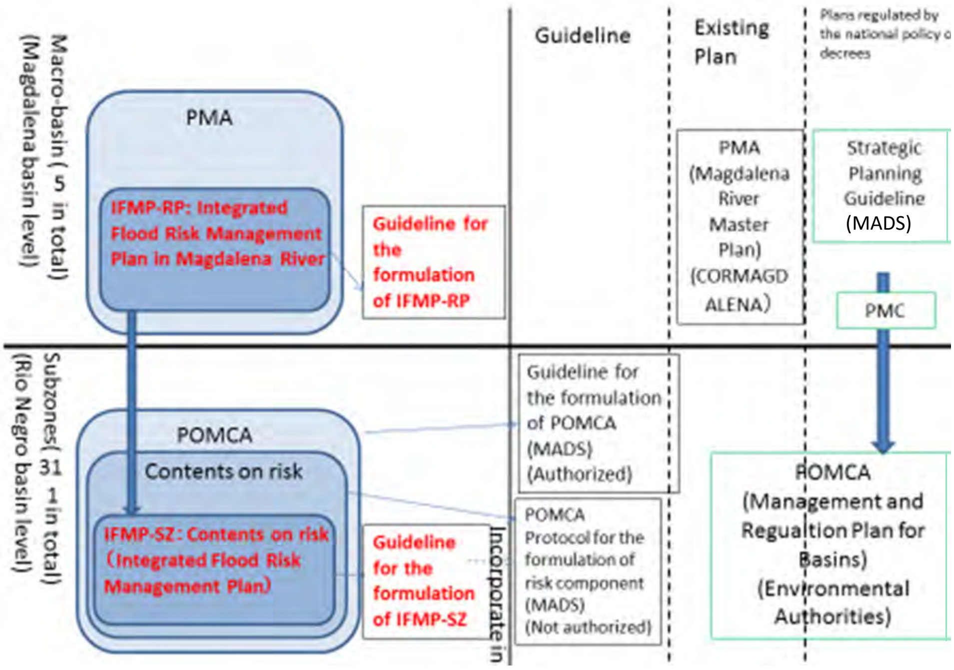


Figure 3.1 Relationship between IFMP-RP and Existing Plans

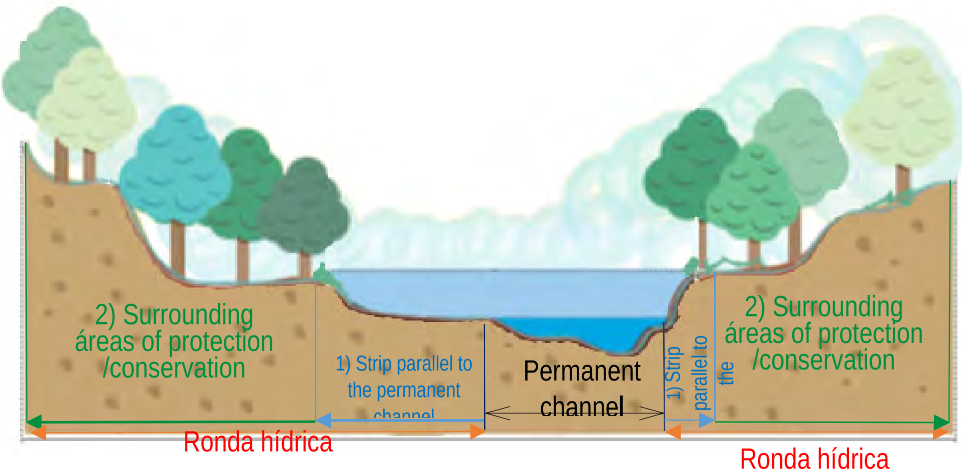
Existing Regulations/Decree: *Ronda Hídrica* (River Area)

In Colombia there is a decree that regulates the administration of riverside areas (*Ronda Hídrica*):

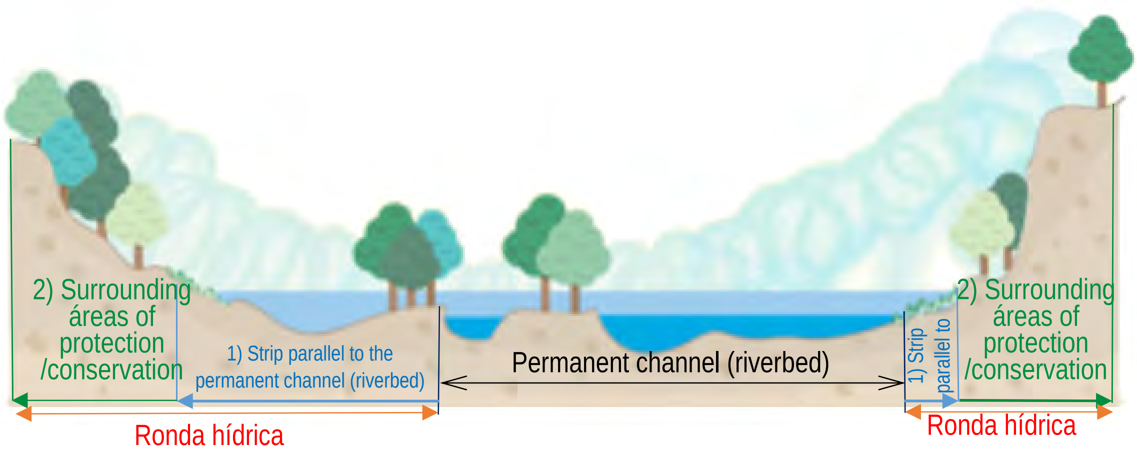
> Decree 2811 of 1974 Article 83 D:
>
> Except for rights acquired by individuals, they are inalienable and imprescriptible property of the State: d) A strip parallel to the line of the maximum tide or to the permanent channel of rivers and lakes, up to thirty meters in width.

Considering that this area of up to 30 meters may be insufficient in most of the Colombian rivers in valleys and plains, in article 206 of Law 1450 of 2011 established that the *ronda hídrica* includes "a strip parallel to the maximum tidal line or that of the permanent channel of rivers and lakes, up to thirty meters wide, and the afferent protection or conservation area." In this area, activities such as urban development and construction, land use, among others, are controlled. This concept is the basis of river management related to floods.

a)



b)



Constituent elements of the *ronda hídrica* in accordance with article 206 of Law 1450 of 2011 for lotic system (a) and lentic system (b). Images adapted from FISRWG (1998).

Figure 3.2 *Ronda Hídrica* (River Area)

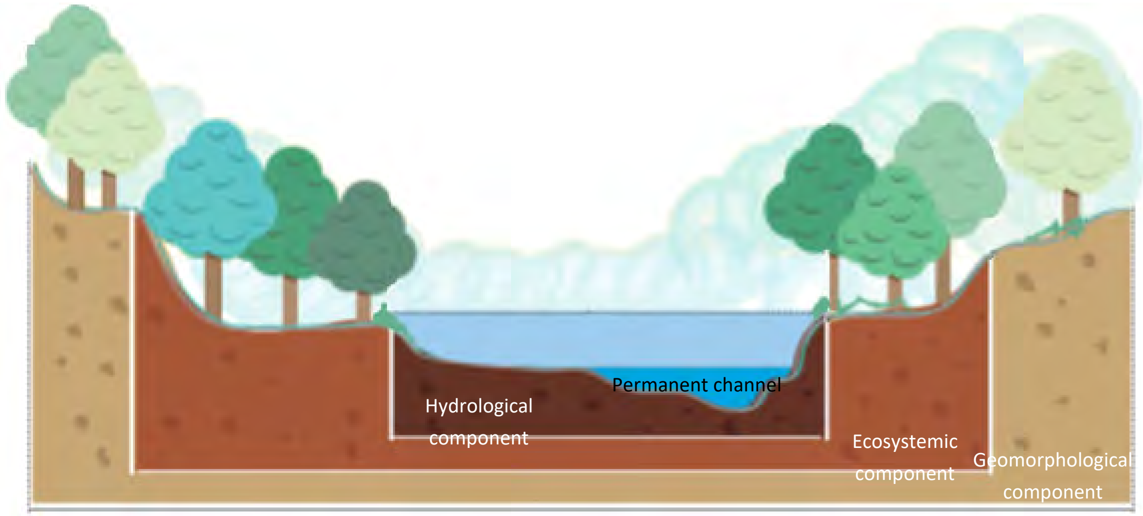
The review of the Ronda was carried out taking into account the experiences of the 2010-2011 flood.

The key points of this process are the following:

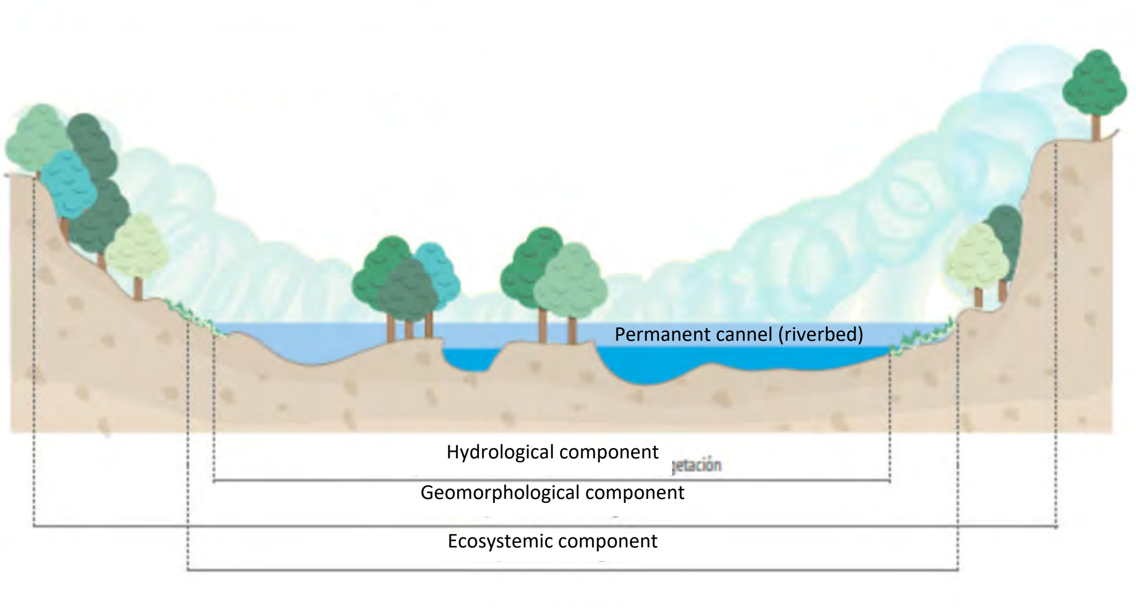
- The *Ronda Hídrica* will be delimited from the hydrological (floods), ecosystem (riparian vegetation) and geomorphological (morpho-structural, morphogenetic and morphodynamic aspects) points of view.
- The *Ronda Hídrica* will be defined using the outermost line of the three elements described above.
- The *Ronda Hídrica* becomes an area for conservation purposes in which preservation strategies can be given (e.g. maintenance of native forest coverage), restoration (recovery of native vegetation) or sustainable uses (e.g. seasonal crops, infrastructure for passive recreation).
- Regarding the hydrological point of view (floods), the flood with he return period of 15 years (in systems not altered in morphology) and 100 years (in systems where the plain is densely occupied) is taken into account. In the latter case, the concept of "intense floodway" of the United States of America is used.

The regulatory process of the aforementioned Law was promulgated in 2017 (2245 of 2017).

Below is a figure that summarizes these concepts:



Physical-biotic components to define the physical limit of the *Ronda Hídrica* in lotic systems. Image adapted from FISRWG (1998).



Physical-biotic components to define the physical limit of the *Ronda Hídrica* in lentic systems. Image adapted from FISRWG (1998).

Figure 3.3 Water Round taking into Account the Three Physical-Biotic Components

3.2 Review of Past Technical Studies

When preparing the IFMP-RP, flood-related information on past damage, current response situations, future predictions taking into account global warming, etc is collected. Then the contents that can be used for the IFMP-RP are reviewed.

【Explanation】

- Importance of collecting and reviewing relevant information

  One must study the past to acquire new knowledge. Therefore, past experience for future use must be documented.

- Analysis of usable information

  Create the list of information of documents and maps, associate it with raw data to facilitate the supply of this to the official database.

- Collection and exchange of existing information at various levels of related organizations and related materials created by universities/laboratories/research centers

Example) History of the definition of *Ronda Hídrica*

In Colombia, the decree related to the management of riverside areas (*Ronda Hídrica*) has evolved as follows.

Decree 2811 of 1974 Article 83 D:
Except for rights acquired by individuals, they are inalienable and imprescriptible property of the State: d) A strip parallel to the line of the maximum tide or to the permanent channel of rivers and lakes, up to thirty meters in width.

The *Ronda Hídrica* was defined in this manner, and it is understood as an area that consists of the "normal width of the river + 30m", where activities such as urban development and construction, among others, are regulated. This concept was the basis of river management related to floods.

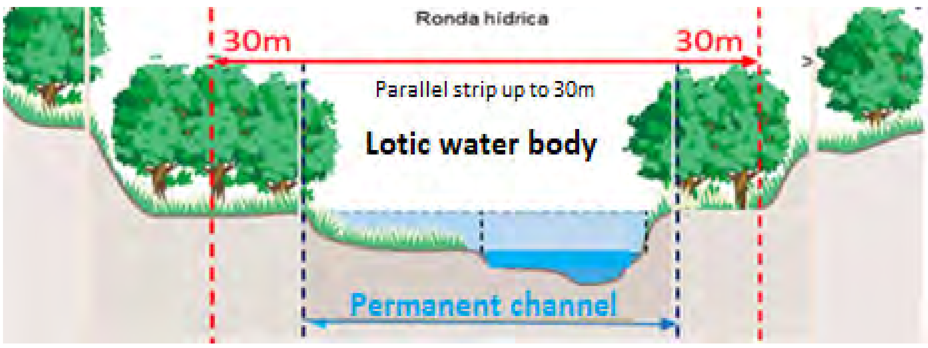


Figure 3.4 *Ronda Hídrica* (River Area)

① The purpose of the decree (without considering floods): to prohibit activities within areas defined as *Ronda*.

DECREE 2811 OF DECEMBER 18, 1974 is called the National Code of Renewable Natural Resources and Protection of the Environment, and its objective is the protection of the environment, as Article 1 stipulates that "[t]he environment is common heritage".

The term "flood" appears once in article 306; however, it is noted that there was no intention of using it in the context of flood measures.

> Article 306: In fire, flood, pollution or any other similar event that threatens to damage renewable natural resources or the environment, the necessary measures shall be adopted to prevent, contain or repress the damage, which shall be in effect as long as the danger lasts.

② Definition of 30m

It is also mentioned in Article 83 D that the area of 30m wide as public property.

> Article 83 D: Except for rights acquired by individuals, they are inalienable and imprescriptible property of the State: d) A strip parallel to the line of the maximum tide or to the permanent channel of rivers and lakes, up to thirty meters in width.

③ Activities prohibited within the 30m

> Article 86: Every person has the right to use public waters to satisfy their basic needs, those of their families and their animals, provided that this does not cause harm to third parties. The use must be made without establishing derivations, or using machinery or apparatus, or stop or divert the course of water, or deteriorate the channel or the margins of the current, or alter or contaminate the water in a way that makes it impossible for third parties to use it.
>
> … The ban on urban development and construction was added later.

④ Problems with the decree

Following problems exist:

・ For its purpose, the definition of "the natural channel + 30m" is not appropriate for a river that has a large channel and flood width.

・ Although it is assumed that the area of the normal width of the channel + 30m must be under the jurisdiction of Environmental Authorities, there are several restrictions when administering it in reality.

Therefore, the new method of defining the *Ronda Hídrica* was created with new points of view, as described in Section 3.1.

4. Analysis of Use and Other Sectors' Impact on the Dynamics of the Rivers

In the preparation of the IFMP-RP, after clarifying the activities of the other related sectors, analyze the factors of mutual influence and create an adaptation plan.

In addition, there are rivers with basins that cross several countries, so the items that require coordination with the relevant countries will be organized.

【Explanation】

In Colombia, the Ministry of Environment and Sustainable Development (MADS) is in charge of the river environment, while IDEAM leads the observation of water level during the flood, etc. Table 4.1 shows the additional related entities in other sectors such as navigation, hydroelectric generation, environment, agriculture and fishing, etc.

Table 4.1 Other Sectors Eelated to River Administration

	Related Entity	Magdalena River
Navigation	Ministry of Transport	Ministry of Transport/CORMAGDALENA
Hydroelectric Generation	Ministry of Energy and Mines	Ministry of Energy and Mines
Environment	Environmental Authorities	Environmental Authorities
Agriculture	Ministry of Agriculture (Floodplains)	Ministry of Agriculture
Fishing	National Authority of Aquaculture and Fisheries (AUNAP)	Ministry of Agriculture / AUNAP
River Environment	Ministry of Environment and Sustainable Development (MADS)	Ministry of Environment and Sustainable Development (MADS) / Environmental Authorities
Water Level Monitoring	IDEAM	IDEAM / Environmental Authorities

Additionally, the departments in the basin are related to the intervention of the river. For example, 14 departments exist in the Magdalena River basin.

In the formulation of IFMP-RP, write about the current situation and future plans, etc. regarding the state of the use of the river, the current state of the impact on the river, etc. in sectors such as river transport, hydroelectric generation, the environment, agriculture, fishing, etc.

Analyze the impacts of the actions of the administration of other sectors on the flood sector, and describe the results.

Example) Influence of navigation structure (spurs) on structures to mitigate flooding
Influence of the discharge of the hydroelectric generation dam on the flood
Appropriate flooding and floodplain environment
Clashes between the administration of floodplains and agricultural measures
Current situation of fishing in rivers

5. Defining the Scope of the IFMP-RP

In the IFMP-RP, the situation of the floods will be studied and the measures to mitigate the floods in the channels of the "principal rivers" and their flood plains will be studied.

However, in the hydrological model of flood events, the basin is examined as the main target.

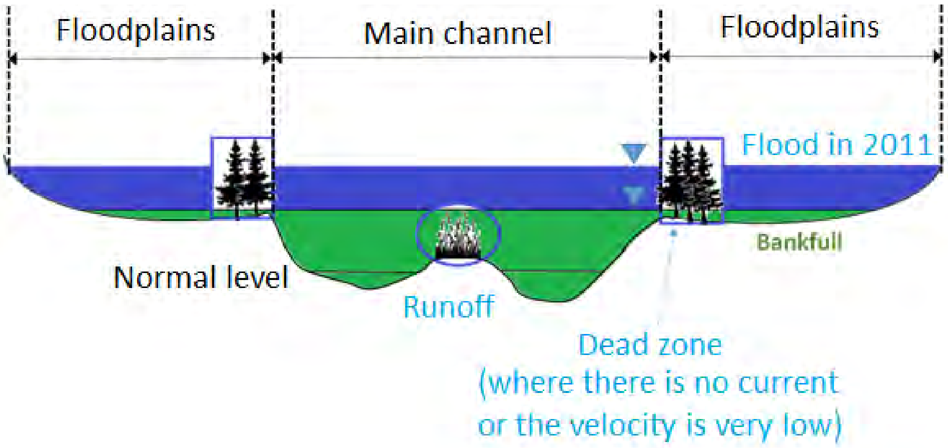
【Explanation】

Most areas that report lood damage are land along river channels. For this reason, a hydrological model will be created as the basis of the evaluation of the IFMP-RP for the main channel and the floodplains, where the flood flows. This model will cover both parts.

Figure 5.1 shows a visual example.

This consists of the following:

- Main channel
- Floodplains



Source: prepared by JICA Project Team

Figure 5.1 Image of the Hydraulic Model

In the IFMP-RP, it is necessary to consider flood mitigation measures not only in the river channel but also in the entire basin. Different types of land use exist in the basin.

For example, forest areas, wetland areas (water retention area), etc. have the function of temporarily storing the floods and delaying the runoff to the "principal river" to avoid the concentration of runoff in the river channel, contributing to the reduction of flood damage.

Even in urban areas, upon carrying out the maintenance of the rainfall storage structure and the installation of the permeable pavement, the runoff to the channel can be delayed.

Also, if it is difficult to relocate residents from a place where small floods occur, and they must live in that area, the damage can be reduced with the piloti residence, for example. Consider measures to preserve the function of water retention that the wetlands already have, in order to consider the runoff control measures of rain that falls in the basin.

Source: elaborated by the JICA Project Team basado on Materials of
Ministry of Land, Infrastruture, Transport and Tourism, Japan (MLIT)

Figure 5.2 Example of Measures within the Basin of a Principal River

6. Characterization of the Flood in the Basin and Definition of the Flood Sector

IFMP-RP aims to protect against floods, and its content consists of the process of "characterization of the river", "preparation of the plan" and "evaluation of the measures".

In preparing each process, a theory of planning based on scientific methods will be described while coordinating with activities from other sectors.

6.1 General Characterization of the Flood Phenomenon in the Main Channel (and Floodplains)

【Explanation】

In the IFMP-RP, flood prevention measures are described for the main channels and the floodplains that are flood areas of the "principal rivers".

The items to be studied for this purpose are organized into 3 stages, "understanding of river characteristics", "study of basic items in the plan" and "evaluation of measures." Figure 6.1 includes the details of each process.

The "principal rivers" have different characteristics such as the distribution of rainfall, runoff mechanism, flood mechanism, concentration of population and goods, and situation of flood damage. The first step in the stage "understanding the characteristics of the river" is to study and understand these characteristics.

In the "study of basic items" stage, the planned flood discharge is defined, the projected level and the projected flood area are calculated, and the section for which flood protection will be planned is determined.

At the stage of the "evaluation of measures", appropriate measures of the options of structural measures such as dams, flood walls and reservoirs and of non-structural measures such as the flood hazard map and early flood warning are selected and comprehensively evaluated.

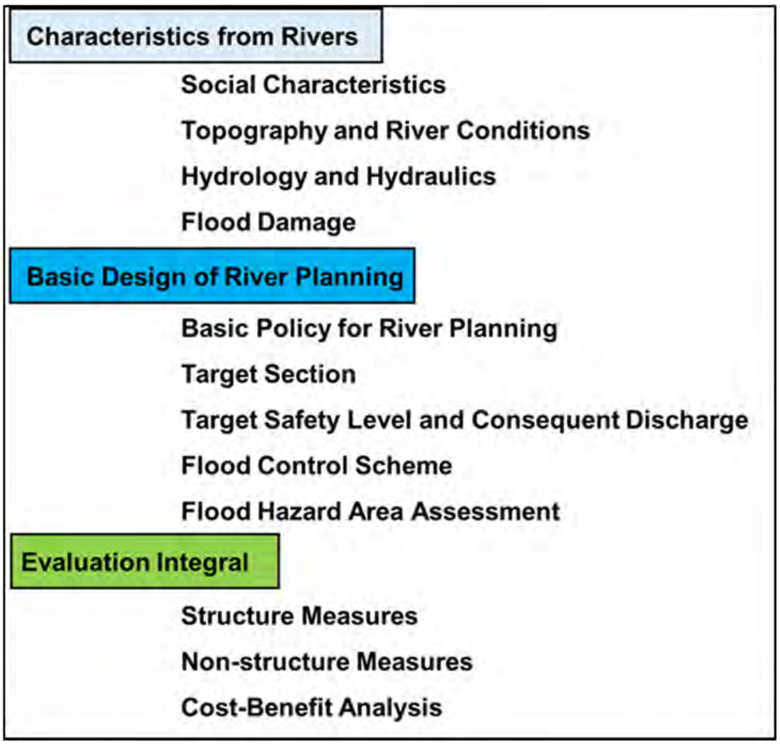


Figure 6.1 IFMP Formulation Process

The previous process is for to the main river of the "principal rivers".

The process is based on the principles of river engineering to carry out a scientific planning based on objective data. In response to decisions on measures, it is necessary to conduct a comprehensive assessment that includes cost-benefit analysis, present the plan of measures in a fashion that is easy to understand, and clarify the process of formulating this plan.

In the integral evaluation, the historical background of the relationship between the river and the people in each river and the natural and social characteristics are considered, in order to study the alternatives. It is necessary to evaluate them quantitatively as much as possible.

In the "principal rivers", the processes of the "study of basic items" and the "evaluation of measures" have not been implemented so far, and it is not clear which entity should lead the implementation.The details of each process are shown in Chapter 7 and Chapter 8.

6.2 General Characterization of Tributary Basins

IFMP-RP should be planned to include the tributary basin. Plan for the tributary basin should be a balanced plan with the IFMP-RP of the main river.

【Explanation】

The tributary flood prevention plan is created as the IFMP-SZ directed by CAR.

In general, the rainy season continues for several months in rivers in Colombia, so it is assumed that flood in the tributaries affect the discharge of the main river and cause flooding.

In general, in the main river and the tributary, the concentration of population and goods in the river basin is different. In the downstream of the main river, the population/assets are assumed to be concentrated and the potential for flood damage is often much larger than in the upstream.

Therefore, considering the river basin area, the degree of concentration of population and assets along the river, social characteristics (special factors) of the tributary basin, channel form, history of past disasters, etc., it is necessary to make a balanced plan between the main river and tributaries so that flood damage is not concentrated in a specific place in the basin.

It is necessary to take into account the mutual influence between the main river and the tributary at the point of confluence.

(1) Discharge of incoming flood from the tributary

The incoming flood discharge from the tributary should not negatively influence the flood discharge of the main river. In many cases, you do not need to consider the balance with the main river in the plan in general. However, it is preferable to carry out the verification of the volume of tributary discharges in case the basin area is relatively large in relation to the main river or that the volume of tributaries influences the main river due to the topography of the river basin.

(2) Calculation of flood water level of the tributary

It is required to calculate the flood water level of the tributary to determine the height of the dikes on the tributary, etc. In this case, the backwater area of the main river is studied with the design flood level of the main river to calculate the flood level of the tributary. There are 2 methods to incorporate the water level at the lowest downstream point (the exit water level) in the calculation of the tributary water level. The highest value is used between the calculated values with these two methods to calculate the water level of the tributary.

① Use the main river as the design flood level, enter the discharge of the tributary corresponding to the peak discharge of the main river and calculate the water level of the tributary.

② Assume a case in which the design flood discharge enters from the tributary, use the level of the main river corresponding to the discharge of the main river as the level of the exit water, and calculate the water level of the tributary.

6.3 Identification of Benefits and Damages of the Flood in the Main River and Tributaries

Floods not only cause damage but also benefit hydrographic basins and rivers.

In the IFMP-RP, care must be taken so that the benefits of floods are not lost through the implementation of flood mitigation measures.

【Explanation】

Confirm the damages and benefits of the flood. The target area is the main river, its floodplains and tributary basins. Collect data related to the damage and benefits of the flood, and write its characteristics.

The methodology for the study of flood damage situations is detailed in Section 6.5 "Identification and Characterization of the Exposed Elements"

The following are examples of the benefits of the flood.

- Secure water resources
- Stabilize navigation (ensuring water depth)
- Benefits for agriculture and fishing
- Positive influence on the environment due to disturbance (moderate humidity, water purification)
- Beach conservation through sediment transport

It is necessary to collect basic data on social characteristics for the confirmation of the damages and the benefits of the flood. Table 6.1 shows the basic data to be collected and places where the data can be found.

(Affected area, number of people affected, number of homes affected, damage to the infrastructure, the economic value of damages, industrial damage, negative impact on the environment, etc.)

Table 6.1 Basic data on Social Characteristics that Contributes to the Confirmation of the Damages and the Benefits of the Flood

Ítem	Content	Source
Municipalities within the basin	List of municipalities in the basin	POMCA (CAR)
Population/population distribution	Populations in the municipalities described above, projection of the population and distribution of residential areas	POMCA (CAR), statistics (DANE, departments, municipalities)
Producción en la cuenca	Information on agriculture, mining, tourism, etc. inside the basin	POMCA, statistics (department)
Land use (current situation, projection)	Information on the current situation of land use and projection within the basin	POMCA (CAR), POT / EOT (municipalities), PDM (development plan) (municipalities), PDD (department)
Environment (current situation, regulation, plans)	Information on the current situation of the environment, future plans, and regulations within the basin	POMCA (CAR)
Water use (current situation projections)	Information on the current situation of water use and projection within the basin	POMCA (CAR)

Source: JICA Project Team

6.4 Definition of "Flood Risk" for the River Basin

When the IFMP-RP is formulated, the risk assessment of the target area is carried out, and the flood prevention plan is prepared based on the results of this assessment.

【Explanation】

(1) What is flood risk assessment?

The risk of flooding is expressed by the combination of the "return period" and "the magnitude of the damage" of the flood generally caused by the flooding of the river and by the flood caused by the internal drainage.

Disaster risk= Return period * Potential for damage / Coping ability

= Return period * Hazard * Vulnerability / Coping capacity

The "magnitude of the damage" is determined according to the external force of the disaster (hazard), the elements that can suffer damage such as population, assets, and socioeconomic activities (exposed elements) and their vulnerability to hazards.

The risk assessment can not only be used for the formulation of the IFMP-RP and the evaluation of the flood control work, but it can also be used to study the maintenance and operation of the structure.

Table 6.2 Definition of Flood Risk and Evaluation Methodology (1)

Factor	Definition	Index
Hazard	Cause of potential damage and losses	Magnitud
Probabilidad (of occurence)	Likelihood of the hazard event occuring	1/return period, 0 to 1 (100%)
Vulnerability	Physical or social condition that makes the target area vulnerable to the harmful effect or hazard	Susceptibility or 1/resilience, 0 to 1 (100%)
Potential damage	Value added of the elements directly affected by an event	Hazard * Vulnerability
Disaster risk	Combination of the probability of an event and consequential damage	Probability * Potential for damage/Capacity

Table 6.3 Definition of Flood Risk and Evaluation Methodology (2)

Factor	Definition	Index	Item
Exposed elements (Element to hazard)	People, property, systems or other elements present in hazard areas that are therefore subject to potential losses	Monetary value ($), population, etc. that are exposed to the hazard. Monetary value ($), population, etc. that are exposed to the hazard	· Damaged property (houses, furniture) · Damaged property (companies) · Indirect damages
Response capacity	Ability to face and manage adverse conditions, disaster emergencies	1(no) to ∞ (perfect)	

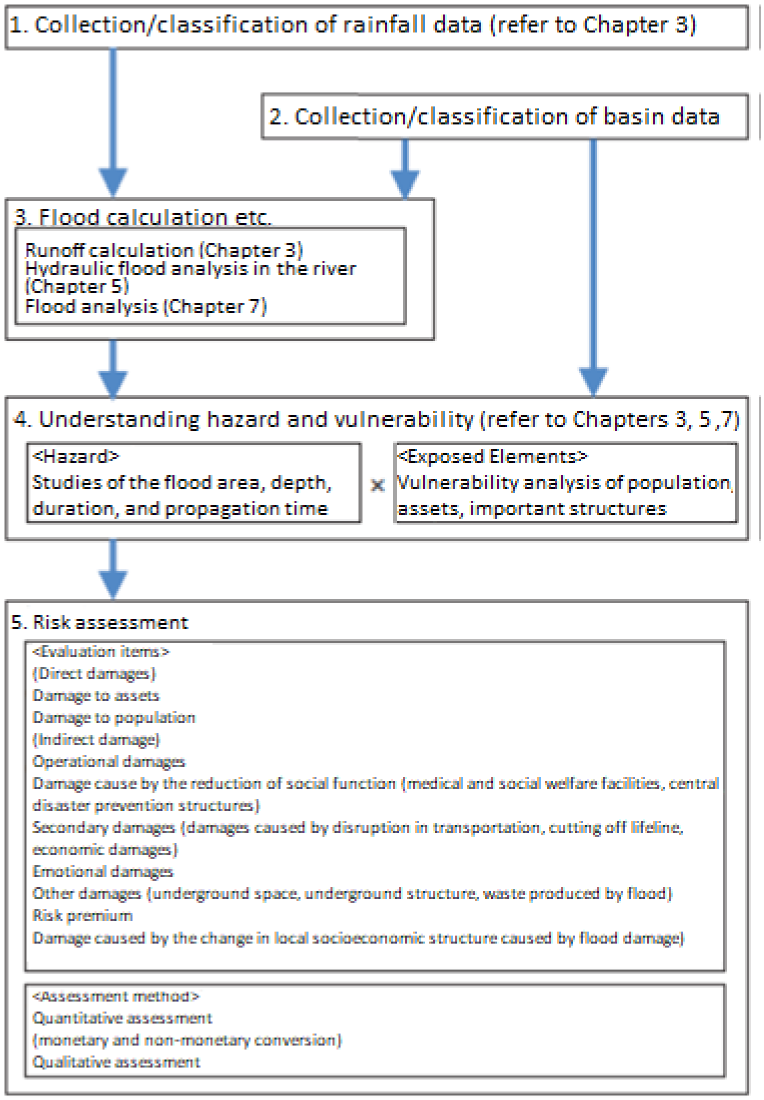
Source: Field Guide by Open Data for Rsilience Initiative

(2) Need for flood risk assessment

In recent years there have been major floods in the world. The loss of relative capacity of flood control structures due to the frequent and heavy torrential rains caused by global warming is a concern.

By clearly understanding the full picture of flood risk, it is possible to implement more efficient projects. In addition, it is possible to consider crisis management measures according to the risk (improvement of the evacuation warning system, activities of emergency measures in the face of the occurrence of flood damage, orientation on lifestyle, education/drills for the prevention of disasters).

The following figure presents the process of risk assessment.



Source: MLIT, Flood Damage Risk Assessment

Figure 6.2 Process of Risk Assessment

6.5 Identification and Characterization of Exposed Elements

Study the flood characteristics of each basin and reflect them in the IFMP-RP.

【Explanation】

In each basin, data such as the area affected by the flood disaster, the number of people affected, the number of homes affected, the damage to the infrastructure, the monetary value of the damage, damage to the industry, negative impact on the environment, etc. are collected, in order to use them as basic data for the formulation of IFMP-RP.

Table 6.4 List of Data to be Collected Related to Flood Damage

Item	Content	Source
List of disasters	A list of past disasters occurring in the basin, including the date and time of the disaster occurrence, the places of occurrence of the disaster (coordinates), the situation of the damage, disaster situations (the context in which the disaster occurred , the maximum depth, duration of the flood, etc), causes of the disaster, the actions taken before, during and after the disaster. Ideally, a detailed list is prepared by urban center.	Department, UNGRD, IDEAM (list of floods)
Disaster reporting materials (reports)	Materials and reports that summarize the studies related to disasters and the results of the analysis.	Contents of the POT (municipalities), research centers such as SGC, departments, UNGRD
Results of field surveys of the places affected by the disaster	Results of the field survey in the places affected by the disaster, including interviews with residents.	Researcher (C/P and project team) and residents (through the survey carried out by the researcher)

It is necessary to clarify the characteristics of the damage in past floods, in order to develop effective flood mitigation measures.

- Know the characteristics: the important basic data include the time of the year when the flood tends to occur, the time between the rainfall and the generation of the flood and the duration of the flood, in order to identify the time when the population should be prepared for the flood, type and scale of structural measures, and the stage at which evacuation measures should be issued.
- Know the places vulnerable to flood damage: knowledge about the types of flood (flood of the river, sediment disasters, landslides, high tide, etc.) and about the places in the basin where the flood occurred, are the important data to introduce the flood observation system in the future (water level and discharge), and study the locations that require effective structural measures and the early warning system.
- Review past measures to be used as a reference to achieve effective measures: knowledge about the characteristics of past floods and the responses are the basic data to study effective measures (structural and non-structural), collaboration between entities at the national, departmental and municipal levels, and collaboration with other sectors.

In the Magdalena River basin, data on the 2010-2011 flood situation and the monetary value of the damage have been categorized and reported, and the severity of the damage is clear.

However, in other basins there is little information about the characteristics of the flood in other basins.

For example, for each macrobasin MADS has prepared documents focused on water management entitled "STRUCTURING STRATEGIC GUIDELINES FOR THE INTEGRAL MANAGEMENT

OF WATER AND TO MANAGE AGREEMENTS WITH KEY ACTORS FOR THE STRATEGIC PLAN OF MACROBASIN".

Most of its content is about the "benefits" of water, such as water resources management and water quality, and there is almost no content on flood damage.

In the document on the Orinoco basin, the flood is only mentioned as an anthropic risk, different from the natural risks (landslides, earthquakes and forest fires), in the conceptual figure.

There is no mention of floods in the Amazon basin.

Since there are macrobasins where flood damage is not recognized as a serious problem according to the above-mentioned documents, first of all the relevant entities must study the characteristics of the flood within the macro-basin, the situation of the concentration of population and assets in the flood areas, and study the need for the formulation of IFMP-RP.

6.6 Analysis and Identification of the Relationship between Floods and Each Economic Sector

Investigate the factors of mutual influence of other sectors related to the flood sector and reflect them in the plan.

【Explanation】

Studying the relationship between the main river and people from a historical point of view, the river has been used for navigation, hydroelectric generation, the environment, etc., and as the river has provided different benefits; the preservation of these functions is important.

As a result of the activities of other sectors, the structures mat be installed in the channels. It is necessary to for the flood sector to coordinate the installation of these structtures with among influencing sectors.

For example, as shown in Figure 6.3, there are cases in which submerged dikes are installed to maintain the navigable channel during the drought.

The submerged dikes are installed in order to maintain the strength of the flow of water to transport sediments, concentrating the flow in the central part of the channel in times of drought, to avoid the accumulation of sediments and ensure the depth of water in the navigable channel.

The spurs dikes are structures that exert their function during the drought, but during the flood there is a possibility for it to become an inhibiting factor of the flow of water in the riverbed.

When preparing the flood prevention plan, it is necessary to evaluate the degree of inhibition of flood flow based on the installation of submerged dikes by a hydraulic calculation method to reflect it adaptively in the plan.

Source: materials from CORMAGDALENA

Figure 6.3　Submerged Dikes to Maintain the Navigable Channel

In Colombia, there are dams for hydroelectric generation. These dams release stored water downstream to power the turbines and produces energy.

On the other hand, there is a concern concern that flood damage downstream would be increased when the water is released from the dams for hydroelectric generation during floods. It is important to discuss if it is possible to create a flood volume in the dams between the flood sector and the hydroelectric generation sector before the formulation of the plan, taking into account these situations.

6.7 Definition of the Target Area

Identify the areas for which flood prevention measures will be considered based on the priority of protection. Consult the historical record of flood damage and results of the review of existing plans.

【Explanation】

The damage caused by the flood occurs in different places depending on the cause.

Because the magnitude of flood damage also varies according to the concentration of population and assets, it is not uniform within the basin. Therefore, we must consider the priority of protection.

For this purpose, with a hydraulic model etc. the flooded area is predicted in a flood of design scale, and the target area of the plan is specified according to priority.

In this process, it is important to refer to the record of major floods in the past. The external forces (rainfall), the flood mechanism, the place of occurrence of damages, the monetary value of damages, etc. of the last flood are examined to be used as a reference when defining the target area.

Examples of reproduction of the flood mechanism, etc. are presented in 7.2.

7. Detailed Flood Analysis in Target Area

7.1 Study of Hydrological and Hydraulic Conditions

Flood prevention measures should be designed following Figure 7.1. Detailed analysis and classification of hydrological and hydraulic characteristics create the basic data for the formulation of flood protection measures.

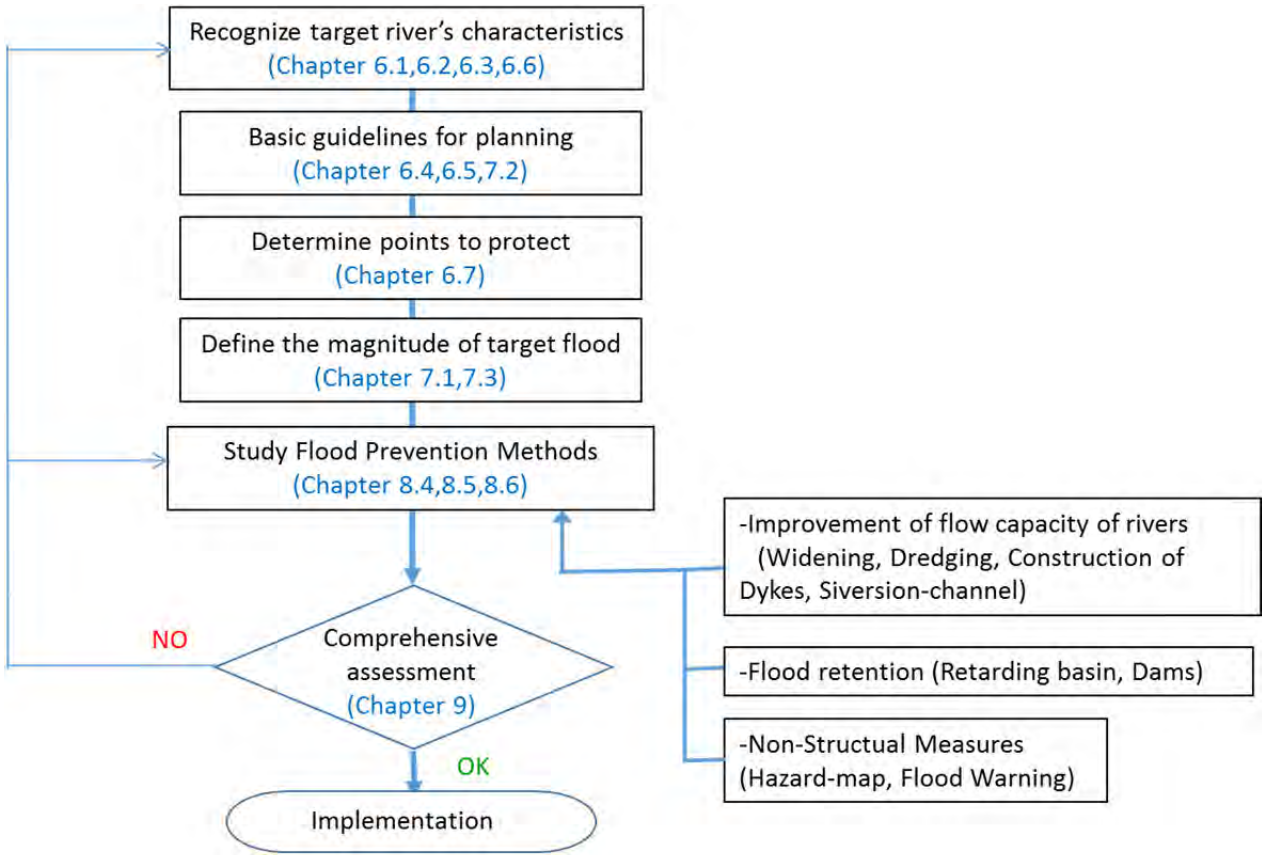
【Explanation】

Based on the contents and results of the study and analysis of hydrological and hydraulic characteristics of the "principal river", guidelines for flood protection measures are prepared, flood mitigation measures are defined and implemented according to the comprehensive assessment.

The following are the steps:

- Understand the hydraulic and hydrological characteristics of the study's target area.
- Establish the design scale. Perform runoff calculations corresponding to the design scale, using the runoff analysis model. The distribution of the target discharge of the plan (design flood discharge) based on the calculation of the existing flood or runoff models is determined.
- Calculate the level of water and flood in the channel and in the floodplains, using the basic discharge.
- Select places to protect and consider the implementation of structural measures and non-structural measures.
- Study B/C in case of implementing structural measures and evaluating economic efficiency.
- Make a final decision on the measures after the relevant entities reach an agreement.
- When new structures such as dams, retention reservoirs and diversion channels are installed, the distribution of the discharge at the installation sites and within the channel will change. Therefore, the design flood discharge will be established.

Figure 7.1 shows these processes.



The numbers correspond to the chapter of this guideline corresponding to the process

Source: JICA Project Team

Figure 7.1 Processes of the Study of Flood Prevention Measures with Hydraulic and Hydrological Data

Here, the results of the study and the analysis of the hydrological characteristics and the hydraulic characteristics of the "principal river" as well as the contents that require additional study and analysis are presented.

➢ General meteorological and hydrological conditions

The summary of the meteorological and hydrological conditions of the basin is explained.

✧ General meteorological and hydrological conditions

Climatic elements that determine the meteorological and hydrological conditions are explained. An example is the fact that it is located in the intertropical convergence zone (ITCZ). It also includes meteorological and hydrological conditions in general, such as the months in which the rainy season and the dry season occur and the average rainfall.

✧ Conditions of hydrological observation

The situations of the meteorological and hydrological observation of the basin are explained. It is ideal to organize the information of the stations in a single place and create a table with data such as the station code, station name, type of equipment, municipality where the station is present, location of the station in coordinates, altitude, period of observation, time of data classification (if it is a hydrological station, the HQ curves and the frequency at which the discharge is measured), along with with the map showing the locations, so that it is easy to use as a reference when studying the results of the analysis.

- Levels and discharge in the main hydrological stations

  The situation of water levels and discharge in the main hydrological stations (level, discharge) is explained. Ideally, the maximum values of the level and discharge and the results of the probability analysis (level, discharge) of the maximum values are presented, and the flow regime in high and low levels is explained.

- Daily rainfall at main hydrological stations

  The rainfall situation in the main hydrological stations is presented. Ideally, the annual maximum rainfall and the result of the probability analysis of the annual maximum value are presented and the annual rainfall, monthly rainfall, maximum rainfall per hour, and the frequency of torrential rain are explained.

To analyze hydrological and hydraulic characteristics, it is essential to collect basic data. Below is a list of the basic data that should be collected and the entities that can provide it, taking into account the experience in this project.

Table 7.1 Hydraulic and Hydrological Data to Collect

Ítem	Content	Source
Station data	A list that includes data from meteorological and hydrological stations in the basin, such as the station code, station name, type of equipment, municipality where the station is located, location of the station in coordinates, altitude, observation period, data on processing time	IDEAM, CAR
Rainfall data (daily, per hour)	Rainfall data (per month, per day, per hour) of the stations in the basin (and within the surrounding basins as needed)	IDEAM, CAR
Water level data	Level data (per day, per hour, peak level) of the stations in the basin	IDEAM, CAR
Discharge data	Discharge data (per day, per hour, peak discharge) of the stations in the basin	IDEAM, CAR
Discharge observation data, cross-section data for each station, H-Q curve	Observation data of the discharge and data of the cross section of the station (current and past), and H-Q curves (current and past), of the stations in the basin	IDEAM, CAR

On Runoff Calculation

Runoff calculation refers to calculation of the amount of runoff from the rain and the river, and it is a necessary step for the river flood protection plan.

The flood drains into the river as a result of the complex causal relationship between the topography, geology, slope, vegetation, and distribution of rainfall in the basin. We can better understand the phenomenon of flood that actually occurs when using appropriate parameters of the calculation model and comparing the calculated discharge rate with the observed discharge.

It is quite likely that it will be difficult to calculate the runoff by using a single planned rainfall value since the rainfall would vary greatly in the basin of the large target river of this plan. As a reference, the Mississippi River and the major European rivers are divided into sections and in each section the maximum historical value or the maximum theoretical value is used.

Therefore, it is appropriate to determine the distribution of the discharge (planned flood discharge) that will be the objective of the plan based on the existing discharge observation data in Colombia and the calculations of the existing runoff models.

If there are no discharge observation data, check the result with the observation data of the water level. When verifying the water level at the time of the flood using the runoff obtained by the runoff calculation, it is possible to verify with the observeda water level.

When calculating the runoff from the flood using real rainfall and predicted rainfall, it is possible to estimate the runoff of the river several hours later. By doing so, it is possible to make a precise flood forecast.

Because this leads to estimating the impact of possible structural measures such as dams and retention reservoirs, it will help develop the optimal flood control plan.

7.2 Detailed Analysis of Past Flood Phenomena

Study the great floods of the past, in the past, and identify and analyze the cause of the floods, the mechanism of floods, and the measures that are considered effective, as they are useful for the IFMP-RP.

【Explanation】

(1) Items related to the flood mechanism to be organized and analyzed

- Detailed analysis of the relationship between flood events and hydrological conditions in the basin.

  A detailed analysis is carried out on major disasters, hydrological conditions during the disaster and the relationship between them, in order to understand the characteristics of the flood within the basin in a precise manner.

  - Hydrological conditions in flood events

    The observed values of the level and the discharge in the main hydrological stations and the observed values of the rainfall in the main meteorological stations at the time of the generation of the disaster within the basin are categorized and analyzed, and the results are presented. The analysis must be carried out with the appropriate time scale data (data per hour or per day), taking into account the generation time and the duration of the disaster, although there are limitations on usable data. It is recommended to carry out the analysis, not only with the rainfall data of the day of the disaster or a day before, but also with the accumulated rainfall data of longer periods (1 month or more) as needed.

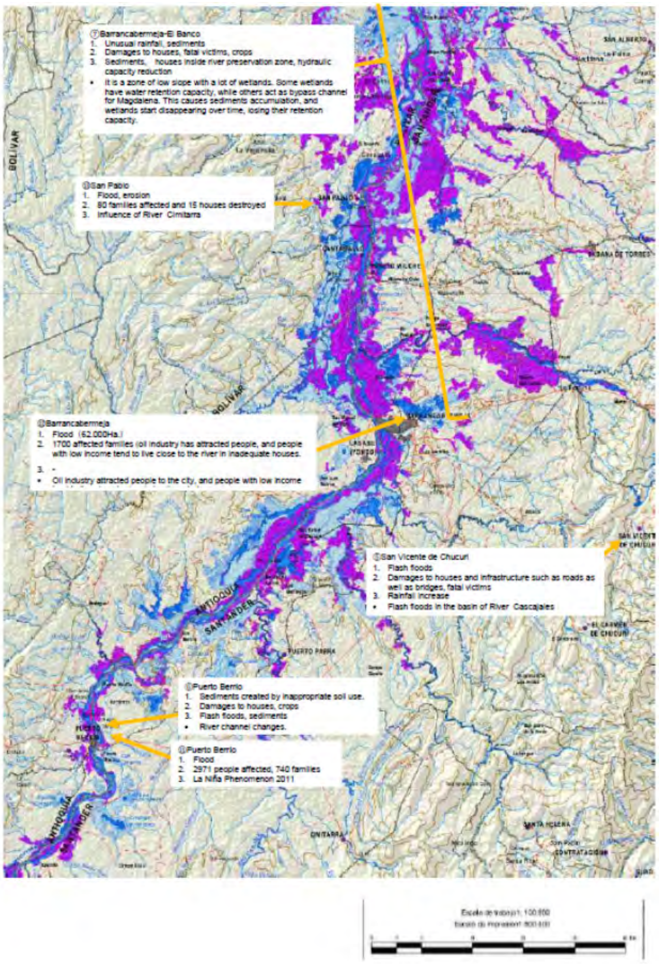
- ✧ Relationship between heavy hydrological conditions and the occurrence of flood events

Apart from the "analysis of hydrological conditions at the time of the generation of the disaster," the "relationship between large hydrological values and the occurrence of disasters" is analyzed in the main stations, and the results are presented. Ideally, not only the relationship between the occurrence of the disaster and the day when an extreme value was observed in a single season is analyzed, but also the relationship between the occurence the day on which an extreme value of the average rainfall in the basin was observed, the day on which that an extreme value was observed at several stations within the basin, etc. should be analized.

- ✧ Actual flood conditions in several places based on the flood study

Conduct field surveys in the places where past disasters occurred, confirm the specific situation at the time the disaster occurred, and present the results. Select places that experienced great damage in the past or places where disasters occurred for field surveys. In the field surveys, items that contribute to the detailed analysis of disasters or to the study of measures are studied, such as the date and time of the occurrence of the disaster, the places of occurrence of the disaster (coordinates), the situation of the damage, maximum depth, duration of the flood, disaster situations, causes of the disaster, actions taken before, during and after the disaster.

Figure 7.2 shows the floodplain of the Magdalena River in the 2010-2011 floods.



Source: IDEAM

Figure 7.2 Flooding Area around the Magdalena River in 2011

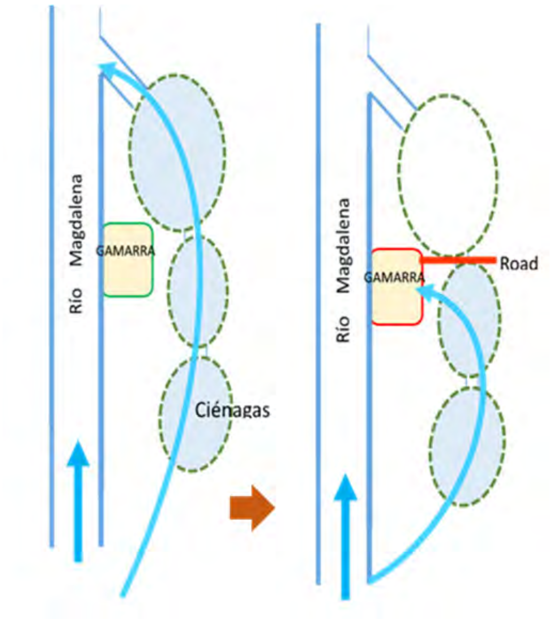
(2) Points of consideration

For example, wetland/marsh areas along "principal rivers" not only become flood areas but also become channels for flood discharge during flood. For this reason, paying attention to the construction of transverse roads in swamp areas can cause unexpected flood damage.

These are usually difficult to express in the analysis.The following is a case study on the Magdalena River.

Example 1 : Gamarra

- There were swamps parallel to Magdalena River.
- During the flood, the water was retained in these swamps that had the effect of preventing the increase of water level in the river.
- A road that cuts the connection of the marshes was built.
- As a result, the flood that would have been retained began to flow towards the urban center.
- Currently the municipality is trying to prevent flood damage with peripheral dams

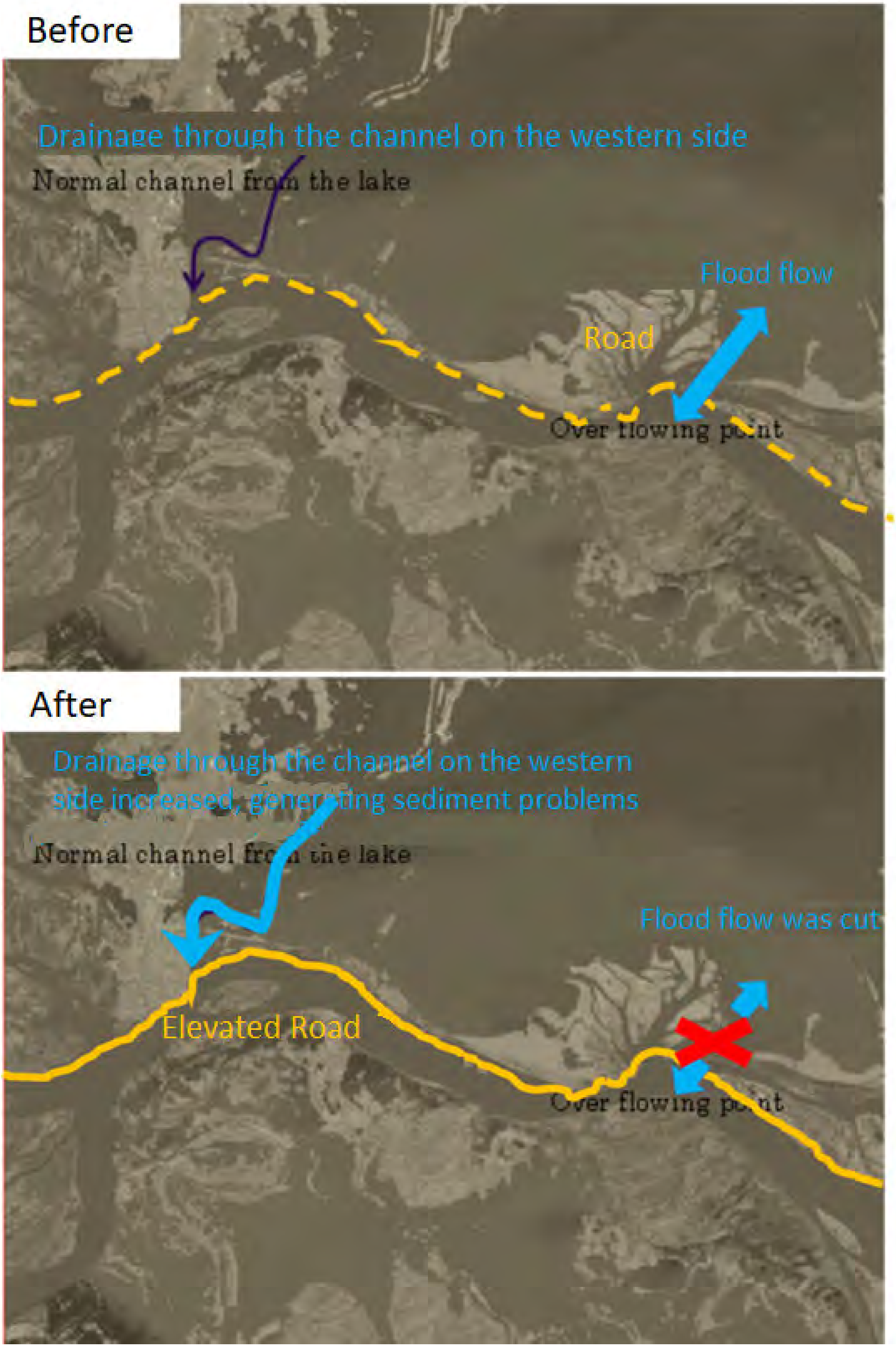


Source: elaborated by the JICA Project Team

Figure 7.3 Example of Gamarra

Example 2: El Banco

- Cutting the channel that communicatesn the swamps by the construction of highway closed the channel almost completely where the runoff of the river used to enter the swamps during the flood. Only the channel that passes under the bridge near El Banco on the western side remained for the river to flow into the swamps. The entrance of sediments into the swamps was also reduced.
- The water level of the swamp increases slowly during the flood because the swamp is connected to the river by the channel on the western side as explained above.
- Before the construction of the road, when the level of the river decreased, the water entered from the swamp to the river by the same channel (figure above). After the construction of the road, when the level of the swamp is below the level of the road, it is drained by the canal on the western side, near El Banco.
- Enough sediment accumulated in the western part of the main Magdalena River to interfere with navigation, and channel change was also generated. In addition, as the retention capacity of a large swamp has been reduced, it is assumed that it has affected the increase in the level downstream during the flood.



Source: elaborated by the JICA Project Team

Figure 7.4 Example of El Banco

7.3 Recreation and Prediction of the Flood Risk Area

Recreation of past floods and prediction in case of flood design scale is done by building hydraulic models and analyzing them. The results of the analysis are verified using local data of flood marks, etc.

【Explanation】

(1) Methods of flood recreation and prediction

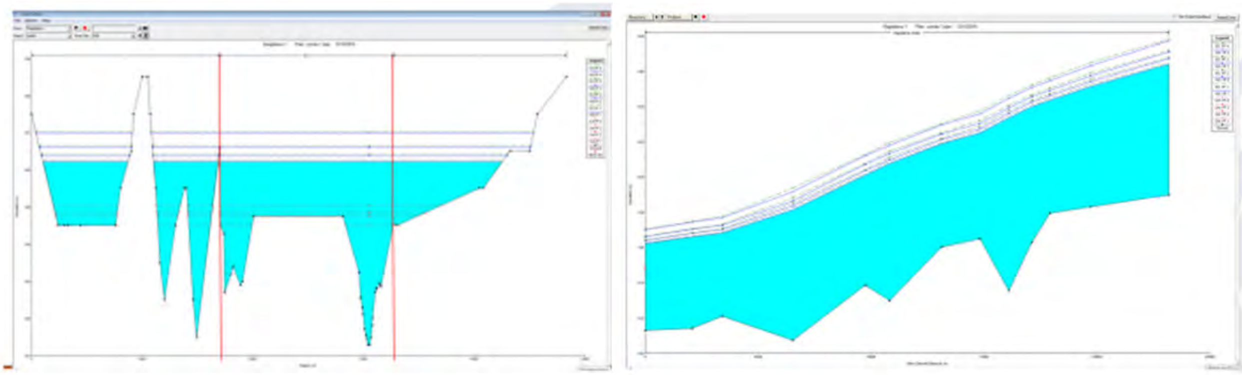
To reproduce floods and predict design scale floods, it is necessary to quantitatively know the discharge, the water level and the flood volume water during the flood. A hydraulic model is used for flood reproduction and prediction.

The types and characteristics of the main hydraulic models used for flood analysis are shown in Table 7.2.

Table 7.2 Types and Characteristics of the Main Hydraulic Models

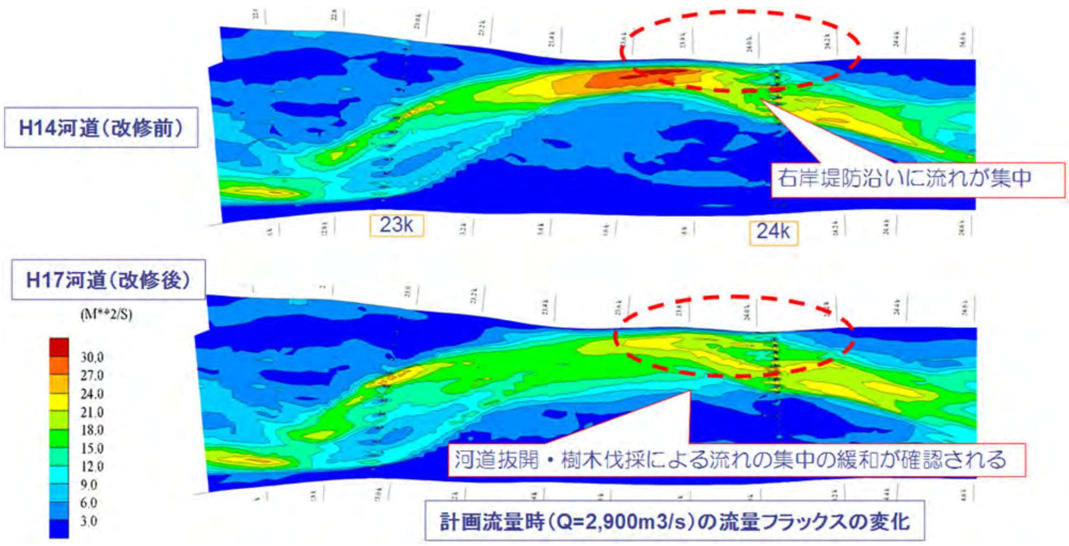
Type	Analysis Target	Examples of Analysis Results	Example of Model
Runoff model	After subdividing the basin, place rainfall data in each sub-area to calculate runoff at any point in the basin.	Runoff at any point in the basin (m^3/s)	-HEC series -MIKE series
Level calculation model	Depending on the LIDAR data of the target section or with any interval (for example, 1 km), or survey data, altitude data of the cross section of the river channel are created. Enter the discharge and the downstream level for each target longitudinal section and calculate the water level in case this discharge flows down.	Flood level in any interval (MSL + m)	-HEC series -MIKE series -IRIC Model
Flood analysis model	Enter the elevation data in the basin and river channel using LIDAR data, etc. Evaluate the discharge and water level downstream for each section and calculate the water level within the channel or the flood within the basin. The flooded section in the basin is considered as the flood area.	Flood area and flood depth	-HEC series -MIKE series -IRIC Model -RRI Model
Sediment transport model	Calculate the sediment volume that can be transported by the flood (sediment load) and the sediment in suspension. When this is done in the longitudinal direction, the fluctuation in the height of the channel bed is estimated, obtaining the volume of accumulated sediment in any section during a period of flooding.	Sediment volume that can be transported in any cross section, fluctuations in the riverbed in any cross section	-iRIC- -IRIC Model

(2) Example of Analysis with Models



Source: elaborated by IDEAM

Figure 7.5 Example of the Calculation of Non-Uniform Flow in the Magdalena River
(left: cross section configuration, right: result of the longitudinal level calculation)



Source: elaborated by the JICA Project Team

Figure 7.6 Example of Two-Dimensional Flood Calculation

(3) Study with local data

To verify the result of the water level calculation, use the flood mark data and carry out a cross check.

Since the flood mark may take an abnormal value due to the change in local water surface, it is desirable to acquire the densest data possible.

Source: Website of MLIT

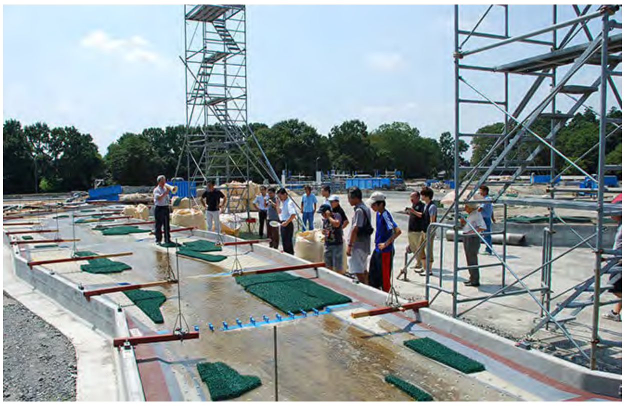
Figure 7.7 Real Examples of the Flood Mark (Japan)

(4) Characteristics of the experiment with hydraulic model

Natural phenomena in rivers and coasts are complex, and it is difficult to elucidate them sufficiently by means of numerical calculation. Therefore, to deepen the understanding of certain hydraulic phenomena, or when it is necessary to achieve a prediction with sufficient precision, experiments with hydraulic models are a useful option.

As characteristics of the experiments with hydraulic models, the following points can be raised.

1. It is an effective means for local problems that the numerical analysis does not solve well (eg, local erosion of the dock base).
2. Multiple cases can be easily compared.
3. In particular, the more complex the phenomenon (for example, three-dimensional), the more time and cost are saved compared to the numerical analysis.
4. Since the model is a visually easy technique to understand, it is a tool to demonstrate what happens and reach an agreement with the residents in the area in question.



Source: elaborated by the JICA Project Team

Figure 7.8 Examples of Experiments with a Water Channel Model
(left: full model, right: example of channel rectification)

8. Land Use and Disaster Risk Management for Flood Zones

8.1 Definition of "Critical Flood Hazard Zones" and selection of "Critical Flood Hazard Zones" in the Basin

Evaluate the critical flood hazard zone during the flood. Reflect the results of the flood vulnerability analysis of Numeral 8.2 in the evaluation.

【Explanation】

Define the "critical flood hazard zones" in the target river, taking into account the contents of Chapters 6 and 7, and using the depth and duration of the flood as indicators.

According to the definition, the critical zones of flood hazard in the target "principal river" are identified, using the results of Chapter 7.

According to need, the results of the flood vulnerability analysis explained in the following section and the risk assessment are reflected, the parameters and definition are studied again, and the critical zones of flood hazard are determined.

It is important to bear in mind that flood zones are not necessarily critical areas that must be intervened in the face of flood risk in macrobasins such as Orinoco and Amazonas, since they are areas in which flood events are part of the natural dynamics of the territory required for the social, environmental and economic development of the region.

8.2 Risk Assessment, including Analysis of Flood Vulnerability within the Flood Area

Analyze the vulnerability in the projected flood area and evaluate the flood risk, taking into account the land use on the river banks and the concentration of population and assets.

【Explanation】

Select the indicators to be used in the vulnerability analysis and define the vulnerability (determine the standards to determine the degree of vulnerability), taking into account the social and flood characteristics in the target river as well as the availability of the data.

Based on this definition, analyze the vulnerability and assess the risk of the projected flood area (or only the critical hazard area or include the surrounding areas).

8.3 Identification of the Critical Flood Risk Zone

Determine the flood risk zone based on the result of the risk assessment.

【Explanation】

Determine the flood risk zone based on the results of the risk assessment explained in the previous section.

When the preparation of the guideline for the risk assessment of the flood hazard zone is completed (projected date: mid 2018), it is recommended to carry out the evaluation according to this guideline.

8.4 Study of the Need to Respond to Flood Risk

For flood mitigation measures, as a basic idea of comprehensive flood prevention, structural measures and non-structural measures are selected.

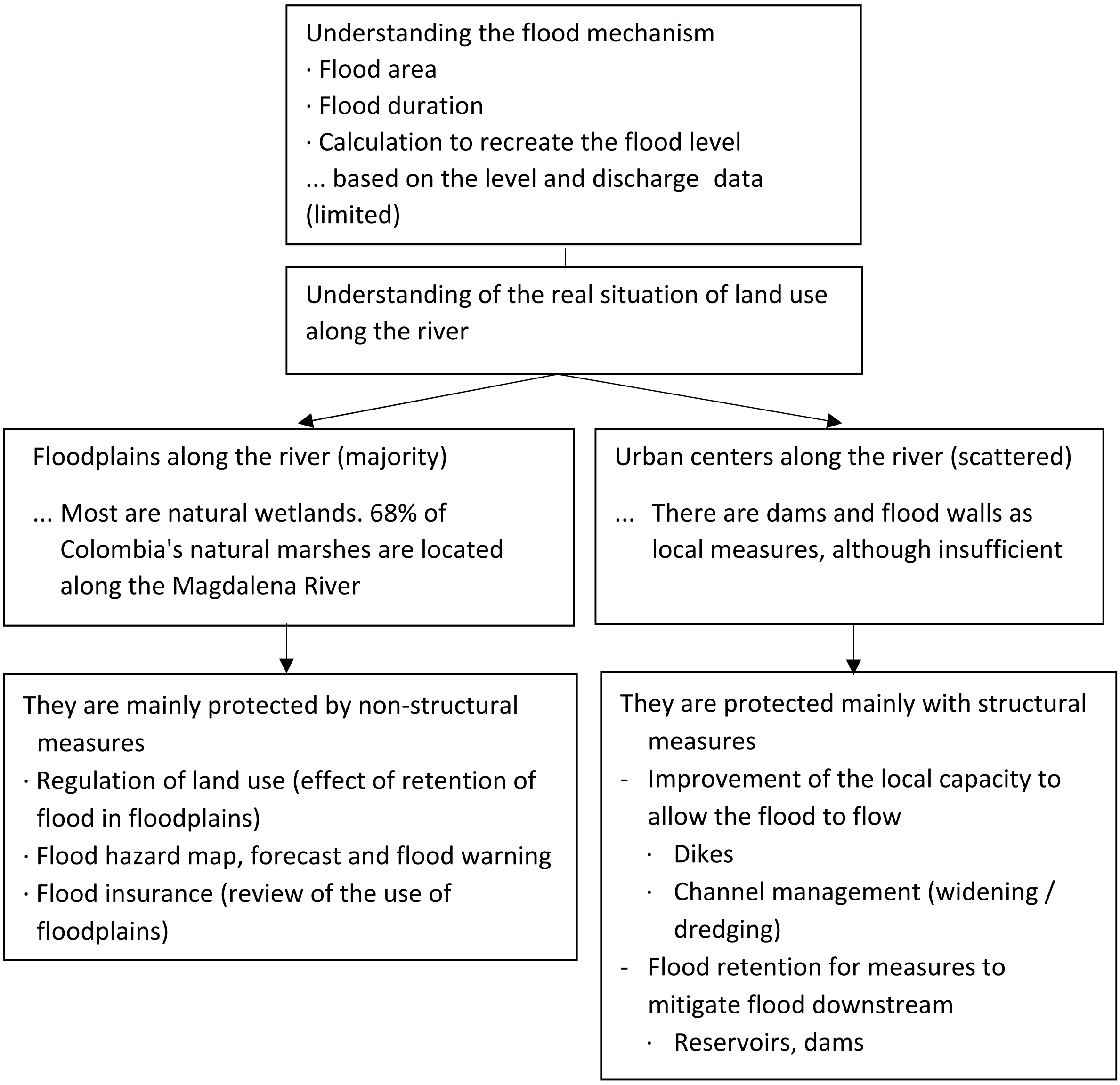
【Explanation】

When considering flood prevention measures, in addition to measures in riverbeds and floodplains, we will also consider measures to control runoff from river basins to riverbeds, such as forest conservation, conservation of wetlands and marshes, and structures of control in the river basin.

Flood mitigation measures can be divided into two categories, structural measures and non-structural measures. The following table shows the main measures of each category:

Among these measures, in terms of structural measures for river channels and floodplains, it is necessary to examine several alternatives in consideration of the impact on other sectors, such as the river use. Then, it is required to perform the integral evaluation in an objective manner, from the point of view of feasibility based on natural, social, and technical limitations among others, the social utility of the structure, economic efficiency, and environmental impact, etc.

Study and analyze the need for response to flood risk.



Source: elaborated by the JICA Project Team

Figure 8.1 Methodology of the Study and Analysis of the Flood Response

8.5 Study of Structural Measures

Structural measures are effective measures to directly reduce flood damage. When it comes to structural measures, it is important to achieve a balance between its objective, its effects, economic evaluation, places that benefit from the measure and places that are negatively affected by the measures.

【Explanation】

Structural measures are effective to prevent flood damage to a certain extent.

Structural measures can be divided into two categories: measures that improve the ability to allow the flood to flow, and measures that temporarily store the flood around the river to slow runoff to the river and reduce peak flood flow.

Table 8.1 shows the characteristics of each measure

Table 8.1 Structural Measures Options

	Flood Control Strategy	In-stream	Basin	Information
Prevention and mitigation	Reduce flood Dikes, levees and polders Diversion channel, short-cut Channel improvements Dams and reservoirs	 ✓ ✓ ✓ ✓	 ✓ ✓ ✓ ✓	

1) Dike/flood wall

Dike/flood wall is a structure to prevent the flood discharge from overflowing within the area enclosed by the structure. Dam/flood wall is a measure that works effectively when it is built continuously.

Since it is not realistic to contemplate the continuous installation of these structures along the entirety of the rivers in Colombia from the point of view of land use and cost, these structures are valid measures of local protection of (to circle) the municipalities along the river where the population and the assets are concentrated.

The rupture of dikes and flood walls is a direct cause of disasters. Therefore, its durability and safety are important. Normally, the dike is constructed using the sediments of the river bed and near the construction site. As there are some criteria on whether the particle size, viscosity, etc. of sediment are suitable materials for the dike, the technical document on the materials for dikes should be consulted.

Flood wall	Dike
- Prevent the entry of flood with a wall. - Structure of metal and concrete ▲ High implementation cost 	- Prevent the entry of flood with a slope of land. - As a base rule the sediments of the target river are used ▲ Cheaper than a flood wall, but require measures against erosion in steep rivers. 

Figure 8.2 Examples of Flood Wall and Dike

2) Cut off work

It refers to the measure where a meandering channel is straightened to increase its capacity to allow the flood to flow.

By straightening the channel, the capacity of the channel to allow the flood to flow is increased, since the length of the channel is reduced and the slope of the riverbed is increased. However, in rivers that have a stable river bed with meanders, this stability will be lost. For example, upstream of the shortened section, water velocity is increased and sediment transport is facilitated, deepening the riverbed. In contrast, in waters below the shortened section, there is a possibility of sediment accumulation. It is important to take into account the above described to implement this measure, from a long-term stability point of view.

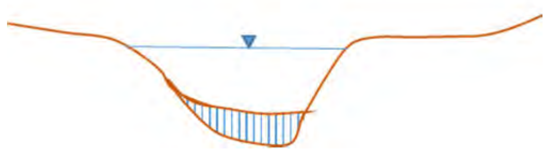
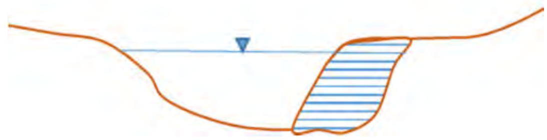
In Colombia, cut off work has been implemented in the Canal del Dique, in the section below the Magdalena River, in order to reduce the time required for navigation.

Source: elaborated by the JICA Project Team

Figure 8.3 Example of Cut-off Work in a Hydraulic Model

3) River channel improvement

It is a measure where the channel capacity is increased to allow the flood to flow, increasing the area of the cross section of the river by widening or dredging the channel.

Dredging the river bed	Channel expansion
- Carry out dredging in the channel bed, increase the channel area where water can flow and reduce the level of flooding. ▲ It requires hundreds of meters of dredging in the longitudinal direction. Maintenance problems	- Expand the channel horizontally, increase the channel area where water can flow and reduce the level of flooding. ▲ Requires hundreds of meters of amplification in the longitudinal direction. Maintenance problems.
	

Source: elaborated by the JICA Project Team

Figure 8.4 Channel Improvement Method

4) Reservoir / dams

Reservoir is a structure that counteracts flood by storing flooding outside the riverbed in the plains on temporarily to reduce the discharge in the channel downstream the reservoir during the flood.

The area where the wetlands extend along the river can now function as a natural reservoir in some cases. By preserving the current condition by regulating development, etc., it is possible to maintain the function of storing flood. If there are areas that can not be flooded around wetlands, such as residential areas, there is also a method of building a dike around the area that preserves the function of storing the waterand.

Source: Website of MLIT,
Iwate Office of the River and National Roads

Figure 8.5 Summary of the Function of Flood Control with Reservoir

The dam for flood control is a structure that controls the discharge of the channel below the dam during the flood by temporarily storing the river water in its reservoir. The water stored in the reservoir of the dam is gradually released downstream after the flood.

In Colombia, there are dams for hydroelectric generation or the water use. If the function of flood control is added, they are converted into multipurpose dams.

Source: MLIT website

Figure 8.6　Example of Multipurpose Dam

In Japan, there are several multipurpose dams that have functions of flood control, hydroelectric generation, water use and the environment.

Source: Web Page of the Chubu Region Planning Office, MLIT

Figure 8.7　Summary of Flood Control by Dam

8.6 Study of Non-Structural Measures

Non-structural measures are measures to reduce flood damage used along with structural measures. They are also measures that have the effect of minimizing damage in the event of a flood that exceeds the design scale of the structural measures plan.

【Explanation】

Structural measures represented by levees / retaining walls directly alleviate flood damage. However, if the flood design scale, levees alone can not mitigate floods completely. Non-structural measures are studied for such cases. Table 8.2 shows the options for non-structural measures.

Table 8.2 Non-structural Measures Options

	Flood Control Strategy	In-stream	Basin	Information
Prevention and Mitigation	<u>Preserving the Natural Resources of Floodplains</u> Floodplain zoning and land use regulation <u>Reducing Susceptibility to Damage</u> Floodplain regulation, storm water retention Surface water infiltration Flood proofing buildings and facilities	✓ ✓ ✓ ✓	✓ ✓ ✓ ✓ ✓	
Preparedness and Response	Flood forecasting and warning	✓	✓	✓
Rehabilitation and Reconstruction	Flood insurance	✓	✓	✓

1) Land use regulations in floodplains

It is realistic to reduce flood damage by reducing the discharge with flood storage in the floodplains to control the flood in the principal rivers without dams that have immense floodplains.

For this purpose, it is important to consider the concept "floodplain management = land useregulation " as flood mitigation measures.

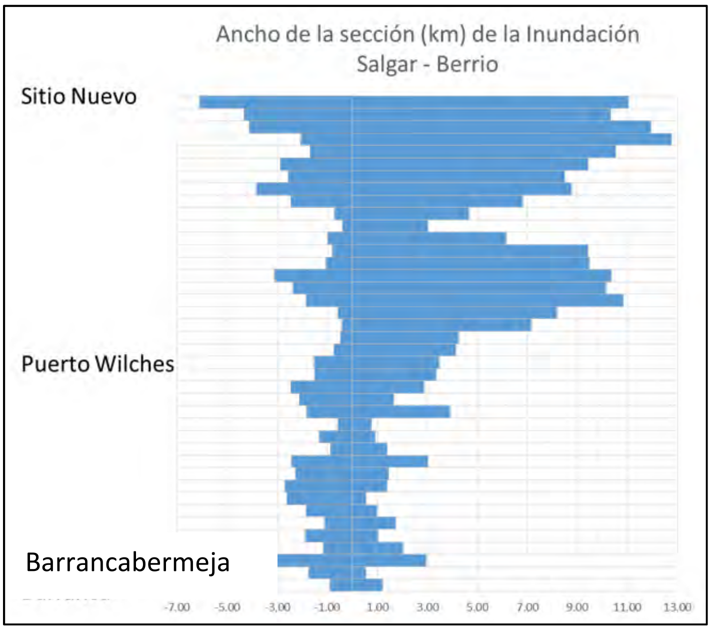
For example, approximately 68% of Colombia's natural wetlands are located in the Magdalena River basin. Therefore, wetlands and marches are important medium between developed areas and the river.

Wetlands and marshes in the basins store flood in the same manner as dams, and delay the runoff into the principal river, reduce the discharge and contribute to the reduction of flood damage. The conservation of these wetlands is not only an effective and feasible method from the point of view of the flood measures but also from the environmental and economic point of view.

The proportion of the flood that flows through the floodplains is high, and the development of the floodplains should be avoided as much as possible, in order to reduce flood damage.

Below is an example of the calculation of non-uniform flow, where the data set of the cross sections of the channel and floodplains were prepared with the topographic survey data (IDEAM) and the height data obtained by satellite images, taking into account the middle basin of the Magdalena River as the target area, based on the idea of "considering the floodplains as part of the river".

In this case, the flood width was maximum 17km during the flood, and that the flood can be seen flowing through the floodplains.

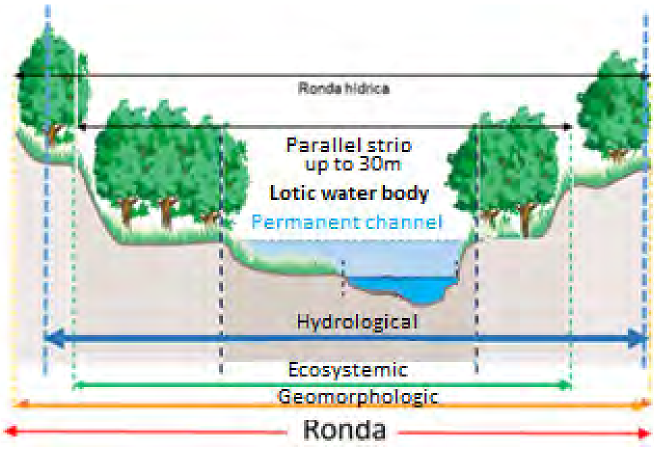


Source: elaborated by the JICA Project Team based oncalculations by IDEAM

Figure 8.8 Example of Flood Width Calculations in the Magdalena River during 2011

As presented in the chapter 3 according to the Ministry of the Environment and Sustainable Development, progress is being made in the revision of the Ronda Hidrica, taking into account the experiences of the 2010-2011 flood, as a basis for the land use regulation in floodplains.The key points of this process are the following:

- The Ronda will be delimited from the hydrological (floods), ecosystem and geomorphological points of view,
- The Ronda will be defined using the outer-most line of the three elements described above.
- The zone between the previous Ronda and the new Ronda will be a conservation zone.



Source: MADS

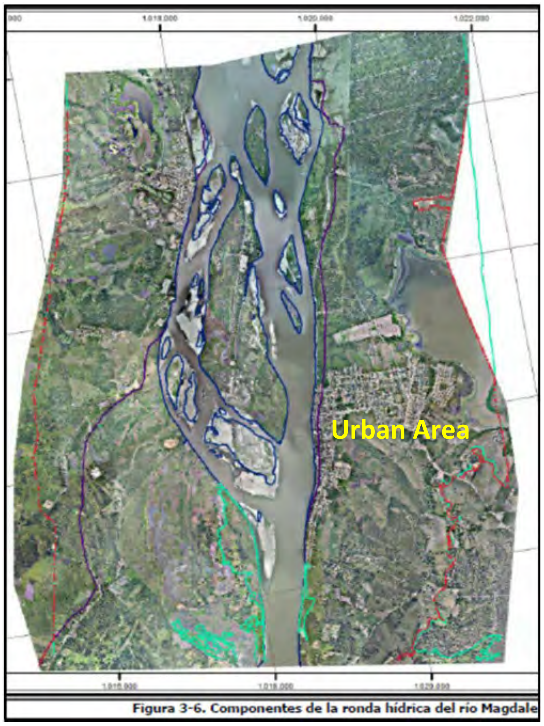
Figure 8.9　Ronda taking into Account 3 elements

Regarding the hydrological point of view (floods), the flood wirg the return period of 25 years is taken into account (calculation in process).

The process of legalization is in process. The figure that summarizes these concepts is presented below:

On the right is an example in Puerto Wilches prepared by the Ministry of Environment.

- Red : outer-most line : Ronda (new)
- Green : Hydrological area (flood area, 25 years return period)
- Blue : old channel
- Purple : geomorphological area



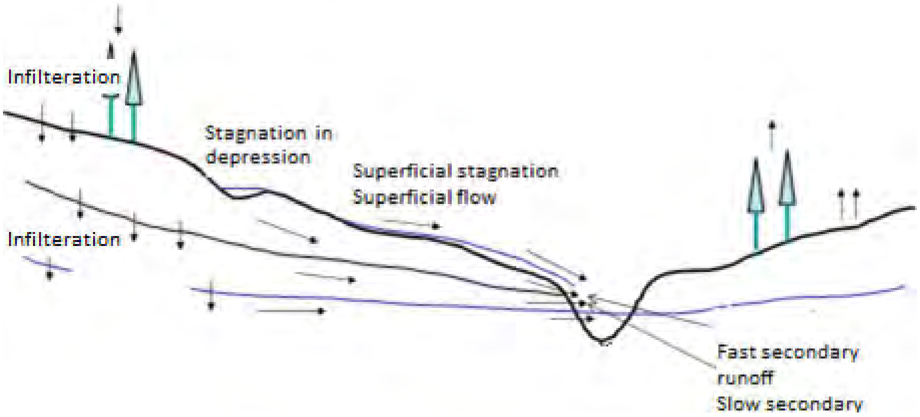
Source: MADS

Figure 8.10　Example of Delimiting New Ronda in Pto.Wilches

2) Forest Conservation

Forest conservation as measures to mitigate flooding refers to the control of the discharge and sediment runoff during the flood with the reduction of runoff in lands without vegetation by means of tree planting or the improvement of underground penetration of the rainfall through partial cutting of forests.

As shown in the following figure, planting trees on land without vegetation delays surface runoff, and surface runoff is reduced by the ease of underground penetration of rainfall and the consequent increase in secondary runoff. In case of cutting trees down for development, it is necessary to study appropriate measures, such as the limitation of the deforestation area, considering the influence of runoff from rainfall.



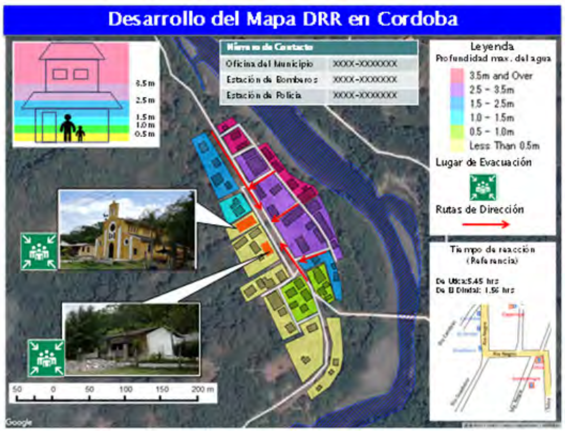
Source: Website of the Asai Research Room of Yamaguchi University

Figure 8.11 Mechanism of Rainfall Runoff

3) Organization of flood disaster risk reduction map

The disaster risk reduction map (flood) is a map that is made with the main goal of preventing damage to the population, providing residents with information related to flood and evacuation in a way that is easy to understand.

The disaster risk reduction map (flood) contains the projected flood area, the location of the shelters, and evacuation routes. Residents evacuate referring to this map in case of flooding, and flood damage is minimized.

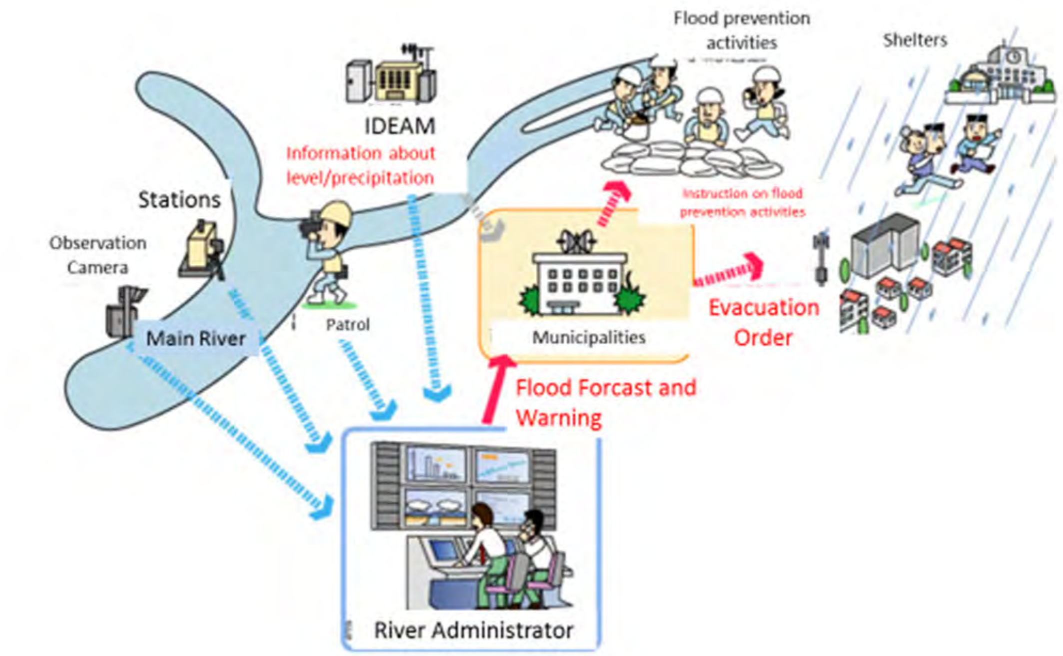


Source: elaborated by the JICA Project Team

Figure 8.12 Example of Disaster Risk Reduction Map (flood)

4) Flood forcast and warning

Flood early warning refers to the issuance of alert as needed, which shows the water level and discharge during the flood and which serves as a reference for flood prevention activities due to overflow or increased water level of the river, or for evacuation of residents. The flood warning is issued based on the results of the observation of the level and rainfall and the results of the water level forecast based on the runoff calculation. Flood warning is used for flood prevention activities of departments and municipalities, and is communicated to local residents through municipalities and communication systems.



Source: Website of the MLIT

Figure 8.13 Summary of the flood forecast and warning

In Colombia, the introduction of the agricultural subsidy for farmers in the floodplains and the flood insurance as conservation measures for the floodplains (result of the interview with CORMAGDALENA) was discussed. It is assumed that this is due to their intention to increase the regulatory power on housing and agricultural activities within the basin with the economic factor.

Flood insurance is out of the scope of this guideline; however, the US case is presented in a column as a reference for future discussions.

Column Flood Insurance

Flood insurance is a way to regulate and guideline the land use within the floodplains in order to prohibit or control the construction of housing in these areas.

Currently flood insurance does not exist in Colombia. However, in the United States there is an example of the flood insurance system led by the federal government.

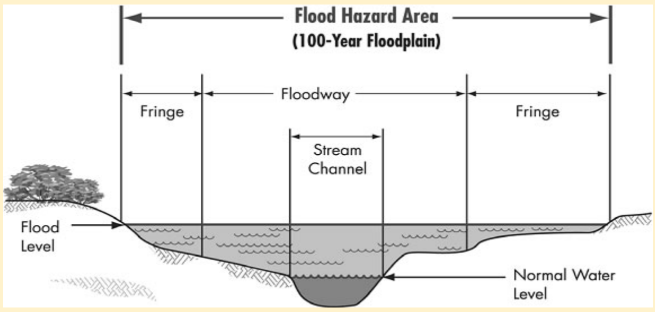
In the case of the USA, it is basically forbidden to live in the floodplains. However, residents who decide to live in the floodplains are required to obtain flood insurance. In order for a resident to obtain flood insurance, their municipality must be affiliated with the flood insurance.

In the US, the federal government has no responsibility to compensate victims for flood damages.

In the US, FEMA (Federal Emergency Management Agency) performs risk mapping, risk assessment and plan formulation (the risk map program), identifies flood hazards and assesses the flood risks. This data is entered into the flood maps called FIRM (Flood Insurance Rate Map). These are the basis of support from the national flood insurance support program, community floodplain management standards, and conditions for affiliation with flood insurance.

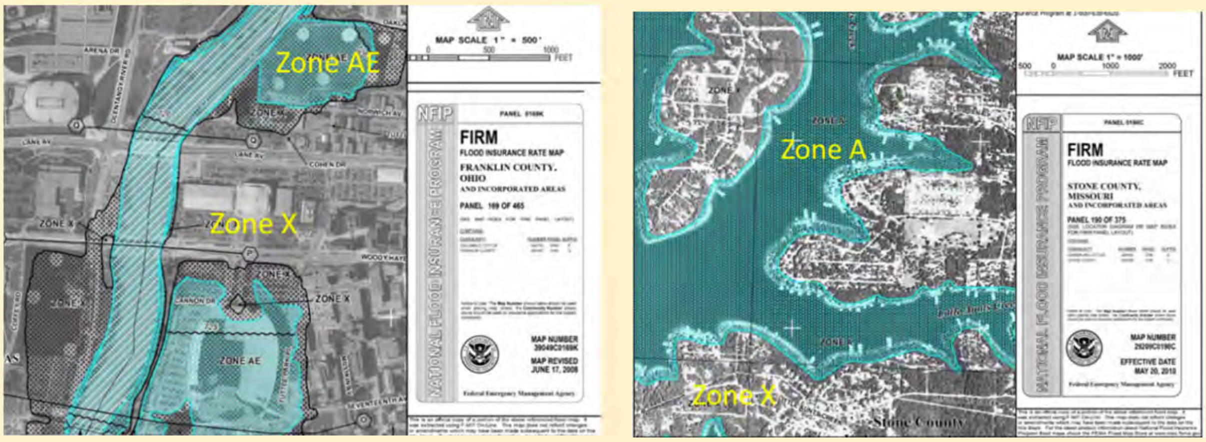
Regulations in flood insurance in the US.

- Standard flood has 100 year return period
- The flood hazard area is divided into "floodway" and "fringes".
- The passage of the flood is determined by the engineering study of the river
- "Fringes" are the areas between the floodplains of the 100-year return period and the passage of the flood.



Source: FEMA

Figure 8.14 Methodology to Identify the Flood Hazard Zone in the US Flood Insurance



Source: FEMA

Figure 8.15 Map of the Flood Insurance Rate

Zone B and Zone X (shadowed): an area of average flood hazard. It is a zone protected by dikes, located between the flood plains of the return period of 500 years and 100 years normally, or a drainage area with an average depth of less than 1 foot and with an area smaller than 1 square mile.

Zone A: an area with less than a 1% chance of a flood occurring in a year, and with less than a 26% chance of the flood occurring within the 30-year mortgage. Since a detailed study is not carried out here, there is no information about the depth and basic water levels.

9. Formulation and Comprehensive Assessment of the IFMP-RP

9.1 Development of the Flood Management Plan (Focused on the Flood Sector)

In the process of formulating the IFMP, coordination among entities at the national and regional levels in order to reach an agreement is extremely important. In such case, it is appropriate for the Ministry of Environment and Sustainable Development, IDEAM and the relevant entities in each target basin to lead the process.

The IFMP-RP should be studied following the order described in this guide, as a base rule.

【Explanation】

It is necessary for the leading entities of the formulation of the IFMP-RP to work in an integrated fashion with the Environmental Authorities or local municipalities, take each step of the following list and develop the steps described below in order to reach an agreement as a minimum requierement (projected).

- Publicize the purpose of the preparation of the IFMP-RP: Chapters 1-4 of the guide.
- Confirm the items to coordinate with other sectors: Chapter 5
- Select problems related to flood in the basin: Chapter 6
- Determine basic policy for measures to mitigate the flood: Chapter 7
- Present measures based on technical studies and comprehensive assessment: Chapter 8
- Reach agreements among the relevant entities regarding the measures based on the comprehensive assesment: Chapter 9
- Reach agreements among the relevant entities regarding the plan: Chapter 9

It should be taken into account that the target area of the study in the IFMP-RP are the channel and the floodplains (in some cases it includes the measures in the basin).

IDEAM provides information on the water level within the channel, discharge and rainfall in the floodplains and performs a part of the analysis.

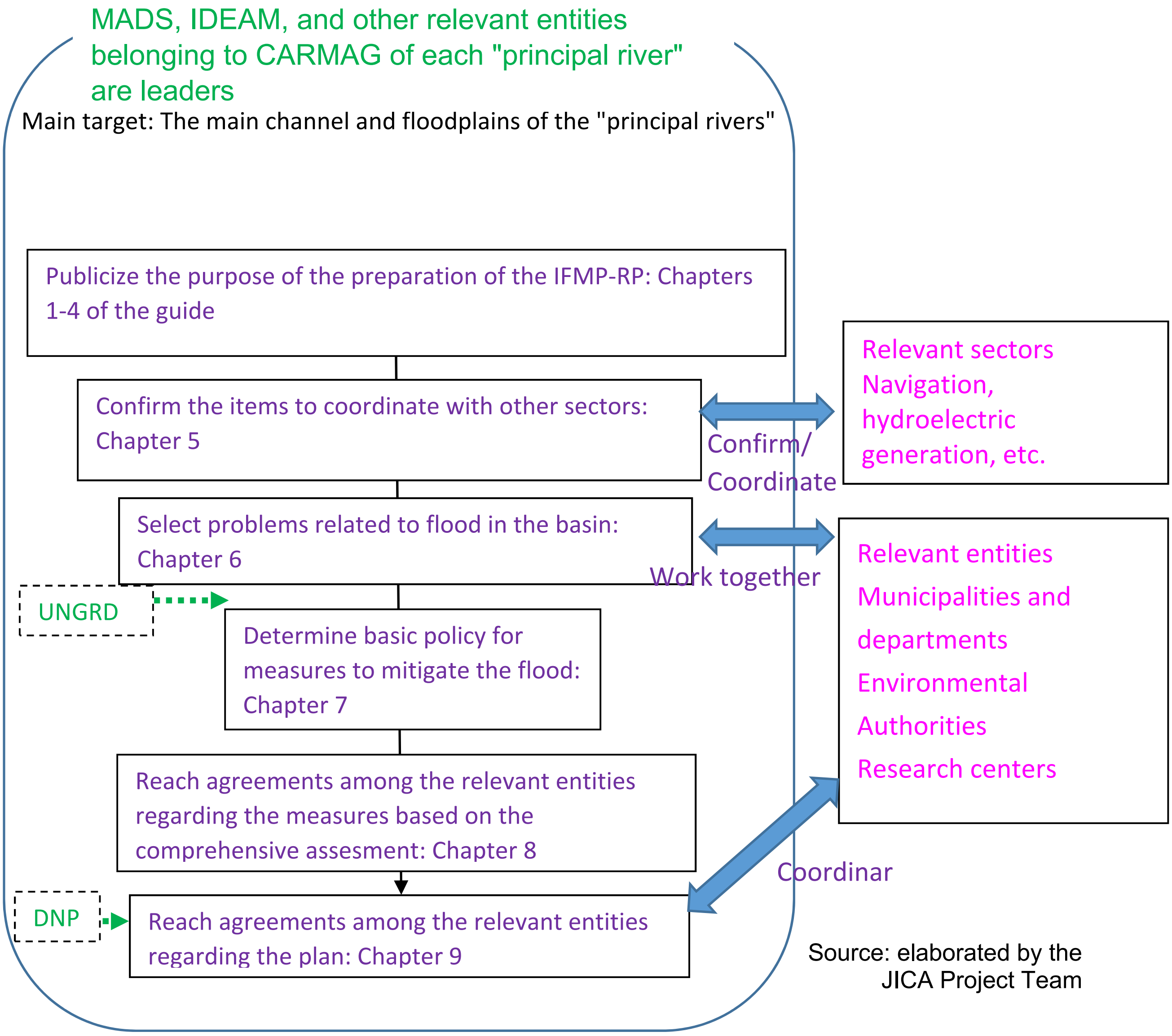
There are entities that have responsibility and authority over navigation within the channel (CORMAGDALENA in the case of the Magdalena River).

TheEnvironmental Authority is the entity that has the responsibility and authority in the floodplains. The Ministry of Environment can instruct Environmental Authorities through the POMCA guideline.

It is not clear which entity has the responsibility and authority if the focus is measures to mitigate flood within the riverbed and floodplains. However, it is appropriate for the MADS, IDEAM and the relevant entities of the objective "principal river" (CORMAGDALENA as an allied entity in the case of the Magdalena River) to lead the formulation of the IFMP-RP.

In particular, MADS should be the entity that leads the general formulation process through coordination with the relevant entities such as Environmental Authorities, local municipalities within the framework of CARMAC.

The Orinoco and Amazon basins are of international rivers, and it is projected that the coordination of flood mitigation measures, including the use of the river in downstream countries, will be even more complex. Therefore, it is considered appropriate for an entity at the national level to lead the process of formulating the IFMP-RP.



Source: elaborated by the JICA Project Team

Figure 9.1 Formulation Steps of the IFMP-RP and Relevant Entities

Regarding the implementation of the items in IFMP-RP, within the framework of the existing regulations and in agreement in the CARMAC, it will be the responsibility of the entities that comprise the CARMAC to carry out the activities for the risk mitigation and reduction in the channel and floodplains of the rivers targeted by IFMP based on their jurisdictions.

9.2 Clarifying the Role Sharing

The responsibilities in the preparation of the IFMP-RP and in the implementation of the measures based on the IFMP-RP are shared among the relevant entities.

【Explanation】

There are cases in which the relevant entity that should lead the process changes according to the stage in which the formulation of the IFMP-RP is (recognizing problems/studying measures / reaching an agreement/implementing the measures).

Below is an example of a study of the role shaing in different stages of planning and in floods of different magnitudes.

Table 9.1 Example of the Role Sharing

Items to implement				Central Governmanet				Regional Government			
				UNGRD	CARMAC	MADS	IDEAM	COR MAGDALENA	Departamento	CAR	Municipio
Recognition of problems	Understand flood damage situations	Where did the flood occur? The magnitude of the damage (response just after disaster)	current situation	Support during large scale flood			information providing		Support during mid scale flood		○
			ideal	Support during large scale flood			information providing		Support during mid scale flood		○
		The cause of the flood?	current situation				Implement against large scale flood			Implement agaisnt middle scale flood	△
			ideal				○	Support	Support	Support	Support
	Comprehensive assessment and organization of problems		current situation							△	
			ideal	○	○	○	Support (only for hazard)	Support	Support	Support	Support
Study measures	Determine the goal of flood risk management - Determine target area and design scale		current situation				information providing		○		○
			ideal	○	Support	Support	○	Support			
	Where will these measures be implemented? - Determine design flood discharge and inundation area - Study of cost benefit ratio		current situation				information providing		○		○
			ideal	○	Support	Support	○	Support			
Impliment structural measure (Levee development)		Study and design	ideal	○			information providing	Support	Support	Support	Support
		Works	ideal	Support			information providing	Support	Support	○	Support
		Maintenancee and administration / Monitoring	ideal	Support			information providing	Support	○	○	○
Implement non-structural measure (Land use regulation in floodplains)		Policy and guideline	ideal			○					
		Study and planning / Regulation / Monitoring	ideal							○ Land use management	

○ : Principal entity

10. Revision of IFMP-RP

The IFMP-RP should be reviewed after the formulation at an appropriate time. Monitoring is carried out on the contents, and IFMP-RP is updated as needed.

【Explanation】

After the formulation of the IFMP-RP, it is also necessary to collect data on the damage and the cause if a large flood occurs again to accumulate more complete data.

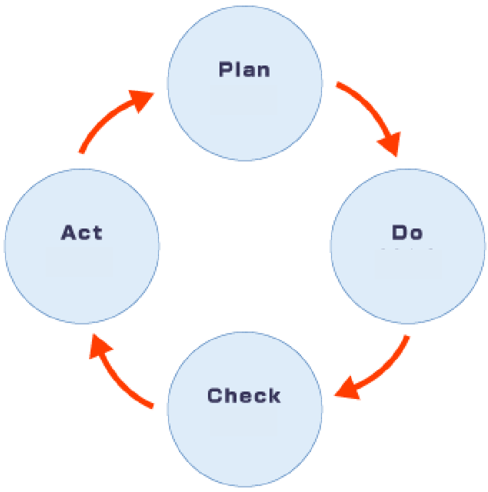
These ongoing monitoring activities help improve IFMP-RP and flood prevention techniques.

It may also be necessary to carry out discussions on the role sharing among related entities if there is a change in the entities related to disaster prevention.

A methodology to perform the review in an organized manner is the PDCA cycle methodology (Plan, Do, Check, Act).

Repeating 4 steps that are "Plan → Do → Check → Act", we try to improve the level of each stage (spiral up, spiral improvement) and work continuously.

The stage of "Do" for flood management based on this guideline has not yet been carried out. However, should the situation that requires the revision in the implementation stage arise, the desirable action for the continuous management of the river is to refer to the PDCA cycle, "check" and "act" to improve the plan.



Source: elaborated by the JICA Project Team

Figure 10.1 PDCA Review of the plan based on the PDCA cycle