MINISTRY OF AGRICULTURE AND ANIMAL RESOURCES
REPUBLIC OF RWANDA

DATA COLLECTION SURVEY ON IRRIGATION DEVELOPMENT IN NGOMA DISTRICT OF EASTERN PROVINCE IN RWANDA

Final Report

July 2012

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

Sanyu Consultants Inc.

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PREFACE

Japan International Cooperation Agency (JICA) decided to conduct “DATA COLLECTION SURVEY ON IRRIGATION DEVELOPMENT IN NGOMA DISTRICT OF EASTERN PROVINCE IN RWANDA” and entrust the survey to Sanyu Consultants Inc.

The survey team held a series of discussions with the officials concerned of the Government of the Republic of Rwanda, and conducted the field survey. As a result of further studies in Japan, the present report was finalized.

JICA dispatched the study team to Rwanda from March to June, 2012.

I hope that this report will contribute to the promotion of the project and to the enhancement of friendly relations between our two countries.

Finally, I wish to express my sincere appreciation to the officials concerned of the Government of the Republic of Rwanda for their brotherly and their cooperation given to the survey team.

July, 2012

Teruyoshi KUMASHIRO
Director General,
Rural Development Department
Japan International Cooperation Agency

S U M M A R Y

Schematic Concept

【Construction cost】: 4,215,000,000 RWF (7,000,000 US$, Based on local costs)
Contents; Dam and spillway: 1.93 million US$
Intake and irrigation facilities: 4.27 million US$
Temporary works: 0.80 million US$
*The construction cost related to irrigation facilities is predominant due to the introduction of pumping irrigation system and the increase of construction cost for on-farm irrigation facilities brought from the introduction of saving irrigation.

【Beneficial Area】: 275ha (Dry field 240ha, Paddy field 35ha)
- Gravity Irrigation Area: 149ha (Dry field 114ha + Paddy field 35ha)
- Pumping Irrigation Area: 126ha (Dry field 126ha)

【Water Resources Plan】
- Utilization possibility of river water : 709,000m^3
  (The dry year with the probability occurrence of 3/10)
- Under water and surface water : 158,000m^3 (Supplemental water resources)

【Water Resources Facilities】
Specifications of Dam
- Dam height: 13.55m
  (Foundation excavation 1.5m, Included in Overflow flood water depth 0.35m and Freeboard 1.1m)
- Volume of dam : 86,400m^3 (Main bank48,700m^3， Blanket 37,800m^3)
- Reservoir capacity: 700,000m^3
  (Effective storage capacity 450,000m^3， Dead water capacity 250,000m^3)

Groundwater use facilities (Supplemental water resources)
- Number of installed: 3 locations

【Irrigation Canal】
- Main canal and lateral canal : 27.3km（Open canal）+ 2.5km（Pipe line）
- Secondary canal : 36km（Pipe line）

【Pumping Station】： 17location (Solar pump : For each one)

【Execution Schedule】
- Construction period: 1 year
- Flooding examination: 1 year

【Main Crop】
- Main crop : Rice, Maize, beans, Vegetables (Carrot, Tomato, Cabbage, Tree tomato), Coffee
- Annual land use rate (Cropping rate) : 185%

【Project evaluation】
- Internal Rate of Return : Economic 12.1%, Financial 15.7%
- Benefit/ Cost Ratio : Economic 1.01, Financial 1.36
- Net Present Value: Economic 23,000, Financial 1,550,000

1. Irrigation Project Plan

(1) Beneficial Area : 275ha

- Crops distinction : Dry field 240ha，Paddy field 35ha
- Different irrigation methods :

  Gravity Irrigation Area: 149ha (Dry field 114ha + Paddy field 35ha)

  Pumping Irrigation Area: 126ha (Dry field 126ha)

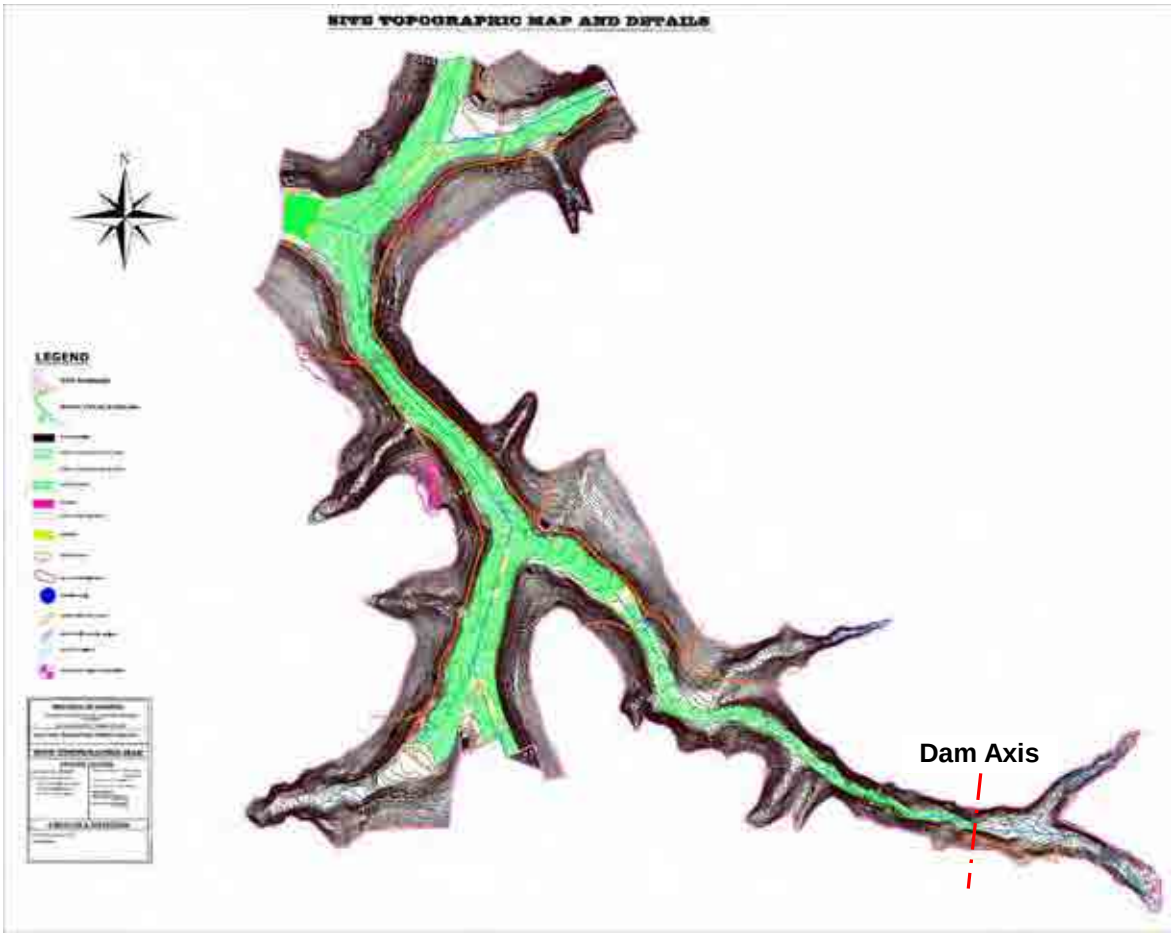


Fig. Plan of beneficial area

(2) Water Resources Plan

(a) River

- Reference year for design : 1970 AD
- Available flow quantity : 709,000m^3

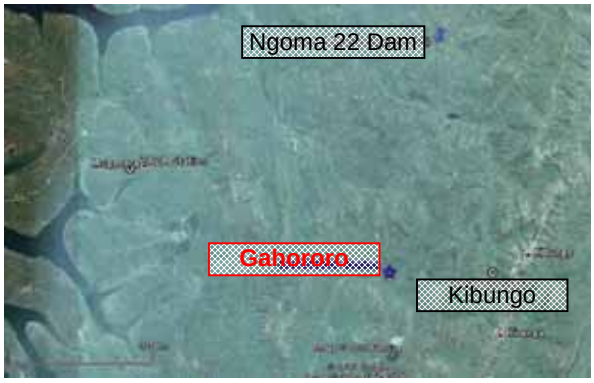


Fig. Location of observatory (Gahororo)

(b) Under water and Surface water (Supplemental Water Resources)

- Potentiality : 158,000m^3

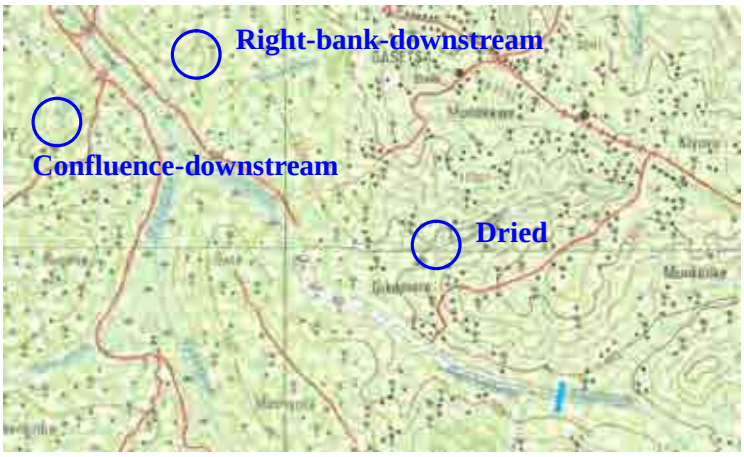


Fig. Location map of candidate site of grand water for gravity irrigation

(3) Main Construction Work Plan

(a) Water Resources Facilities

Dam

- Catchment area : 8.8km^2
- Type of dam : Homogeneous embankment dam
- Dam height: 13.55m
  (Foundation excavation 1.5m, Included in Overflow flood water depth 0.35m
  and Freeboard 1.1m)
- Crest length : 180m
- Volume of dam : 86,400m^3(Main bank48,700m^3, Blanket 37,800m^3)
- Foundation treatment method : Blanket method of construction
- Reservoir capacity: 700,000m^3
- Active capacity : 450,000m^3(Available depth : 4.1m = FWS 1,390.60m - DWS 1,386.50m)
- Dead capacity : 250,000m^3(Raising water depth: 6.5m = DWS 1,386.50m - EL. 1,380.00m,
  Include sediment 30,000m^3)

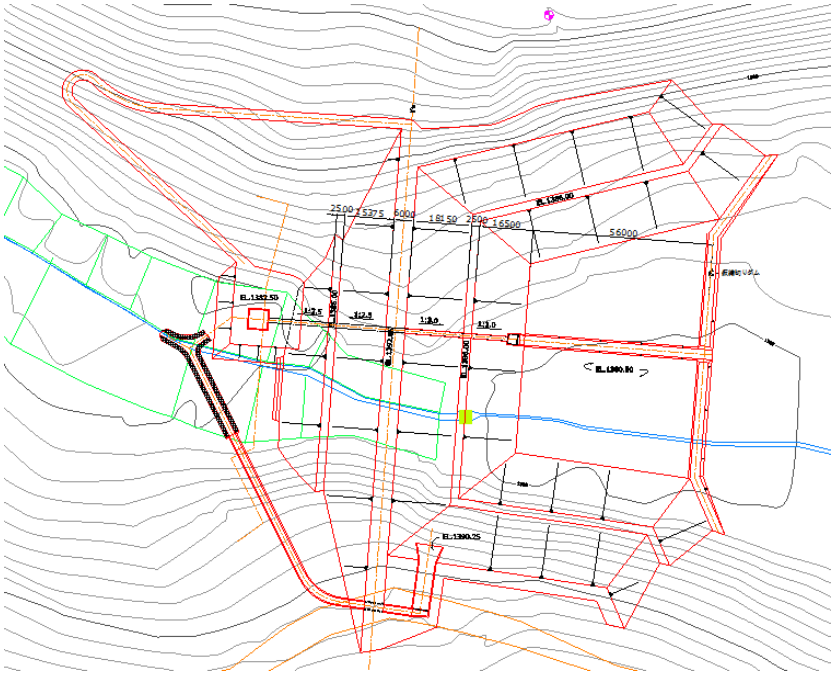


Fig. General plan of dam

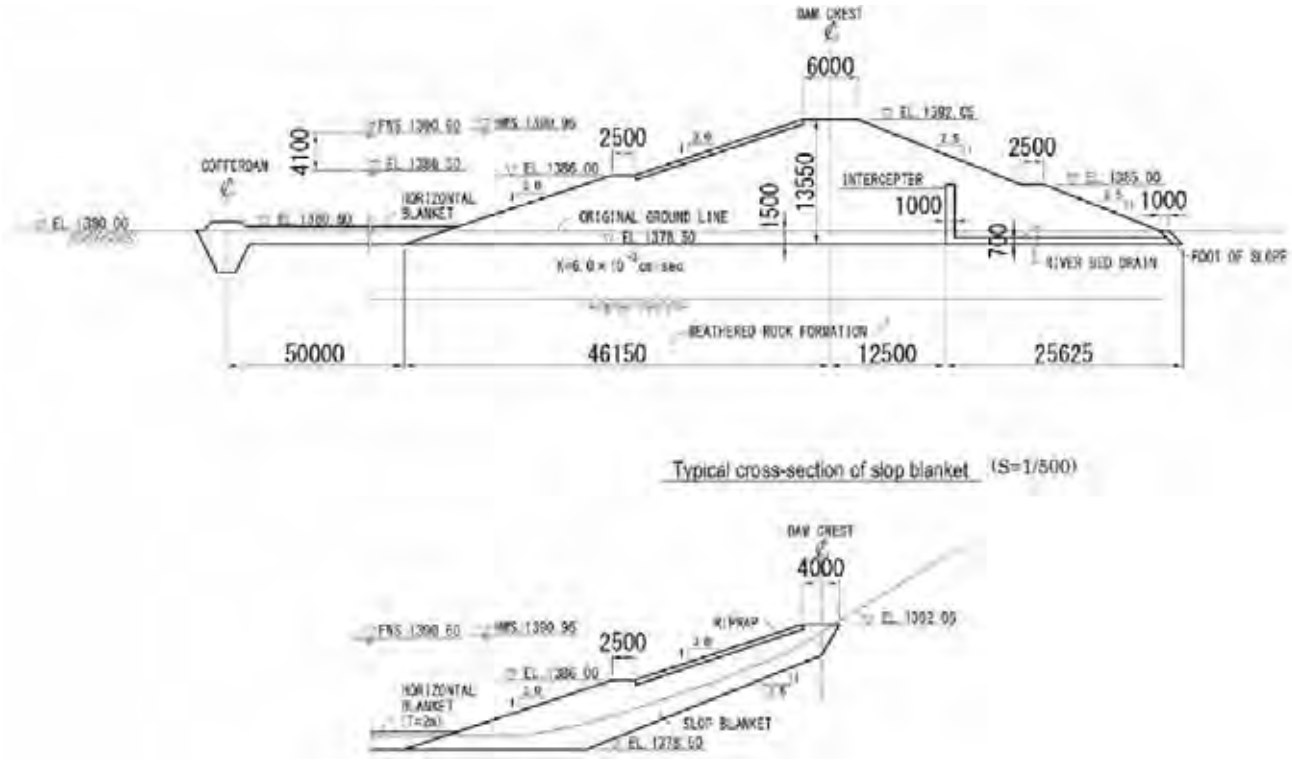


Fig. Typical cross-section of dam

Spillway

- Type of spillway : Side weir type
- Design flood discharge : 2.2m^3/sec (50 years probability)
- Overflow depth : 0.35m (= HWS 1,390.95m - FWS 1,390.60m)

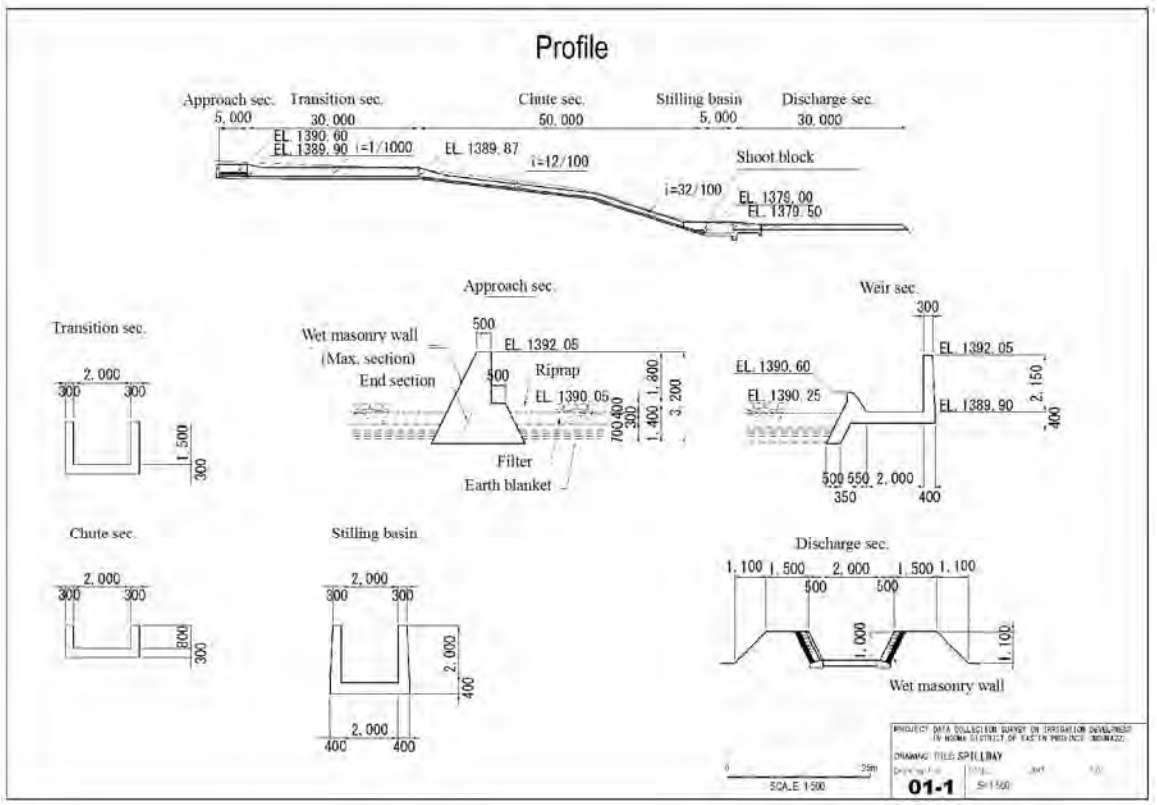


Fig. General Profile of Spillway

Intake facilities

- Type of facilities : Intake tower + Bottom outlet
- Water intake method : Surface water intake with the water intake gate

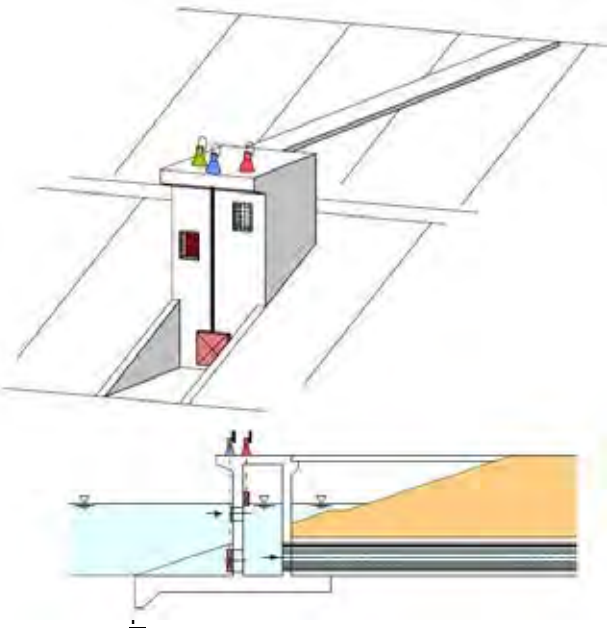
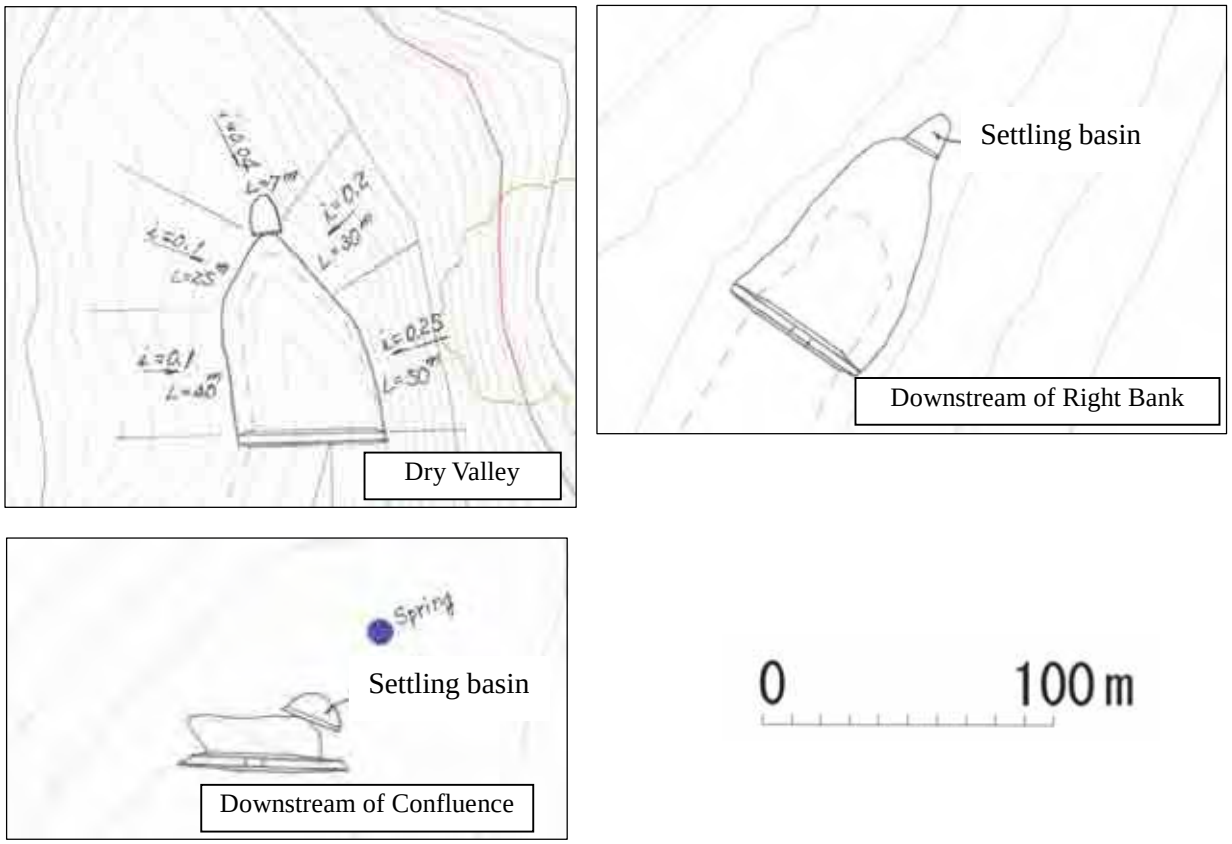


Fig. Image of the intake facilities

Groundwater use facilities (Supplemental water resources)



- Type : water-stop work (Soil cement, 3 locations)

Fig. Plan of water-stop work

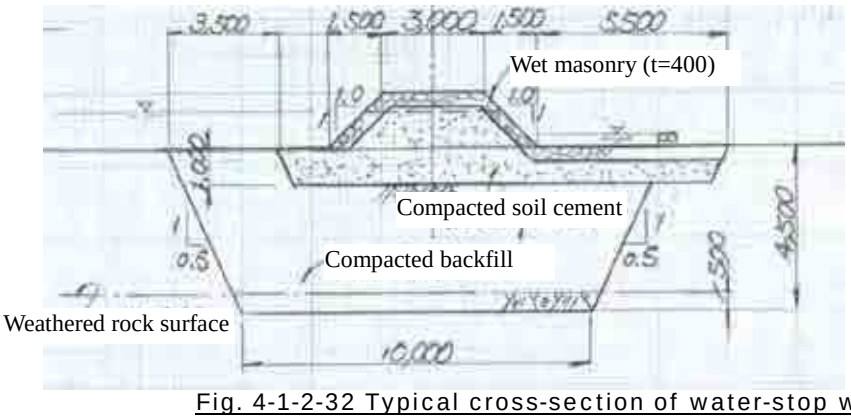


Fig. 4-1-2-32 Typical cross-section of water-stop work

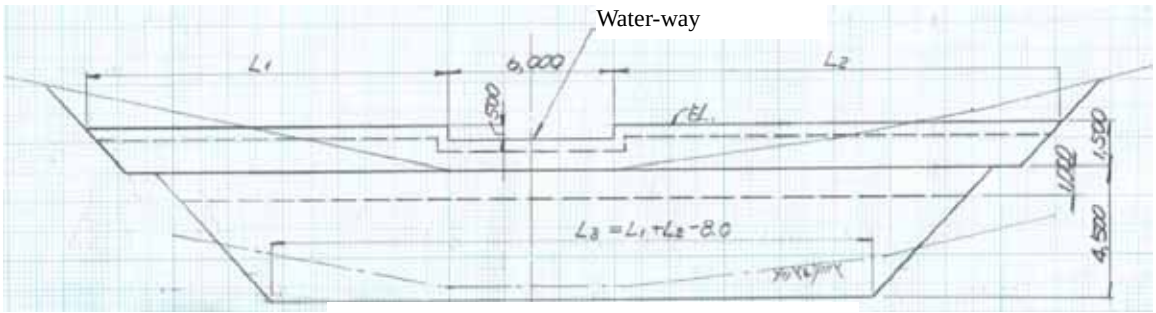


Fig. 4-1-2-33 Longitudinal profile

Table Specifications of water-stop work

Location	Crest EL.	Crest Length	L1	L2	L3	Pond Capacity
Dry Valley	EL.1397.0	35.5m	13.2m	16.3m	21.5m	1,300m^3
Downstream of Right bank	EL.1378.0	51.0m	24.0m	21.0m	37.0m	3,000m^3
Downstream of Confluence	EL.1370.5	53.0m	19.0m	28.0m	39.0m	470m^3

(b) Irrigation Facilities

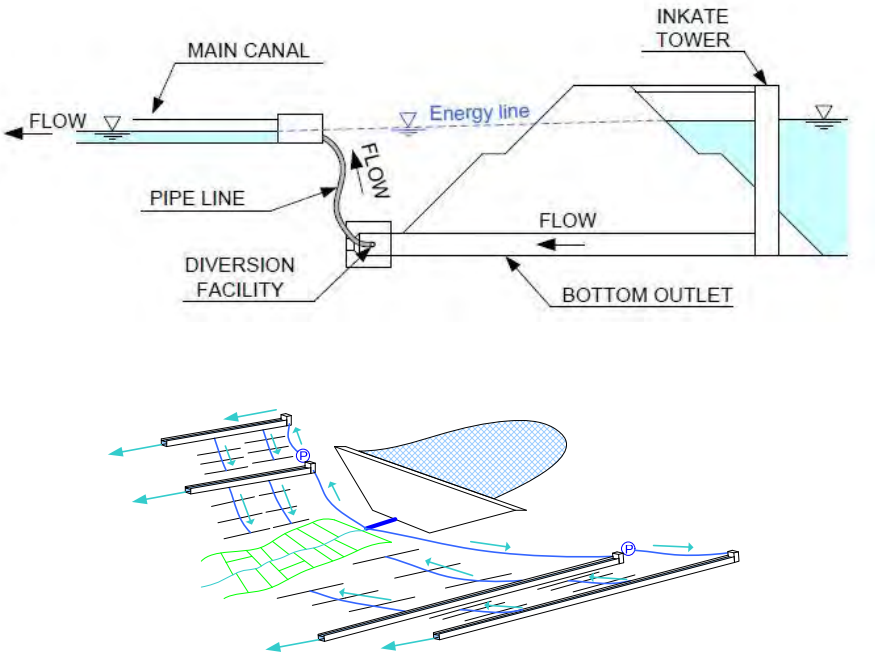


Fig. Image of diversion of the main canal

Irrigation Facilities of Dry Field

i. Main Canal

- Type : Wet masonry
- Canal length : 14.3km (Left bank : 5.3km, Right bank : 9.0km)

ii. Pumping Station (solar pump)

- Number of installed: 17 locations (Irrigation area : 7.6ha/ unit)
- Output : 3.7kw
- pump head : 20m
- Average of water discharge : 5.6ℓ/sec

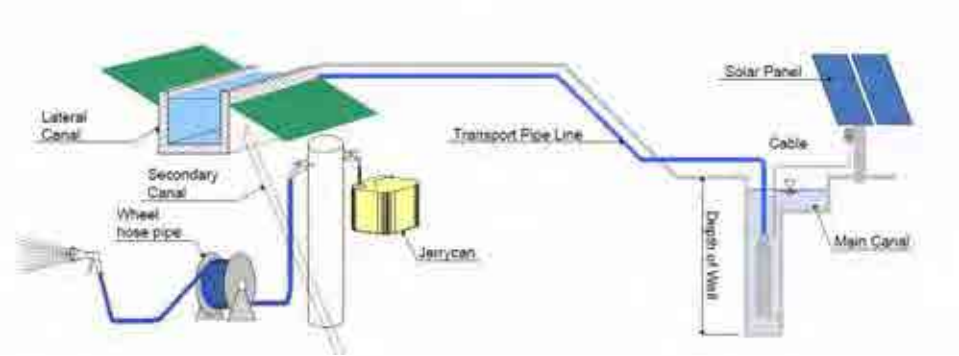


Fig Image of the pumping irrigation

iii. Lateral Canal

- Type : Wet masonry
- Canal length : 13.0km (Left bank : 4.7km, Right bank : 8.3km)

iv. Secondary Canal (on-farm canal)

- Type : Pipr line (HDPE pipe)
- Pipe line length : 36.0km

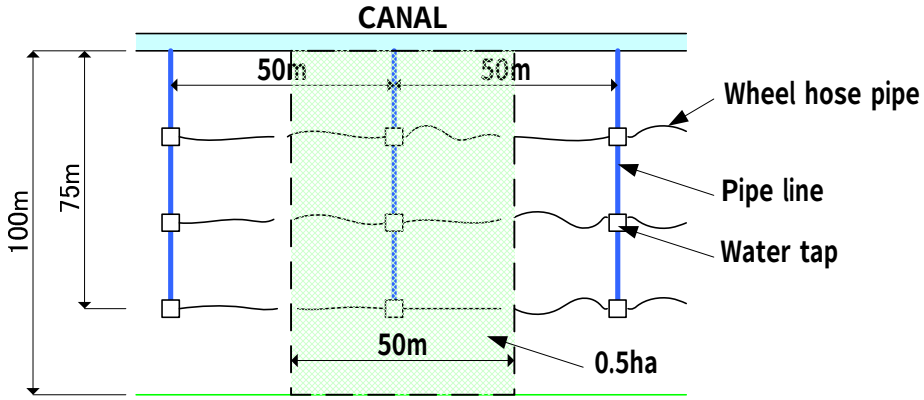


Figure Secondary canal

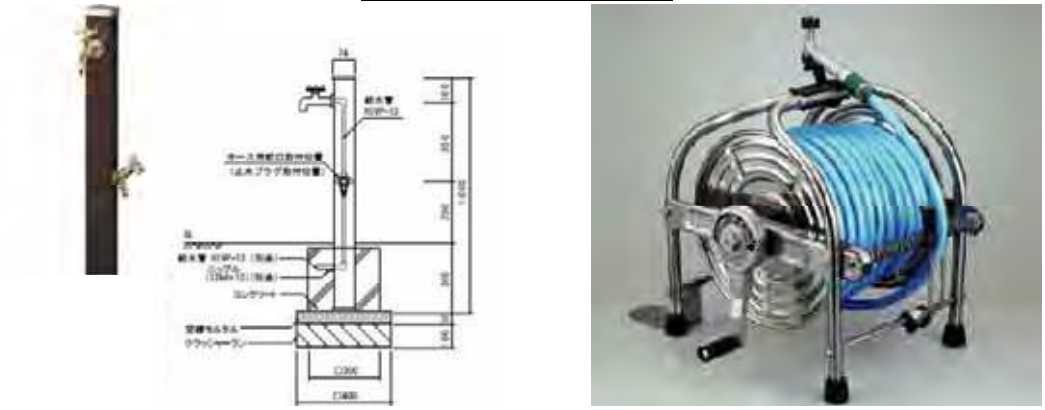


Figure Water tap and Wheel house pipel

Irrigation Facilities of Paddy Field

- Intake facility : Check gate (Status of use, 20 locations, 200m interval)
- Canal :Lined canal wet masonry

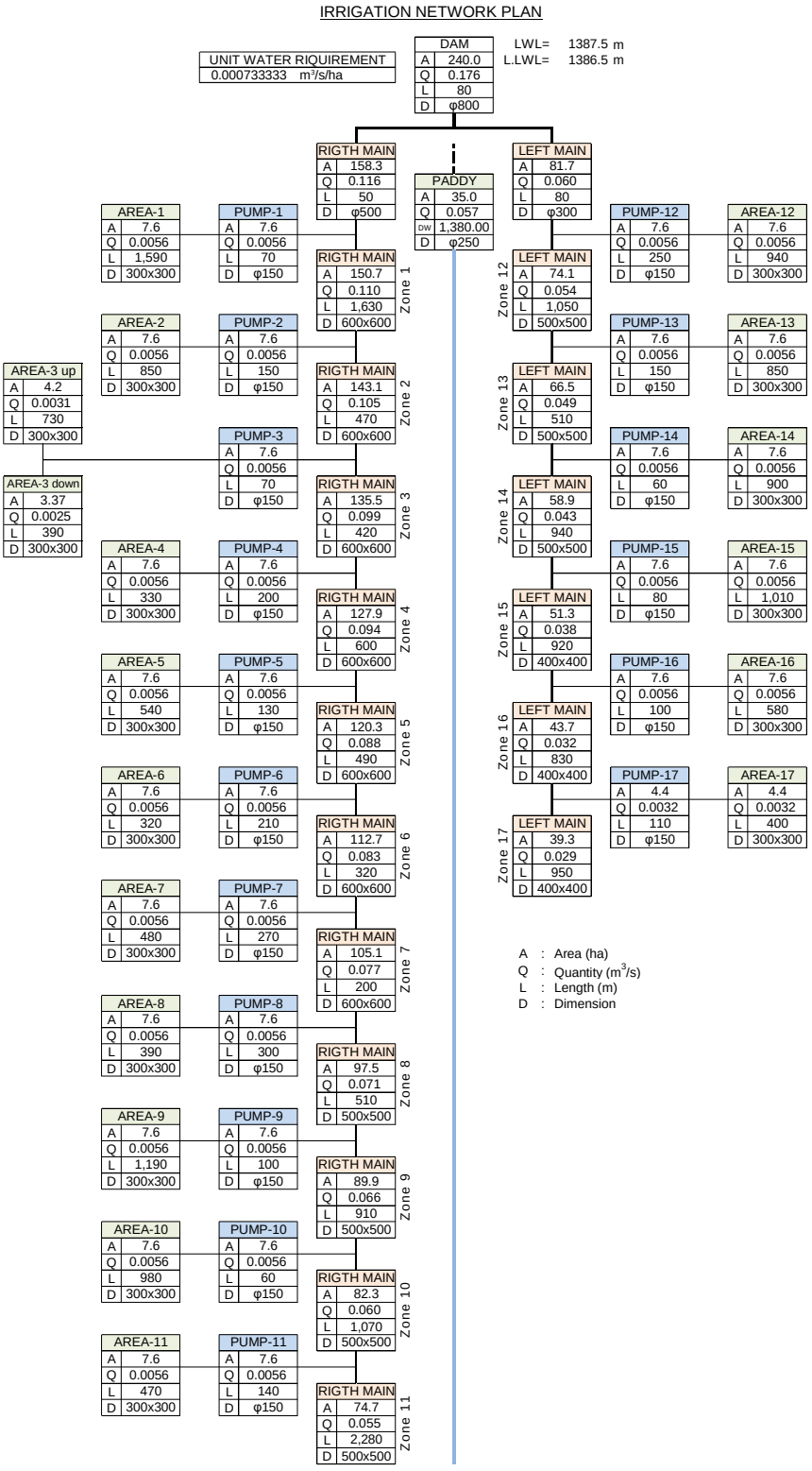


Fig. Irrigation Network Plan

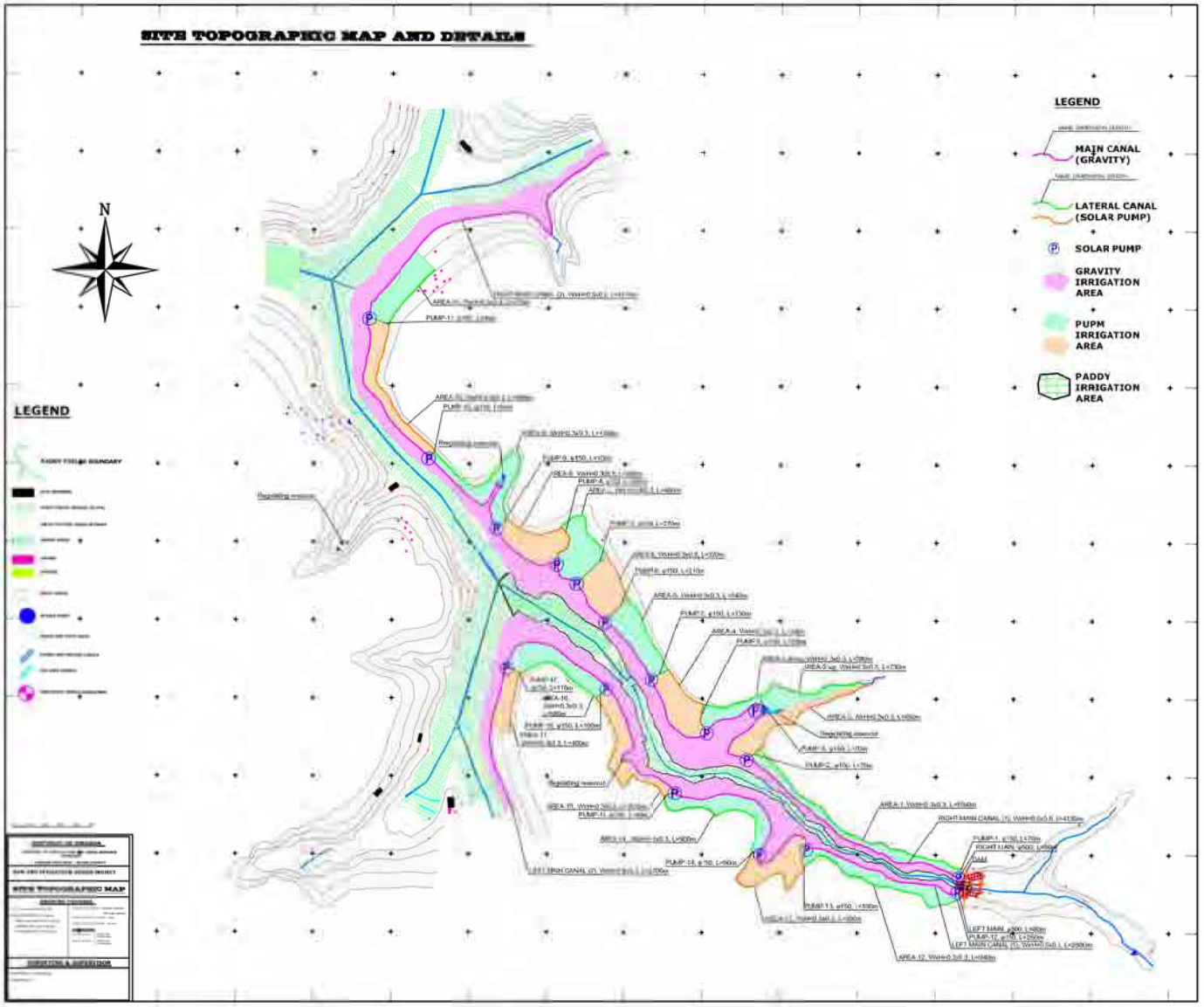


Fig. General Plan of irrigation facilities

(c) Execution Schedule

- Construction period: 1 year
- Flooding examination: 1 year

Table Execution Schedule

Item \ Month	1	2	3	4	5	6	7	8	9	10	11	12
Rehabilittion of existing road												
Site preparation												
Site office												
Site Laoratory												
Cut down and cleaning												
Temporary road												
Intake structures												
Foundation excavation												
Coffer dam												
Hoizontal blanket												
Slope blanket												
Dam embankment												
Riprap												
Crest protection work												
Slope planting works												
Spillway construction												
Main canal construction												
Secondary canal construction												
Installation of solar pump system												
Tertiary canal construction												
others												
Site cleaning												

(d) Construction cost

• Temporary work	:	RWF 467,485,000
• Dam dody	:	RWF 1,099,675,600
• Spillway	:	RWF 67,042,000
• Intake facilities	:	RWF 266,256,000
• Irrigation facilities	:	RWF 2,315,325,000
• Total cost	:	RWF 4,215,783,600

(4) Cropping Plan

(a) Basic principle

- Marketing : Planting crop are higher irrigation effect and profitable.
- Productivity: readily introduced crop should be selected taking current technical level on cultivation into consideration.
- Food security: cropping of maize is recommended as measures of procuring food supply in cases that food supply is influenced in this area, also as an efficient cash crop with high marketability.

(b) Main crop

Rice, Maize, beans, Vegetables (Carrot, Tomato, Cabbage, Tree tomato), Coffee

(c) Annual land use rate (Cropping rate) : 185%

Table Cropping Plan

Crop	Area	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Rice	35 ha (13 %)	R-B	Rice A							Rice B			
Maize+Beans	140 ha (51 %)		Maize							Beans			
Vegetable-1	20 ha (7 %)	Cab	Carrot						Cabbage				
Vegetable-2	40 ha (15 %)	Cab	Tomato						Cabbage				
Vegetable-3	20 ha (7 %)	Tomato Tree						Tomato Tree					
Coffee	20 ha (7 %)	Coffee											
Total	275 ha (100 %)												

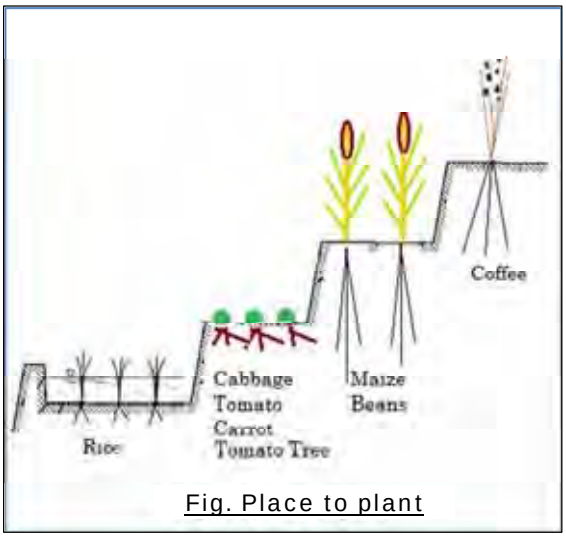


Fig. Place to plant

(5) Project Evaluation and Sensitivity analysis

(a) Project evaluation

Table Result of project evaluation

IRR		B/C(i = 12%)		NPV(000Rwf) (i = 12%)	
Economic	Financial	Economic	Financial	Economic	Financial
12.1%	15.7%	1.01	1.36	23	1,552

(b) Sensitivity analysis

Table Sensitivity analusis on economic internal rate of return(EIRR)(unit:%)

Eirr	Cost + 10% a	Benefit - 10% b	a+b	Gross Income -10%	Producs Praice -10%
12.1	11.1	10.9	10.0	10.4	10.6

(c) Benefits predictable in future

Table Benefits predictable in future

Benefit			Resident	Water Users	Dan Site Users	Inland Fishers
Rural Area	Economic	Inland Fisher			+	+
		Eco-Tourism	+		+	
	Environment	Improved lakeside landscape around the dam:	+		+	
		Improved eco-system		+		+

2. Adequacy of Cooperation and The Adequate Scope and Scale of The Cooperation

(1) Adequacy of cooperation

It is judged to be adequate to execute this project under the Japan grant aid scheme based on the following reasons.

① The government of Rwanda has several programs supergrade to this project that are 1) Rwanda Vision 2020, 2) Economic Development and Poverty Reduction Strategy, 2008-2012: EDPRS 2008-2012, 3) National Agriculture Policy (NAP): 2004, 4) Strategic Plan for Agricultural Transformation in Rwanda 2004: SPAT, and 5) Land-husbandry, Water harvesting and Hillside-irrigation: LWH. In these programs, the main and common targets are the reduction of poverty, the economic development and the food security. This project was formulated and has been reconsidered under the scheme of LWH program, accords with the contents of the mid to long term development programs above, and contributes for these programs to accomplish their purposes.

② According to the papers, the philosophy or targets of LWH program is/are improvement of farmlands, accommodation of farmlands, execution of market-oriented agriculture through

hillside irrigation, and strengthening of the technical or institutional capacity of staff or related organizations. And the Government intends to construct 101 irrigation purpose reservoirs throughout the country. One of the main targets of this project is to introduce the market-oriented vegetable farming through the hillside irrigation, which accords with the target of the LWH program mentioned above.

③ Japan Government made a public commitment in the forth Tokyo International Conference on African Development to support African countries concentrated in the fields of 1) increase of food production and improvement of agricultural productivity, 2) improvement of utilization and management of water resources and lands, 3) development of water-related infrastructures, 4) reduction of hazard risks and 5) accommodation of safe water resources. This project aims at the development of water resources through a dam construction and the modernization of agriculture so that it can contribute the achievement of all the items of the commitment above.

④ This project has suggested not only the fundamental technology in terms of the reservoir planning and the design of homogeneous dam with horizontal blanket, but also the new idea of introducing the solar pump system for the hillside irrigation and the utilization of shallow ground water by stopping its flow at the neck of the valley, so that it would be able to become a model case of hillside irrigation project in Rwanda. Followings are also included in these suggestions.

i) Setting up the utilization plan of the limited water resources for the paddy field irrigation and the dry field irrigation based on the water balance study through the catchment area and the command area. (Limited condition was confirmed by the Tank Model runoff analysis to the observed rainfall and river flow rate record at the site.)

ii) Clarification of the precedent water supply to the dry field irrigation being possible through rationalizing and saving the irrigation water use in the paddy field, the study of which was done based on the field survey on the existing paddy field conditions. (Stable water supply and fair distribution of irrigation water would be preferable for the farmers to be benefited from the stable rice production and would be able to contribute to the Water Users Union activities in terms of the easy collection of water fee and the farmers' cooperation to the maintenance works of the irrigation facilities.)

iii) Suggestion of the utilization method of ground water as the supplemental water resource considering the limited quantity of the river flow rate that came out from the runoff analysis based on the observation record.

iv) Suggestion of the introduction of the solar pump system which is relatively low cost and is going to come into wide use based on the recognition that the command area irrigated by gravitational water supply is limited and is not enough to satisfy the planning concept because of the topographical conditions, specific to Rwanda and the topographical survey result brought to surface more clearly, of the narrow valley lying between hills.

(2) Scope and scale of the cooperation

(a) Scope

The range of the cooperation in this project is to develop the facilities/structures ranging from the dam to on-farm irrigation equipments. In this project, one of the main schemes is the saving irrigation by means of micro-irrigation method so that the materials such as the hose inevitable for execution of micro-irrigation are included in the scope of cooperation. And the paddy fields that expand on the downstream river bed from the dam site are included in the command area. Then it becomes

necessary to control and manage the water supply quantity to the paddy fields and avoid the water wasted. To control and manage the water, it is necessary to improve/rehabilitate the existing ridges that have no ability of keeping water. Therefore, development/rehabilitation of the facilities for the paddy field irrigation, including the rehabilitation of ridges, is included in the scope of cooperation. It is the common recognition among authorities and donors concerned that the land-husbandry and the hillside irrigation are inseparable, that they should be implemented at the same time and that the increase of productivity brought from the land-husbandry should be counted as a part of benefit of the hillside irrigation; but this time the land-husbandry is considered not to need the technological assistance of Japan and is not included in the scope of cooperation.

(b) Scale

At this moment, the facilities for utilizing ground water as a water resource for irrigation is not included in this construction design due to the difficulty of estimating its available quantity though its utilization is recognized to be possible and effective. The planned command area 275ha might be increased at the stage of ground water utilization plan taking form.

(3) Problems in future

(a) Problems in this project (short-term problems)

ⅰ) Review of the available river in-flow rate

It is necessary to review the available river in-flow rate based on the annual observation record that includes the one in the dry season, July and August.

In addition, it is necessary to study the available quantity of ground water taking its conditions in dry seasons into account.

ⅱ) Review of the design flood discharge to the dam

At this moment, referring to the observation record of river flow rate during February to April, the design flood discharge to the dam is estimated as the peak flood rate calculated by the rational formula to the maximum daily precipitation with 50 years exceedence probability. It is also necessary to review this result referring to the annual observation record of river flow rate by applying the more analytical methods such as the Tank Model Method or the Storage Function Method.

ⅲ) Execution of the stability analysis of the dam body, Hydraulic and structural design of the spillway

At this moment, the cross-sectional shape of the dam body is decided empirically, so that at the next stage it must be decided based on the stability analysis of the dam body.

And also, the spillway must be designed based on the hydraulic and structural analysis.

ⅳ) Wetting area coefficient

At this moment, the wetting area coefficient is estimated to be 0.7 that ranges from 0.4 to 0.7 in the papers regarding the saving irrigation. This value must be reviewed based on the result of the field conformation survey on the saving irrigation that is going to be conducted in the site.

v) Effective reservoir capacity 450,000m^3

It is of course for the effective reservoir capacity 450,000m3 to be reviewed based on the newly applied available quantity of the river water, but also the adequate effective reservoir capacity must be examined based on the long-term simulation analysis on the reservoir operation.

vi) Improvement of the paddy field conditions

It is necessary to carry out the further survey and examination of adequate and effective improvement method from or to the paddy field conditions in terms of the leakage restraint through ridges and the installation of check gate structures.

vii) Land Husbandry

It is recommended in terms of Land Husbndry works in command areas of this project that the compost shall be concentrated on the farming lands with poor fertility and high prmeability by Rwandan government authorities.

(b) Mid to long term problem

After the completion of this project, technical support programs are essential to let the project effectiveness appear as clearly or highly as possible and make the project effectiveness as durable as possible. The themes or the fields of these support programs would be as follows.

i) Technical support for dry field farming

It is the first experience for the farmers in this district to conduct the irrigated dry field farming. And the hose irrigation method introduced as the on-farm irrigation method in this project is the first experience for them. On the other hand, the yield increase plays an important role to increase the farmers' income according to the result of economic analysis on farming (sensitivity analysis). Therefore, it is crucial for the future dry field farming how to get high yield of products by applying fertilizer and irrigation water adequately; to this, the Rwandan Government shall be requested to provide technical supports.

ii) Technical support for paddy field farming

The rice farming in this district has about 20 years history, but this history is the one of fighting or resisting against the low temperature that is brought from about 1500m of the high altitude in spite of this country being situated in the tropical area. Therefore, there are many problems to challenge such as the introducing of suitable variety of rice by means of breed improvement, and the selecting/introducing of suitable farming method from the special or radical ones, for example the intermittent irrigation method, the non-plowing irrigation method and the organic farming method. To these, the Rwandan Government shall be requested to provide technical supports.

iii) Support for strengthening the farmers' organization and technical support to operation and management of irrigation facilities

The establishment of cooperation system in the local community is inevitable to perform the operation and maintenance works to the irrigation facilities such as the dam and the canals. This establishment of cooperation system would be done at the same time of the accomplishment of the Water User's Association and the cooperative being strengthened institutionally; this means the establishment or the accomplishment must be achieved by the farmers' voluntary activities. Not only to these, the Rwandan Government shall be requested to provide technical supports, but also at the same time to the operation of irrigation facilities such as operation and management of the solar pump system, the intake gate of the dam, intake gate at the regulation pond, and the check gate along the river.


LOCATION MAP
N
W
E
S
Butale
Gasabo
KIGALI
Bandazi
Nyarugenge
Karama
Kicukiro
Gahengele
RWAMAGANA
KAYONZA
TANZANIA
Nawe
Model Area
Bihembe
Kanzenze
No. 22
Nguzi
BUGESERA
Jenda
NGOMA
KIREHE
Gashoba
Birenga
RWANDA
Gakamba
Lugarama
Gasenyi
BURUNDI
LEGEND
Study Area
National Boundary
Provincial Boundary
District Boundary
Road
0
10
20
kilometers
Democratic Republic of the CONGO
UGANDA
United Republic of TANZANIA
EASTERN PROVINCE
RWANDA
NGOMA DISTRICT
Study Area:
NGOMA District,Eastern Province
BURUNDI
Sources: UNHCR, Rwanda National Institute of Statistics, Global Insight digital mapping - 1998 Europa Technologies Ltd

List of Figures & Tables

Abbreviations

AfDB	African Development Bank
B/C	Benefit/Cost
BTC	Belgian Development Agency
CIDA	Canadian International Development Agency
DFID	Department for International Development
DEITEX	Project on Development of Efficient Irrigation Techniques and Extension in Syria
EIA	Environmental Impact Assessment
EIRR	Economic Internal Rate of Return
EL	Elevation
FAO	Food and Agriculture Organization
F/C	Foreign Currency
GDP	Gross Domestic Product
GPS	Global Positioning System
GoR	Government of the Republic of Rwanda
IRR	Internal Rate of Return
JICA	Japan International Cooperation Agency
L/C	Local Currency
LWH	Land-husbandry, Water-harvesting and Hillside-irrigation Project
MINAGRI	Ministry of Agriculture and Animal Resources
NAP	National Agricultural Policy
NIS	National Institute of Statistics of Rwanda
PAPSTA	Support Project for the Strategic Plan for the Transformation of Agriculture
PiCROPP	Project for Increasing Crop Production with Quality Extension Services
RAB	Rwanda Agricultural Board
RCA	Rwanda Cooperative Agency
RDC	Rural Development Cluster
RWF	Rwanda Franc
RSSP	Rural Sector Support Project
SCF	Standard Convertion Factor
SCI	Sanyu Consultants Inc.
TC	Technical Committee
TICAD	Tokyo International Conference on African Development
TP	Test Pit
UNCDF	United Nation Capita; Development Fund
USAID	United States Agency for International Development

WB	World Bank
WFP	World Food Programme
WUA	Water Users Association

Units

1 meter (m)	=	3.28 feet
1 kilometer (km)	=	0.62 miles
1 hectare (ha)	=	2.47 acres
1 acre	=	0.405 ha
1 inch (in.)		2.54 cm
1 foot (ft.)	=	12 inches (30.48 cm)
1 ac-ft		1233.4 cum

Exchange Rate

US$ 1.00	=	RWF 605
US$ 1.00	=	80 Japanese Yen
RWF 1.00	=	0.132 Yen

CHAPTER 1 BACKGROUND OF THE PROJECT

1-1. Background of the Project

The Republic of Rwanda is a landlocked country located in the Central Africa region. In the year 2010, as many as 10.3 million population lives in the 26,000 km2 land area. According to the National Agriculture Policy (2004), the number of people is projected to be increased to 15 million in the year 2020 and further to 20 million in 2030. Such population increase is regarded as serious and critical problems for attaining the national food security in Rwanda.

In accordance with the Economic Development and Poverty Reduction Strategy, 2008-12 : EDPRS 2008-2012 by the Government of Rwanda, the agriculture sector shares as large as 36.4 % of GDP, next to the 1st ranked service industry sector which shares 43.8 %. Also, the Strategic Plan for Agricultural Transformation in Rwanda 2004: SPAT indicates the shares by the agriculture sector at as high as 90 % in working labor force, 47 % in GNP and 71 % in export earnings, implying that the agriculture is the most important industry in the country.

Based on the "Rwanda Vision 2020", the long term national development vision, the government aims at reducing of the GDP share by the agriculture sector from the peak 48 % in 2006 to 33 % in 2020 through emerging from the self-sufficiency economic type depending on agriculture so as to transform the country to a middle income status. It is, however, concluded in the economic policy in the Rwanda Vision 2020 that the agriculture sector will be the most important industrial sector in future too with maintaining the major position in GDP shares and in providing employment opportunities sharing the far largest portion among various sectors.

The agriculture in Rwanda is operated by about 1.4 million farming households with the average land holding of only 0.76 Ha/family and as much as 66 % of farm produces are for farmers' own home consumption. It is considered necessary to materialize the crop diversification to have higher productivity and more competitiveness, with which the national economy of Rwanda can be grown up through promotion of agriculture. Those traditional and key cash crops like coffee and tea are easily and instantly affected by the effects of climate changes on global basis and price fluctuations in the international market as those commodities are treated as one of major international speculation targets, being in need of crop conversion to more stable crops with high value at an early date.

The causes of low productivity of agriculture sector in Rwanda can be tabulated as the followings.

1) Very small farm land operated per family at 0.76 Ha

2) 80 % of farm land is located in hilly areas with 5 to 55-degree slope

3) Soil erosion and deterioration in rainy season

4) Lower rate of irrigation system development at sloping hilly areas

5) Low rate of agricultural extension service coverage

Towards possible attaining of national food security, sustainable irrigation technologies in hilly areas are to be implemented for betterment of the present conditions as noted above.

1-2. Objectives of the Project

The objectives of the subject survey are as indicated as follows.

Objectives of the Survey

Objectives	1) To grasp the outline of irrigation sector (latest policy, legal framework, organizations, planning and execution system for development project, development plans and supports by donors) in Rwanda 2) Based on the analysis results of 1), site surveys be carried out to collect basic data/information on irrigation development for Ngoma 22 and the District as a whole 3) Based on 1) and 2), to examine feasibility of irrigated agriculture for Ngoma 22 site as a model. 4) Based on 1) and 2), to examine the possibility of cooperation (sector, area and outlines) by JICA to LWH by Rwanda

In carrying out the subject survey, due integration between the LWH program and this survey shall be secured and attention shall be paid so as to avoid duplication of surveys with the existing works on irrigation sector by the World Bank and those surveys done by JICA. For the target area, Ngoma 22, attention shall be paid on the concept of autonomous O&M activities by the Rwandan government and the beneficiary farmers' organizations. It is noted that in the examination of possible cooperation by JICA, the scope is open for all types of JICA's cooperation schemes and target crops. In examining feasibility of irrigated agriculture for Ngoma 22 as a model, cost-benefit analysis shall be also made for a case where Japan's grant aid scheme is applicable.

1-3. Schedule of the study team

Month	Day		Schedule of The Study Team				
			Hitoshi TOKU Chief Consultant / Irrigation Planning	Haruo HIKI Water Souce Planning	Yasunori YAMAGISHI Agriculture	Ken KOUZAI Social Economy Analysis	Hideki ISHIKAWA Facility Planning
	1	Thu	–	–	–	–	–
	2	Fri	–	–	–	–	–
	3	Sat	–	–	–	–	–
	4	Sun	Kansai - Kigali	Kansai - Kigali	–	–	–
	5	Mon	Meeting with JICA	Meeting with JICA	–	–	–
	6	Tue	Filed survey	Filed survey	–	–	–
	7	Wed	Filed survey	Filed survey	–	–	–
	8	Thu	Meeting with MINAGRI	Meeting with MINAGRI	–	–	–
	9	Fri	Filed survey	Filed survey	–	–	–
	10	Sat	Filed survey	Filed survey	–	–	–
	11	Sun	Preparation of the Topographic & Geological Survey	Preparation of the Topographic & Geological Survey	–	–	–
	12	Mon	Filed survey	Filed survey	–	–	–
	13	Tue	Preparation of the Topographic & Geological Survey	Preparation of the Topographic & Geological Survey	–	–	–
	14	Wed	Preparation of the Topographic & Geological Survey	Preparation of the Topographic & Geological Survey	–	–	–
	15	Thu	Meeting with JICA	Meeting with JICA	–	–	–
Mar	16	Fri	Filed survey	Filed survey	–	–	–
	17	Sat	Bidding of the Topographic	Bidding of the Topographic	–	–	–
	18	Sun	Filed survey	Filed survey	–	–	–
	19	Mon	Filed survey	Filed survey	–	–	–
	20	Tue	Kigali - Doha	Meeting with JICA and MINAGRI	–	–	–
	21	Wed	Doha - Kansai	Filed survey with JICA	–	–	–
	22	Thu	–	Filed survey with JICA	–	–	–
	23	Fri	–	Filed survey	–	–	–
	24	Sat	–	Meeting with JICA	Narita - Doha	–	–
	25	Sun	–	Filed survey	Doha - Kigali	–	–
	26	Mon	–	Filed survey	Filed survey	–	–
	27	Tue	–	Draw up Report of Site Survey	Filed survey	–	–
	28	Wed	–	Filed survey	Filed survey	–	–
	29	Thu	–	Bidding of the Geological Survey	Filed survey	–	–
	30	Fri	–	Filed survey (Nyanza)	Filed survey (Nyanza)	–	–
	31	Sat	–	Draw up Report of Site Survey	Draw up Questionnaire	–	–
	1	Sun	–	Filed survey	Filed survey	–	–
	2	Mon	–	Meeting with related ministries	Filed survey	–	–
	3	Tue	–	Draw up Report of Site Survey	Filed survey	–	–
	4	Wed	–	Draw up Report of Site Survey	Filed survey	–	–
	5	Thu	–	Meeting with related ministries	Filed survey	–	–
	6	Fri	–	Draw up Report of Site Survey	Filed survey	–	–
	7	Sat	–	Draw up Questionnaire	Draw up Report of Site Survey	–	–
	8	Sun	–	Filed survey	Draw up Report of Site Survey	–	–
	9	Mon	–	Meeting with MINAGRI	Draw up Report of Site Survey	–	–
	10	Tue	–	Draw up Report of Site Survey	Draw up Report of Site Survey	–	–
	11	Wed	–	Meeting with WB	Filed survey	–	–
	12	Thu	–	Meeting with MUNAGRI	Filed survey	–	–
	13	Fri	–	Meeting with USAID and CIDA	Draw up Report of Site Survey	–	–
	14	Sat	–	Filed survey	Draw up Report of Site Survey	–	–
	15	Sun	–	Draw up Progress Report	Draw up Report of Site Survey	–	–
Apr	16	Mon	Meeting with JICA	Draw up Progress Report	Draw up Progress Report	–	–
	17	Tue	–	Draw up Progress Report	Draw up Progress Report	–	–
	18	Wed	–	Meetign about Progress Report with JICA	Draw up Report of Site Survey	Narita - Doha	Kansai - Kigali
	19	Thu	Meeting about Progress Report with JICA	Meeting about Progress Report with JICA	Meeting about Progress Report with JICA	Doha - Kigali	Meeting about Progress Report with JICA
	20	Fri	–	Meeting with RAB	Filed survey	Meeting wite RAB	Filed survey
	21	Sat	–	Filed survey	Filed survey	Filed survey	Filed survey
	22	Sun	–	Draw up Progress Report	Draw up Report of Site Survey	Draw up Report of Site Survey	Filed survey
	23	Mon	–	Draw up Progress Report	Filed survey	Meeting with FAO	Filed survey
	24	Tue	–	Filed survey	Filed survey	Meeting wite RAB	Filed survey
	25	Wed	–	Filed survey	Draw up Report of Site Survey	Filed survey	Draw up Report of Facility Planning
	26	Thu	–	Draw up Progress Report	Meeting with Sector	Filed survey	Draw up Report of Facility Planning
	27	Fri	–	Meeting about Progress Report with JICA	Draw up Report of Site Survey	Filed survey	Meeting about Progress Report with JICA
	28	Sat	–	Filed survey	Draw up Report of Agriculture Plannig	Draw up Report of Site Survey	Filed survey
	29	Sun	–	Filed survey	Draw up Report of Agriculture Plannig	Draw up Report of Site Survey	Filed survey
	30	Mon	–	Draw up Report of Site Survey	Draw up Report of Irrigation Plannig	Draw up Report of Site Survey	Draw up Report of Facility Planning
	1	Tue	–	Draw up Report of Site Survey	Filed survey	Draw up Report of Site Survey	Filed survey
	2	Wed	–	Draw up Report of Site Survey	Draw up Report of Irrigation Plannig	Meeting with Sector	Draw up Report of Facility Planning
	3	Thu	–	Draw up Report of Site Survey	Draw up Report of Irrigation Plannig	Filed survey	Draw up Report of Facility Planning
	4	Fri	Kansai - Kigali	Draw up Report of Site Survey	Draw up Report of Irrigation Plannig	Meeting with JICA	Draw up Report of Facility Planning
	5	Sat	Meeting with JICA	Meetinf with JICA	Draw up Report of Irrigation Plannig	Draw up Report of Social Economy Analysis	Draw up Report of Facility Planning
	6	Sun	Teem meeting	Draw up Report of Site Survey	Kigari - Doha	Draw up Report of Social Economy Analysis	Draw up Report of Facility Planning
	7	Mon	Explanation and Discussion about Progress Report with MINAGRI	Explanation and Discussion about Progress Report with MINAGRI	Doha - Narita	Draw up Report of Social Economy Analysis	Draw up Report of Facility Planning
	8	Tue	Draw up Report of Irrigation Planning	Filed survey	–	Meeting with RAB	Draw up Report of Facility Planning
	9	Wed	Draw up Report of Irrigation Planning	Draw up Report of Water Souce Planning	–	Draw up Report of Social Economy Analysis	Draw up Report of Facility Planning
	10	Thu	Draw up Report of Irrigation Planning	Draw up Report of Water Souce Planning	–	Draw up Report of Social Economy Analysis	Draw up Report of Facility Planning
	11	Fri	Draw up Report of Irrigation Planning	Draw up Report of Water Souce Planning	–	Draw up Report of Social Economy Analysis	Draw up Report of Facility Planning
	12	Sat	Draw up Report of Irrigation Planning	Draw up Report of Water Souce Planning	–	Draw up Report of Social Economy Analysis	Draw up Report of Facility Planning
	13	Sun	Draw up Report of Irrigation Planning	Draw up Report of Water Souce Planning	–	Draw up Report of Social Economy Analysis	Draw up Report of Facility Planning
	14	Mon	Draw up Report of Irrigation Planning	Draw up Report of Water Souce Planning	–	Meeting with NAEB and RAB	Draw up Report of Facility Planning
	15	Tue	Draw up Report of Irrigation Planning	Draw up Report of Water Souce Planning	–	Filed survey	Draw up Report of Facility Planning
May	16	Wed	Draw up Report of Irrigation Planning	Draw up Report of Water Souce Planning	–	Filed survey	Draw up Report of Facility Planning
	17	Thu	Meeting with MINAGRI	Draw up Report of Water Souce Planning	–	Filed survey	Draw up Report of Facility Planning
	18	Fri	Meeting with JICA	Draw up Report of Water Souce Planning	–	Draw up Report of Social Economy Analysis	Meeting with JICA
	19	Sat	Draw up Report of Irrigation Planning	Draw up Report of Water Souce Planning	–	Draw up Report of Social Economy Analysis	Draw up Report of Facility Planning
	20	Sun	Draw up Report of Irrigation Planning	Draw up Report of Water Souce Planning	–	Draw up Report of Social Economy Analysis	Draw up Report of Facility Planning
	21	Mon	Meeting with JICA	Meeting with JICA	–	Meeting with JICA	Meeting with JICA
	22	Tue	Draw up Report of Irrigation Planning	Draw up Documentation of Workshop	–	Draw up Report of Social Economy Analysis	Draw up Report of Facility Planning
	23	Wed	Meeting with JICA	Meeting with JICA	–	Meeting with JICA	Draw up Report of Facility Planning
	24	Thu	Meeting with MINAGRI	Ngoma-22 Workshop	–	Draw up Report of Social Economy Analysis	Draw up Report of Facility Planning
	25	Fri	Discussion with EoJ, JICA and MINAGRI	Discussion with EoJ, JICA and MINAGRI	–	Draw up Report of Social Economy Analysis	Draw up Report of Facility Planning
	26	Sat	Draw up Report of Irrigation Planning	Draw up Report of Water Souce Planning	–	Meeting with JICA	Draw up Report of Facility Planning
	27	Sun	Teem meeting	Teem meeting	–	Teem meeting	Teem meeting
	28	Mon	Filed survey	Filed survey	–	Draw up Report of Social Economy Analysis	Filed survey
	29	Tue	Draw up Report of Site Survey	Filed survey	–	Draw up Report of Social Economy Analysis	Draw up Report of Facility Planning
	30	Wed	Meeting with MINAGRI and JICA	Meeting with MINAGRI and JICA	–	Draw up Report of Social Economy Analysis	Meeting with MINAGRI and JICA
	31	Thu	Kigali - Doha	Kigali - Nairobi - Doha	–	Kigali - Doha	Kigali - Doha
Jun	1	Fri	Doha - Kansai	Doha - Kansai	–	Doha - Narita	Doha - Kansai

1-4. List of Contact

Organization	Person's Name	Position
Ministry of Agriculture & Animal Resources (MINAGRI)	Dr. Jean Jacqies	Chirman of Irrigation & MechanizationTask Force (former chairman)
	Mr. Jean Claude	Administrative Manager of Irrigation & MechanizationTask Force
	Mr. Innocent NZEYIMANA	Chirman of Irrigation & MechanizationTask Force
	Mr. Akihisa Nakano	MINAGRI Advisor, JICA Expert
Rurenge Sector	Mr. Damien NZABARINDA	Sector Agronomist
Remera Sector	Mr. Agoba MUDENGE	Sector Agronomist
Project Staff	Mr. Etienne ISABANE	Agronomist of Ntende Dan Irrigation Project
	Mr. Celestine LADSON	Site Manager of Rilima LUX Project
RAB	Mr. Innocent MUSABYIMAN	Deputy Director General in charge of extension services
	Dr. Claver NGABOYISONGA	Director of Crops
Donor	Mr. Mwumvaneza Valens	Rural Development Specialist , World Bank, Kigali
	Dr. Hudush Seged	Member of LWH Implimentation Unit, World Bank, Kigali
	Mr. Dan Folta	Member of LWH Implimentation Unit, World Bank, Kigali
	Mr. Gary Cramer	Senior Agricultural Advisor, USAID/Rwanda
	Mr. James Parsons	Chef de Bureau et Chef de la Cooperation, CIDA/Rwanda
Japan Embassy	Mr. Kunio Hatanaka	Embassador of Japan
	Mr. Tatuya Nakai	Second Secretary
	Miss. Shoko Nakatomi	Coordinator for Economic Cooperation
JICA, Rwanda office	Mr. Hiroyuki Kobayashi	Represntative of JICA, Rwanda
	Mr. Tatuki Noda	Planning and Coordination Agent of JICA, Rwanda

CHAPTER 2 CIRCUMSTANCES AROUND AGRICULTURAL DEVELOPMENT PROJECTS IN RWANDA

2-1. MINAGRI (Ministry of Agriculture and Animal Resources)

2-1-1. Three major programs for the promotion of irrigation agriculture

Strategic Plan for Agricultural Transformation in Rwanda, 2004, showed the three major programs for the promotion of irrigation agriculture, the first is the marshland development (①) in the section 7-1-3, the second is the small scale irrigation development by a reservoir construction in hilly terrains (②), and the third is the development of pumping irrigation from rivers, lakes and ground water (③) in the section 7-1-4. The RSSP projects (Rural Sector Support Program) correspond to ①, the LWH (Land Husbandry, Water Harvesting and Hillside irrigation) projects to ②, and the Large Scale Pumping Irrigation Projects to ③. They have already been started and the transformation of agriculture by irrigation is going to be improved through the implementation of these three core programs.

2-1-2. RSSP project

The RSSP projects have been being carried out since 2001 as a starter among these three programs and seven or so reservoirs have already constructed; and the totally increased command area through these projects is said to be 3,100 ha. The phase-3 stage of this program ranging from 2012 to 2017 is now on going.

2-1-3. LWH project

Since LWH projects started in 2008, the component of LWH project has made progress in land husbandry field. The construction works for the hillside irrigation have not yet started*; and MINAGRI has shared the project status as follows.

*For the first time in the LWH projects, the bid opening of Nyanza-23 project would be held in August, 2012.

Table 2-1-3-1 LWH project

Survey/Design Stage	Number of Projects
Survey stage	About 10 projects
Feasibility Study stage	About 4 projects
Basic Design stage	
Detailed Design stage	1project(Nyanza-23 project)

The budget for LWH projects is provided through the fund basket of support agencies and the Government of Rwanda.

Table 2-1-3-2 Co-funding fund of LWH project

Support Agency	Amount of fund
WB (World Bank)	34 million US$
USAID (United States Agency for International Development)	5.1 million US$
CIDA (Canadian International Development Agency)	7.8 million US$
GAFSP (the Global Agriculture and Food Security Program)	50 million US$
Government of Rwanda	19.5 million US$
Total(changes due to value in dollars)	109.4 million US$

* Construction cost of Hillside Irrigation projects

MINAGRI showed his opinion as follows on the construction cost of hillside irrigation projects being three to four times higher than the ones of RSSP projects that are said to be about 6,000~7,000 US$/ha.

- It is inevitable for the construction cost to become higher due to the geographical conditions where the hillside irrigation project is implemented.
- It is one selection that the hillside irrigation project shall not be implemented but the land husbandry only be implemented due to the economical conditions in case of the hillside irrigation project concerned being too bad in economical balance.
- Fundamentally in Rwanda where more than 60 % of the country is hilly terrains on which 10 million people live, the low benefit-cost ratio does not mean to give up the LWH project concerned.

2-1-4. Large scale pumping irrigation project

This project proceeds under the own budget of Rwandan government. Two schemes (1,000 ha) are under construction; there are 7,700 ha of schemes including the planning stage, the preparation stage for construction, etc. In these projects, the sprinkler system is applied to the dry field irrigation.

2-1-5. Total movement

There are indications of a large scale transformation arising in Rwandan agriculture. Paddy field developments by RSSP project have already started under more accelerated conditions than before. The large scale pumping irrigation projects are proceeding under the own budget of the Government and additional projects are going to start. MINAGRI has already established WUA (Water Users Association) Supporting Unit that is to be in charge of operation and maintenance works to the water utilizing facilities that would installed in the projects above.

As for the LWH project, component of the land husbandry only has been progressed. Since the component of hillside irrigation seems to have been stagnant, WB assigned 3 engineers to MINAGRI last year, which pushes the project forward. The tender of the Nyanza-23 project is going to be advertised in this coming June. The schedule/strategy of WB-assisted LWH project shared by Dr. Hadush, a member of the Implementation Unit, is shown as follows.

- Watershed-34, 35, Kayanza-4; F/S and D/D shall be carried out simultaneously during seven (7) months from June to December. The construction works are scheduled to start around April, 2013.
- Phase-2; F/S and D/D shall be started around September, 2013 for 2,600 ha of operation area in the project in which the total of 10,000 ha of operation area corresponding to 37 project sites has been identified by the Implementation Unit staff.
- Phase-3; The residual 7,400 ha of operation area in the projects shall be provided to F/S and D/D sequentially after around June, 2014.

2-2. RAB (Rwanda Agricultural Board)

RAB is the institution that provides the agriculture in Rwanda with technical supports in whole agricultural aspects; it plays the following roles.

- Roles as a research organization

  Activities in breed improvements of strategic plants such as rice, banana, etc.

- Roles of formulating development plans in agriculture

  Research and guidance in agricultural developments such as selecting recommendable crops

- Roles as the agricultural extension division

  Extension activities of the recommendable crops by the staff agronomists leading the district/sector agronomists; free of charge distribution of quality rice seed is one of these activities.

- Assistance to modernization activities of agriculture and agricultural communities

  Research and guidance in soil conservation, marshland development, irrigation and water management, processing of agricultural products, and infrastructure development in rural area

- Research and guidance for livestock farming

  Extension of livestock farming and guidance to the livestock diseases based on the activities in research institutions

- Roles as an administrative organ that carries out the government agricultural policy

  The government adopts the market intervention policy that the support-buying at the time of over-supply and the product-supply at the time of short supply are applied to the agricultural products such as maize to stabilize these prices. RAB plays the role of such activities as one of administrative divisions in MINAGRI.

  * Upland rice

  RAB answered our inquiry if upland rice was suitable to the climate conditions in Rwanda that the test growing had been carrying out by China. As the results of subsequent surveys, followings became clear and we concluded that upland rice was not suitable to the climate conditions in Rwanda.

  - Upland rice needs higher temperature than paddy rice. Upland rice does not come to fruition especially in case of the temperature at night becoming low.
  - The time differential between the long day and the short day, that plays the important role to accelerate the growth of upland rice, is scarce in Rwanda, the equatorial country, so that it takes about 150 days for upland rice to be ripe and the advantage of upland rice being ripe in a short period can not be achieved.

2-3. Circumstances around the donors' support to the irrigation development

2-3-1. WB（World Bank）

WB now supports the two irrigation development projects named RSSP project and LWH project. WB has been supporting in one's own the RSSP projects since 2001, and now it comes to Phase-3. As for the LWH project, WB organizes the fund basket system that has the budget of 107 million US$ and covers the period from 2010 to 2015, and takes the role of management of this organization. WB has also established the technical support systems one of which is to assign three expert engineers of Project Implementation Unit to MINAGRI and the other is the safety check system to the high dams

designed in LWH projects where the dam design shall be examined by International Panel of Experts in line with the WB's safety standard to large dams.

WB's opinion on the hillside irrigation project of which construction cost is higher than the one of the RSSP project is that the higher cost is inevitable due to the difference of topographical conditions and the scale of the command area, and it is not appropriate to compare the construction costs of these projects. And regarding the low benefit-cost ratio of the hillside irrigation, WB has the policy of assessing the total economical effectiveness including the economical effectiveness of the land husbandry, and improving the low benefit-cost ratio by planting crops with high profit performance.

2-3-2. USAID

USAID has not any other support scheme than one of the members of the fund basket in the agricultural field. The supporting style of USAID is to dispatch a manager to each field, to build up a project, to support the project by providing fund and not to treat technical aspects. There are five Personnel to be a manager of a project in road constructions, nourishment of private companies, water supply and sewerage systems, environment and the agriculture.

USAID showed his opinion on the high construction cost of LWH projects that it should be assessed totally together with the benefit brought from the productivity progress after the completion of the project, and also together with the contribution to the social aspects.

2-3-3. CIDA

CIDA has been supporting the agricultural field only and is one of the supporting members of the fund basket for LWH projects and GAFSP (the Global Agriculture and Food Security Program). CIDA has his own scheme of supporting NGOs engaged in agricultural development.

CDIA showed his opinion on the high construction cost of hillside irrigation projects that it might not be avoidable to give up the concerned project in case of its construction cost being too high, but fundamentally there is no choice except accepting its high construction cost in some measure.

2-3-4. Common points among the donors

Followings are the common points among the donors.

- There is no choice except accepting its high construction cost in some measure.
- LWH project should be treated as a package of the land husbandry and the hillside irrigation, and its economical effectiveness should be assessed totally including the benefit that arises through the implementation of land husbandry.

2-4. Field surveys on existing projects

2-4-1. Ntende Dam and Kiliba Dam

(1) General

Date of the survey；22nd of March, 2012

Participants；Mr. Suzuki (Senior Technical Advisor of JICA), Mr. Nakano (MINAGRI Advisor), Mr. Noda (JICA Agent), Mr. Hiki (Survey team staffer), Mr. Pascal, Mr. Jules, Mr. Fred

(2) Dam and its appurtenant facilities

(a) Dimensions, etc.

Completion；December 2010 (RSSP project)

Ntende dam；Dam height 6m, Crest length 145m, Total capacity 700,000 m^3, Reservoir surface 64ha

Kiliba dam；Dam height 8m, Crest length 95m, Total capacity 400,000 m^3, Reservoir surface 12ha
(Design：CIMA(Canada)、Construction：EGECOR(Rwanda))

Command area；575ha, Average area of paddy field possessed by one household：20 area

Canal length；Main 92.7km, Secondary 35.2km, Tertiary 51.2km, Drainage 20km

Construction cost per ha；6,000US$/ha (Total project cost : 3.4mil.US$ approximately)

(b) Facilities' conditions・Ntende Dam

Dam（Dam crest～left bank side）

Dam（Dam crest～right bank side）

Riprap on upstream slope

Spillway mouth（spill out in April and November）

Intake (in-let portion)
（Discharge when the water level comes close to the dam crest by 1m below）

Intake (out-let portion)

Confluence of the main canal and the spillway

Reservoir and the catchment area

Main canal and the command area

(c) Facilities' conditions・Kiliba dam

Riprap on the upstream slope

Protection work by grass on the downstream slope

Intake (out-let portion)

Division work（main canal on the right side ）

Spillway mouth

Spillway・chute canal

(2) Operation conditions of the facilities

- Command area；575 ha （under farming；509 ha）（before dam completion : 20 ha）
- Institution in charge of operation；COPRINTENDE Cooperative（= WUA, number of participating household : 3,015）

- Management of irrigation water

  ；COPRINTENDE area is composed of 10 zones. WUA (Water User's Association) is made up by 12 commission members. 10 of them are each assigned to each 10 zones, and 2 of them are each assigned to the gate operation to Ntende dam and Kiliba dam. Discharging the irrigation water from the dams is done from early morning to noon. It is carried out by the agronomist's order who receives the request for discharge from the commission member assigned to the zone concerned.

- Paddy field per one household；20 are （A household which had more than 1ha of farmland now possesses 40 are.）
- Role of RSSP；monitoring, economical analysis for deciding the water fee, advice to farming management
- Seeds；Purchase from RAB (Rwanda Agricultural Board)
- Yield；4.5t/ha（dried rice before threshing）
- Price of rice；long grain rice：242RWF/kg, short grain rice：226RWF/kg (this year)
- Union dues；21RWF/(rice 1kg)
- Fertilizer；NPK: 40kg/20are×320RWF/kg, Urea; 20kg/20are×340RWF/kg
- Agrichemical；against insect : 150cc/20are×8RWF/cc

  against disease : 1kg/ha×13,000RWF/kg
- Water fee；750RWF per one household per one season till last year

  200RWF per 1 are presented by RSSP this year (not yet accepted by farmers)
- Cropping of this year

  ；Cropping of the first term (from February to June) could not be done due to the farmland improving works and the gate maintenance of the Kiliba dam, so that cropping was done in mid of November and the harvest is scheduled in May. This cropping period is ahead of MINAGRI's cropping calendar by three months. This is the first challenge adopted considering the RSSP's advice that Gazibo is the hottest area in Rwanda so that the problem of low temperature in rainy season would be avoidable.

2-4-2. Rilima pumping irrigation project

(1) General

Date of the survey；21st of March, 2012

Participants；Mr. Suzuki (Senior Technical Advisor of JICA), Mr. Nakano (MINAGRI Advisor), Mr. Noda (JICA Agent), Mr. Hiki (Survey team staffer), Mr. Pascal, Mr. Jules, Mr. Fred

Project implementation；LUX (implemented by Luxemburg support in 2008)

Irrigation area；25 ha

Irrigation facilities；

Pumping facilities

Tank placed on the upper edge

Out-let mouth to the canal

In-let mouth to the farmland

Farmland on the gentle slope and the lake of water source

(2) Interview result

Table 2-4-2-1 Interview result

Item		Answer	Remarks
Irrigation water	Quantity	7,000m^3/ha	Farmers are requested to save 15% of the yield to pay the operation cost of the pump.
	Cost	45FRW/m^3	
Irrigation method	Intake method	Pumping	Pump operation: 10～12hr/day, 25days/month
	On farm	Surface irrigation	Irrigation water is not successfully delivered to the every farmland due to the interval of the in-let mouth being too wide and the permeability of the farmland being too high.
Crops	Main	Tomato	Tomatoes are sold to the tomato past producing company (SORWATOM) by contract.
	Sub	Maize、Beans	Maize is sold to RAB (Rwanda Agriculture Board) which pays relatively high price. Beans are consumed as captive use.
Problems		Climate change	It is difficult to perform the farming according to the schedule due to the unstable climate condition.
		Descending of water level in the lake	The water level of the lake tends to descend, and the pump might not work in future.
		Buy-off of land	The farmlands become the candidate for the land of hotel construction related to the airport construction so that the project might be destructed.
		Disease of tomatoes	Tomatoes were attacked by a disease that is supposed to be brought by cassava viruses, and damaged much. At this stage, the cause of the disease has not yet made clear so that any countermeasures can not be applied.
		Poor design of facilities	The capacity of the tank is not enough so that the water sent to the tank is always spilled out.
Farm management conditions	Yield	□□□tons	
	Income	100$/month/ha	

2-4-3. PiCROPP Demonstration Farms for vegetables

(1) Summary of the survey results

- Hand Irrigation is applied as the irrigation method in the horticulture farming.
- In many cases irrigation water is obtained by pumping from marshlands, but sometimes purchased water by jerry cans is used.
- The quantity of irrigation water differs much by each farm even to a same crop. In tomato's case, it ranges from 0.1 mm/m^2/day to 2.0 mm/m^2/day. In case of the purchased water being used, the quantity becomes extremely low such as 0.03 mm/m^2/day.
- The quantity of irrigation water for cabbage differs by each farm ranging from 2.0 mm/m^2/day to 5.0 mm/m^2/day. Eggplant, green pepper and carrot require a bit larger quantity of irrigation water than others such as 5.0 mm/m^2/day or so.
- Farming works for irrigation are carried out in the morning or in the evening.
- The harvest yields differ much by each farm. It is difficult to grasp the relationship between the harvest yield and the quantity of irrigation water, which might be caused by a lack of reliability of information that is obtained from farmers not accustomed to calculations or numbers.

Table 2-4-3-1 Summary table of the survey results in the demonstration farms for vegetables

Crop	Farming Area	Water source	Irrigation method	Timing of irr.	Harvest yield	Quantity of irrigation water
Tomato Atakundamahoro	2.8 ha	Tap water	Hand irr.	Evening	8kg/a	600 ℓ/ha/2days (0.03mm/m^2/day)
Tomato Farmer 1	0.12 ha	marshland	Pumping Hand irr.	Morning Evening	80kg/a	10,000 ℓ/ha/day (1mm/m^2/day)
Tomato Farmer 2	0.15 ha	marshland	Pumping Hand irr.	Morning Evening	167kg/a	16,000 ℓ/ha/day (1.6mm/m^2/day)
Tomato Farmer 3	0.15 ha	marshland	Pumping Hand irr.	Evening	200kg/a	16,000 ℓ/ha/day (1.6mm/m^2/day)
Tomato Farmer 4	1.0 ha	marshland	Pumping Hand irr.	Morning	180g/a	6,000 ℓ/ha/day (0.6mm/m^2/day)
Tomato Farmer 5	0.08 ha	marshland	Pumping Hand irr.	Evening	31kg/a	1,000 ℓ/ha/day (0.1mm/m^2/day)
Tomato Farmer 6	0.5 ha	marshland	Pumping Hand irr.	Evening	20kg/a	2,000 ℓ/ha/day (0.2mm/m^2/day)
Tomato Farmer 7	0.24ha	marshland	Pumping Hand irr.	Evening	7kg/a	8,333 ℓ/ha/day (0.8mm/m^2/day)
Tomato Farmer 8	0.04ha	Tap water	Hand irr.	Evening	75kg/a	11,000 ℓ/ha/day (1.1mm/m^2/day)
Tomato Farmer 9	0.0625ha	Tap water	Hand irr.	Evening	37.6kg/a	24,000 ℓ/ha/day (2.4mm/m^2/day)
Eggplant Farmer 1	0.0018ha	marshland	PumpingHand irr.	Evening	—	22,222 ℓ/ha/day (2.2mm/m^2/day)
Eggplant Farer 7	0.06 ha	marshland	Pumping Hand irr.	Evening	77.5kg/a	53,333 ℓ/ha/day (5.3mm/m^2/day)
Onion Farmer 2	0.02 ha	marshland	Pumping Hand irr.	Evening	—	18,000 ℓ/ha/day (1.8mm/m^2/day)
Onion Farmer 3	0.06 ha	marshland	Pumping Hand irr.	Evening	—	20,000 ℓ/ha/day (2.0mm/m^2/day)
Onion Farmer 7	0.19 ha	marshland	Pumping Hand irr.	Evening	5.7kg/a	13,158 ℓ/ha/day (1.3mm/m^2/day)
Water melon Farmer 2	0.07 ha	marshland	Pumping Hand irr.	Evening	—	13,700 ℓ/ha/day (1.4mm/m^2/day)
Water melon Farmer 4	1.5 ha	marshland	Pumping Hand irr.	Evening	17pcs/a	6,000 ℓ/ha/day (0.6mm/m^2/day)
Water melon Farmer 6	0.175 ha	marshland	Pumping Hand irr.	Evening	28pcs/a	4,000 ℓ/ha/day (0.4mm/m^2/day)
Cabbage Farmer 3	0.04 ha	marshland	Pumping Hand irr.	Evening	—	24,000 ℓ/ha/day (2.4mm/m^2/day)
Cabbage Farmer 7	0.97 ha	marshland	Pumping Hand irr.	Evening	45kg/a	2,062 ℓ/ha/day (0.2mm/m^2/day)
Cabbage Farmer 8	0.05 ha	canal	Hand irr.	Evening	70kg/a	24,000 ℓ/ha/day (2.4mm/m^2/day)
Cabbage Farmer 9	0.03 ha	marshland	Hand irr.	Evening	70kg/a	50,000 ℓ/ha/day (5.0mm/m^2/day)
Cabbage Farmer 10	0.0035 ha	marshland	Hand irr.	Evening	—	57,143 ℓ/ha/day (5.7mm/m^2/day)
Green pepper Farmer 5	0.02 ha	marshland	Pumping Hand irr.	Evening	—	50,000 ℓ/ha/day (5.0mm/m^2/day)
Carrot Farmer 7	0.015 ha	marshland	Pumping Hand irr.	Evening	80kg/a	66,666 ℓ/ha/day (6.7mm/m^2/day)

CHAPTER 3 AREA NGOMA22・EXSISTING IRRIGATION SECTOR

3-1. Social Situation

Division of local administration consists of Kigali City and 4 Provinces including Eastern, Northern, Southern and Western ones. Provinces do not have administrative functions but their subordinate organ, namely Districts have initiative of promoting decentralization of the country. Sectors and Cells are placed under District.

3-1-1. Administrative division of the Study Area

The Study Area is located in Ngoma District of Eastern Province, and the district of Remera Sector and Rurenge Sector belong to this Province. Their administrative border runs at the bottom of a valley in the Province. The Study Area includes Ndekwe Cell and Bugera Cell in Remera Sector as well Rujambara Cell and Muhurire Cell in Rerenge Sector. 9 villages (Imidugdu) are identified in each Cell. All of these villages are located on hilly area situated at higher elevation than 1,400m. These villages are not located in the part of valley where the construction of the dam is planned. Therefore, no house in these villages will be sunk under water of the planned dam. The composition of government organizations related to the Study Area is shown in (Fig. 3-1-1-1).

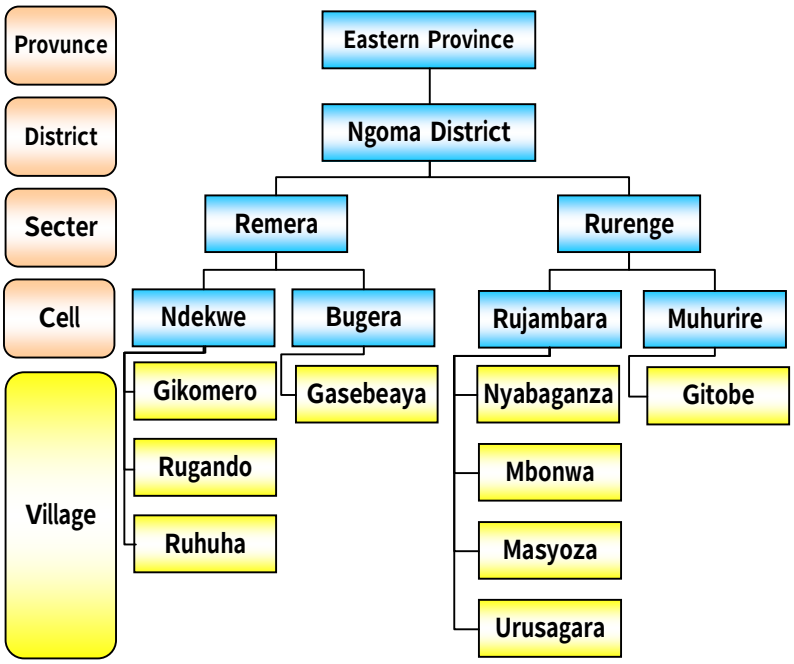


Fig. 3-1-1-1 Government organizations related to the planned area

3-1-2. Local administrative system

Terminal organization of the local administration in Rwanda is Cell. Cell Council composed of representatives elected from villages and Cell Committee are established in each Cell.

3-1-3. Population

9 villages in total are identified in the Study Area, namely Gikomero, Rugando and Ruhuha villages in Ndekwe Cell, Gasebeaya village in Bugera Cell, Nyabaganza, Mbonwa, Masyoza and Ursagara villages in Rujambara Cell, Gitobe village in Muhurire Cell. Population and household composition by village are tabulated in (Table 3-1-3-1). Average family members per household exceed 4 members in 4 villages, the average is in the range of 3 ~ 4 in 2 villages and it is less than 3 members in 3 villages.

According to the result of baseline survey in "Agricultural Productivity Promotion Project in Eastern Province" (March 2011) (hereinafter referred to as "Eastern province baseline survey"), average family members per household in Ngoma District ranges 5.50 members/HH ～ 5.95 members/HH, thus that in 9 target villages lies below this District average by 0.9～2.3 members per household. Similarly, the average household members in Rwanda is 4.3 members/HH（in 2008）. It follows that this average in 7 villages in the Study Area are also below the state average.

Table 3-1-3-1 Family composition in each Village

Ndekwe					
IMIDUGUDU	Male	Women	Total	HouseHold	Family Size
Gikomero	298	335	633	168	3.8
Rugando	551	613	1164	294	4
Ruhuha	562	382	944	208	4.5
Bugera					
IMIDUGUDU	Male	Women	Total	HouseHold	Family Size
Gasebeaya	344	215	559	214	2.6

Rujambara					
IMIDUGUDU	Male	Women	Total	HouseHold	Family Size
Nyabaganza	257	215	472	123	3.8
Mbonwa	319	236	555	201	2.8
Masyoza	487	368	855	206	4.2
Urusagara	224	203	427	167	2.6
Muhurire					
IMIDUGUDU	Male	Women	Total	HouseHold	Family Size
Gitobe	354	215	569	123	4.6

(Source: the result of hearing in Sector offices of Remera and Rurenge)

3-1-4. Gendar composition

Gendar composition in each village is shown in (Fig. 3-1-4-1). Rate of female population is high in two villages, namely Gikomero and Rugando villages. In all other villages, male population is higher, Genocide took place 18 years ago, but nowadays its aftermath still remains in gender composition rates. Two reasons are conceivable of the higher rate of male population, the fact that rate of younger generations in total population has been augmenting and that exodus of female population to urban areas takes place, but the reality is not known. Clear reply of office staff in each Sector to this phenomenon was not obtained.

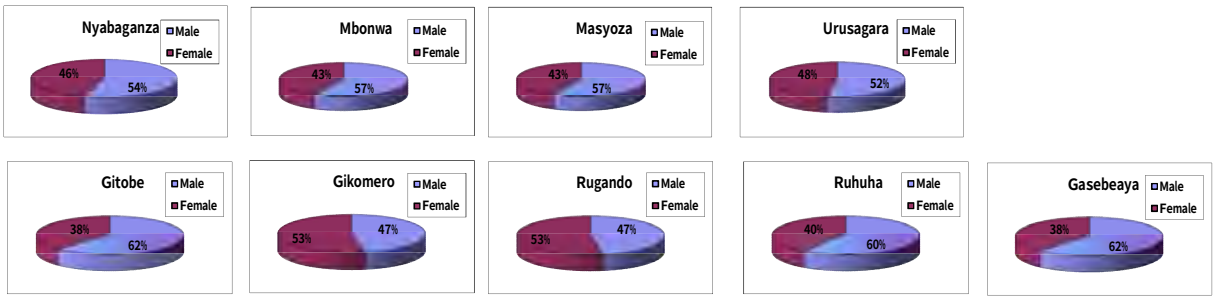


Fig. 3-1-4-1 Gender composition in the village

3-2. Foundation of social life

3-2-1. Education

4 primary schools have been established and maintainedin the Study Area, namely: Nyabaganza., Ursagara, Gitobe and Gikomero. Also, a middle school is distributed in each Cell in Ndekwe and Bugera Cells but no middle school has been established in two other cells, namely Rujambara and Muhurire Cells. After graduating from primary schools, students in Rujambara Cell commute to middle school of Rugese Cell that is situated about 20km away from their homes, and in the case of Muhurire Cell, they commute tothat of Kabuya Cell, 10 km distant from their residences.

Numbers of children by gender and enrollment rates in 3 primary schools are estimated. As to the latter, number of children whose age ranges in school age (school age population) is firstly estimated from the total village population and then the rate has been calculated from actual number of children commuting to these primary schools. School ages of primary school in Rwanda is in the rage from 6 to 13 years old. Population rate of school age population (rate of population in the cluster of 6 ~ 13 years old). As school age population has been predicted at 14% in Rwanda, that in these 3 primary school was estimated by adopting this percentage based on total village population be gender (as total population × school age population).

Enrollment rate for Muhurire Gitobe primary school could not be calculated due to lack of available statistics on child population in neighboring villages except that of Gitobe Village that made the estimation of school age population impossible.

Table 3-2-1-1 Number of Children in Primary School & Enrollment rate

Ndekwe		Gikomero	Rugando	Ruhuha	Total	School Age Population	Enrollment rate
Primaly school	Male	64	-	-	64	206	31%
	Fumel	56	-	-	56	194	29%
	Total	120	-	-	120	400	30%

Rujambara		Nyabaganza	Mbonwa	Masyoza	Urusagara	Total	School Age Population	Enrollment rate
Primaly school	Male	79	-	-	68	147	188	78%
	Fumel	59	-	-	59	118	149	79%
	Total	138	-	-	127	265	337	79%

Muhurire		Gitobe	Total	School Age Population	Enrollment rate
Primaly school	Male	119	119	-	-
	Fumel	85	85	-	-
	Total	204	204	-	-

Note：14% of the total population was assumed as the number of children at school age. refer to Statistical year book

Source: provided by JICA Study Team

National statistical data gives 95% for both enrollment rate of bith boys and girls to primary school in Rwanda, indicating that the said rate in the Study Area stays considerably lower level in comparison with national average. Besides, according to the result of hearing in Nyabaganza Village, constraints of school facilities are found in insufficient number of classrooms, also shortage of desks, chairs, blackboards etc. Only two classrooms are available in Nyabaganza primary school where classes are managed 2-shift of school hours in the morning and in the afternoon.

3-2-2. Health and hygiene

The nearest available clinic facility for villagers in rural villages in Rwanda is Health Post. Two

nurses work in a Health Post with 2-shift working hours of daytime and night services. Simple examinationand treatments for malaria, disentry diseases and practices of infantry vaccination program. Besides, a system has been operated by which patients are transported to Health center in each Cell in emergency cases. Health Centers have been established in each of Cells including Ndekwe, Muhurire and Bugera, however, it has not yet been created in Rujambara Cell. Health Center A medical Assistant[1] and some nurse staff work in each Health center where conventional surgery treatments/ operations, test of HIV and such services as health instruction for maternity people and mid-wife service at deliveries. In emergency cases, transprt network system connecting to district hospitals has also been available.

3-2-3. Electricity

Electrification has been proceeded along the trunk road between Remera and Kibungo, however, diffusion of electrification at village level of has been delayed. According to the result of "Eastern province baseline survey", rate of already elecrified farm households in Ngoma District remains at 6.6%. Similarly, no village in the Study Area has ever been electrified.

Kerosine lamps and parafin ones have been used as fuel in farm households. Kerosine is sold at the unit of 200 ml at the price (200RWF/ 200 ml). Hoever, due to limited cash income in farm households, fsrmers cannot regularly buy kerosine or parafin.

3-2-4. Communication

Cell-phones are not yet popularized in Rwnda, though cell-phone communication services have been provided by such firms as MTN, TIGO and Rwandatel. Even in villages scene of conversations by cell-phone can often been observed, but recharging and fee-payment are not yet available at village level, serving as an element of constraint to delay its diffusion.

3-2-5. Access to information

Access to administrative service information by villagers has been descending down by top-down type in a form "District → Sector → Cell → Village. At villager's level, they obtain information on administrative services and extension services from members of Cell Council and Cell Committee. As means to obtain personal information by individual villager, radios are commonly diffused. Broadcasting services are provided by Community Radio under the umbrella of National Radio Broadcasting Station and a commercial radio broadcasting media "IZURA" that utilizes Kibungo as the base of broadcasting.

3-2-6. Roads / Traffic

The trunk road passing from Kigali City to the Study Area of this Program becomes unpaved section within Remera Sector. No paved road is available in the Study Area. In addition to the fact that roads have been constructed on sloped land, earth used for road construction contains much clay and these results in muddy surface condition during rainy season. Also, as traffic means, regular transport services like public buses have not been available. Traffic/ transport by motor bikes can be

[1] As to the qualification of Medical Assistant service, it is allowed to those who have graduated from faculty related to medical services of 4-year study course.

observed, but bicycles are most popularly diffused. As means of transporting/ marketing local agricultural products, bicycles are mainly utilized, but carriage of goods has been relied on manual means, walking carriage on head is commonly practiced.

3-2-7. Domestic water supply

While tap water has been supplied only a limited part of the Study Area, current state of water supply in many villges is relied on manual fetching of fountain water from fountains in the valley. Water fetching labor depends on the living environment, usually women carry water in polyethylene tanks of the content 20 liters on their heads 3 ~ 4 times a day. At the same time, children also fetch water in polyethylene tanks of the content of 5 ~ 10 liters.

3-3. Village communities

3-3-1. Vocational labor situation

Accordin to "District Dwvwlopmwnr Plan"of Ngoma District, over 90% of the total households in the said District has been engaged in agriculture. In the villages of the Study Area, more than 90% of the existing households is considered living on agricuture. As labor opportunities other than farming, running kiosks and bars, day-to-day basis labor service in Kibungo have been identified.

3-3-2. Time sequence of daily life

Time sequence of daily life of an average farm housheols elucidated from village survey is illustrated by gender in the table below: Villagers do not have custom to have breakfast, and most families subtain their life only having supper. Farm practices are perfomed in the morning, returning home in the afternoon, women are engaged in water fetching, firewood collection, housekeeping chores, preparation of supper. Men are engaged in cre for livestock and other labor work around their houses and participate in meetings. After having supper, the go to bed.

Table 3-3-2-1 Daily life pattern in villages

Time	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Man										Animal Care Field Work			Meeting					
	Wakeup ◄·····					Field Work				·····►			·····►				Go to bed	
Women										Water fetching firewood collection			House Keeping					

Source：JICAStudy Team

3-3-3. Household livelihood

According to the national statistics, monthly average household expenditure of a farm household is 27,500RWF, however, that in the Study Area is estimted at 13,775RWF, indicating considerably lower level than national mean. Out of this expenditure, food expense accounts for about 10%, anf the rest 90% for other expense than food. Out of food expense, cereal grain purchase accounts for 10%, banana and tubers for another 10%, beans and vegetables for 20% while purchase of oil/fat, sugar and salt occupies 35%. As to expense on agricultural production, it accounts for 12% of the total household expenditure (177,260RWF). Rate of educational expense is 7%, medical expense occupies 7% and telephone fee does 7%.

3-3-4. Dietary Habit

According to East Baseline Study, 2 meals a day is common in rural area. Hearing investigation at Ndekwe, Bugera, Rujambara and Muhurire Cells revealed that majority of household have 1 meal a day. For villagers, rice is expensive staple diet. Usually cassava, banana and vines of sorghum sweet potato are their staple diet.. The villagers, meat on Christmas, wedding ceremony, once a year. They have milk for home consumption.

3-4. Current state of farming

According to the result of a questionnaire study covering 61 farm households chosen arbitraly from the upstream, mis-stream and downstream of the project area, mean farmland holding per household with average 5 family members consists of lowland rice 0,.1ha, upland 0.7ha. (Table 3-4-1,3-4-2) Area has actually been measured for 36 households for upland field covering 88% (out of the total 41HH) and for 13 households for lowland covering 32% (the same as above), implying that high interest on farmland holding.The reason why low rate of area measurement for lowland may be attributable to smaller area per farm parcel.

Methods of land acquisition are classified into 4 types, namely purchasing, succession, lease and new-reclamation (Fig. 3-4-1). Farmers acquire their farm land with these combined 4 types. (Fig. 3-4-1) New cultivation means that farmers had reclaimed Marshland before 2005, when new land act was reinforced and marshland was put under protection.

Under these circumstances, farmland utilization ratio is recorded at as high as 100% except for 2 farmers, found as the result of questionnaire (for 61 farm households in the beneficiary of 2 sectors including Remera and Rurenge). Small land holding has oriented farmers to diversified cultivation, in which they have developed their habit of taking countermeasures against drought, crop-disease and food security.

Also, according to the questionnaire survey, lowland paddy is cropped by 87% of the surveyed farm households, followed by 77% for beans and 74% for sorghum (Fig. 3-4-2). Almost all rice is cultivated by double cropping in the cropping pattern currently practiced in Ngoma-22. The basic farming principle of fertilizer application after weeding has been observed. Sorghum is sown after planting tubers and pulses and its cropping period is concentrated in season A that starts from January. As to maize, its cropping is concentrated in season A initiated from September (Fig. 3-4-3).

There are several cropping patterns, Rice-Rice (double cropping), Tubers-Sorghum, Beans-Sorghum, Beans-Maize, Maize-Sorghum and mixed cropping of banana with beans. Compost is applied by 70% in Remera sector, 45% in Rulenge Sector, respectively, though its amount and materials are not known. (Table 3-4-3)

Annual household income is less than 500 US$ (by preparatory stury in 2009) almost without off-farm income (in the quastionnaire study targeting 19 sample farmers, 17 households do not have any off-farm income, a household runs bar, another one sells banana-beer.

Table 3-4-1 Land utilization in expected beneficiary

	(Remera sector)			
	Lowland (m2)	Upland(m2)	Utilization	Remark
Farmer1	Not measured	12580	No answer	
Farmer2	Not measured	Not measured	No answer	
Farmer3	375	5200	No answer	
Farmer4	Not measured	14000	100%	
Farmer5	Not measured	3000	100%	
Farmer6	Not measured	Not measured	100%	
Farmer7	Not measured	20000	50%	short of rain
Farmer8	Not measured	10000	100%	
Farmer9	Not measured	14200	100%	
Farmer10	Not measured	1500	No answer	
Farmer11	Not measured	Not measured	No answer	
Farmer12	Not measured	3900	100%	
Farmer13	Not measured	1750	100%	
Farmer14	600	15000	75%	fallow
Farmer15	374	5000	100%	
Farmer16	Not measured	Not measured	100%	
Farmer17	2250	1600	100%	
Farmer18	Not measured	Not measured	100%	
Farmer19	1125	2100	100%	
Farmer20	Not measured	3050	100%	
Average	945	7525		

Table 3-4-2 Land utilization in expected beneficiary

	(Rulenge sector)			
	Lowland (m2)	Upland(m2)	Utilization	Remark
Farmer1	Not measured	595	100%	
Farmer2	Not measured	3000	100%	
Farmer3	Not measured	8700	100%	
Farmer4	1128	1848	100%	
Farmer5	Not measured	450	100%	
Farmer6	Not measured	600	100%	
Farmer7	Not measured	8400	100%	
Farmer8	795	5800	100%	
Farmer9	600	1750	100%	
Farmer10	2350	23400	100%	
Farmer11	1027	2560	100%	
Farmer12	Not measured	13000	100%	
Farmer13	Not measured	5600	100%	
Farmer14	1000	1800	100%	
Farmer15	Not measured	1200	100%	
Farmer16	Not measured	1875	100%	
Farmer17	400	20800	100%	
Farmer18	Not measured	10000	100%	
Farmer19	Not measured	3000	100%	
Farmer20	Not measured	5242	100%	
Farmer21	1000	1575	100%	
Average	1038	5771		

Fig. 3-4-1 Method of land obtaining

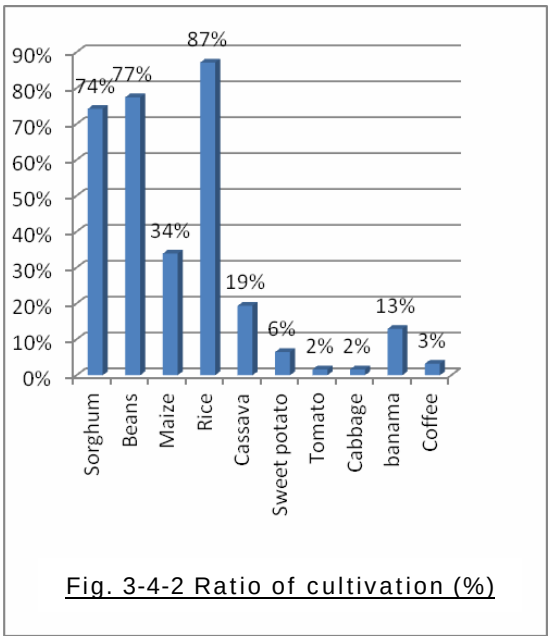


Fig. 3-4-2 Ratio of cultivation (%)

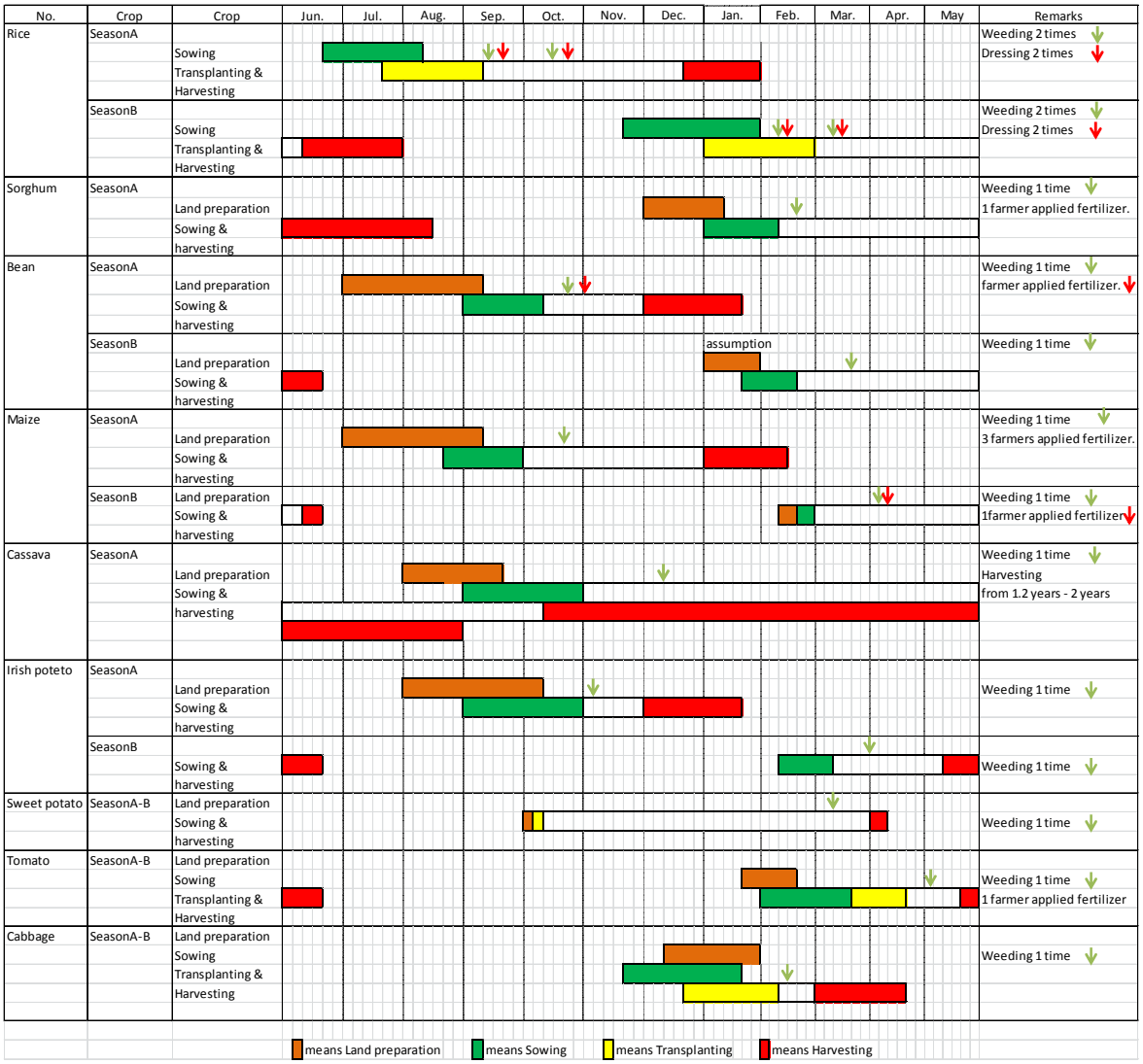


Fig. 3-4-3 Current status of cropping patterns

Table 3-4-3 Compost

	Compost	No use	non-response	application rate(%)
Remera (20 household)	14	6	0	70
Rulenge (41 household)	19	17	6	45

3-5. Survey related to farming

3-5-1. Percolation survey

(1) General

(a) Purpose of the survey

The percolation in the downstream paddy fields that are a part of the command area shall be surveyed and the water requirement (ETc) of the paddy fields shall be estimated based on the survey results.

(b) Definition of the water requirement (ETc)

The water consumption volume per one paddy field is called “the water requirement ETc” that is the numerical character showing the ascent or the descent of the water surface per day in the paddy field and is expressed by mm/day. The water requirement ETc is composed of, as shown in Fig.3-5-1-1, the leakage through ridges, evaporation from the water surface, transpiration from rice and the vertical percolation through the bottom of the paddy field.

- ETc ＝ evapo-transpiration + seepage loss
- Evapo-transpiration ＝ evaporation from the water surface + transpiration from the leaf surface
- Seepage loss＝ leakage through ridges + vertical percolation through the bottom of the paddy field

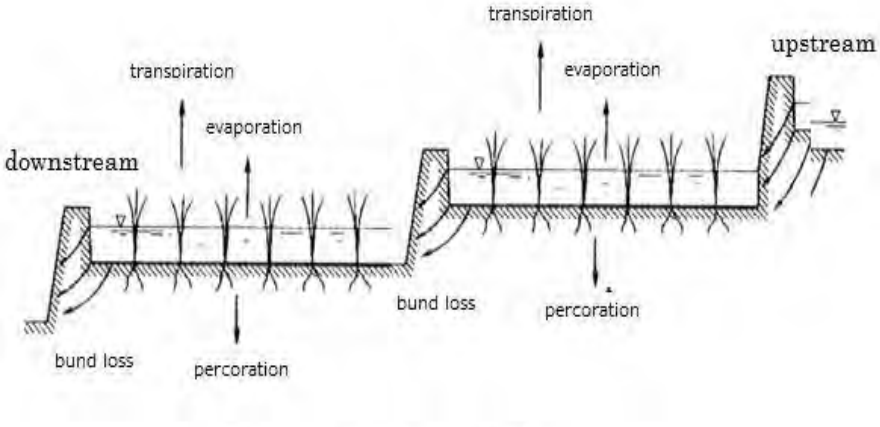


Fig.3-5-1-1 Water loss in depth

(c) Quantity of the survey

Table 3-5-1-1 Summary of the survey quantity

	The first survey				The second survey		
Date	28th of March	29th of March	1st of April	12th of April	21st of April	23rd of April	2th of April
Location	Point A	Point B	Point C	Point D	Point E	Point F	Point G
	Refer to Fig.3-5-1-2						

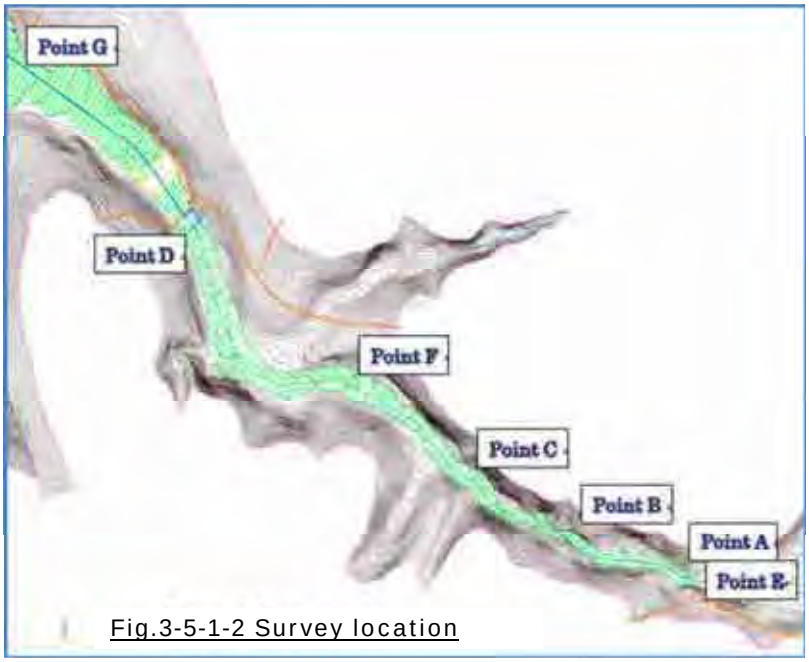
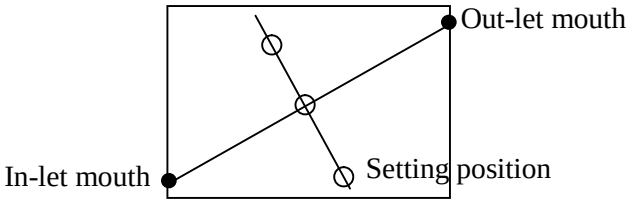


Fig.3-5-1-2 Survey location

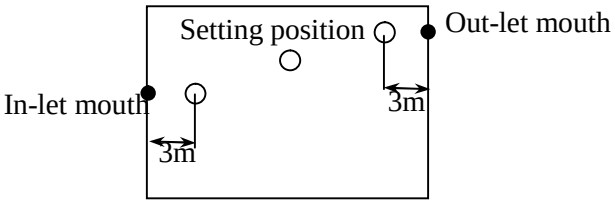
(d) Survey process and method

At first, the in-let mouth and the out-let mouth to or from the paddy field are shut and the leakage mouth to the adjacent paddy field shall be shut by mud covering if any. Then the cylinders and wooden sticks for measuring the water level are set. The location setting manner of them is as follows.

・in case of the in-let mouth and the out-let mouth being on the diagonal line;



・in case of the in-let mouth and the out-let mouth being not on the diagonal line;



Other items/devices are as follows.

・for transpiration measurement
；3 plastic buckets, water is filled and one turnip of rice is put in each bucket. Each bucket is placed beside the cylinder.
・for evaporation measurement；2 plastic buckets with water filled
・for rainfall measurement；one empty plastic bucket
・measurement period； 5.5 hours from AM 11:00 to PM 4:30

Seepage loss and evapo-transpiration are calculated as follows.

・Seepage loss = measured descent by wooden stick× 24/5.5 (mm/day)
(measured descent by wooden stick= leakage through ridges + vertical percolation)
・Evapo-transpiration = (transpiration + evaporation） × 12hours÷5.5×1.15 (mm/day)
(estimated day time by FAO Irrigation paper No56)


Picture-1.Repairing of the bund


Picture-2.Cylinder and stick


Picture-3.Cylinder and stick


Picture-4. Plant for evapotranspiration

(2) Survey result

(a) Evapo-transpiration

Table 3-5-1-2 Evaporation and transpiration

	Weather	Evaporation (mm/day)	Transpiration (mm/day)
28-Mar.	fine	2.20	5.00
29-Mar.	cloudy	0.80	2.30
01-Apr.	cloudy	0.40	1.50
12-Apr	fine	1.05	4.57
21-Apr	cloudy,rain	1.07	4.16
23-Apr	cloudy	1.30	4.45
25-Apr	cloudy	0.95	3.70

The first survey (28-Mar.~12-Apr.); Estimated based on the observation result
The second survey (21-Apr.~25-Apr.); Estimated following the Penman-Monteith Method, FAO as the observation is affected much by the damage degree of plant caused by sampling

(b) Seepage loss

[The first survey]

Let us comparer the results observed in these three survey points, Point B(upstream), Point C(midstream), Point D(downstream), where the both cylinders and wooden sticks were set. In every survey point, the value of leakage through ridges is larger than the one of vertical percolation as shown on (Table 3-5-1-3) and in (Fig.3-5-1-3). In summary, the leakage through ridges occupies 80% and the vertical percolation occupies 20% averagely.

Table 3-5-1-3 Calculated percolation value

date	site	weather	Percoration loss (mm/day)	bund loss (mm/day)	Total water loss in depth (mm/day)
28-Mar.	pointA	fine	7.9	-	-
29-Mar.	pointB	cloudy	18.3	51.5	69.8
01-Apr.	pointC	cloudy	20.1	122.6	142.7
12-Apr.	pointD	fine	20	88.3	108.2
				Remark: each figure is on the average of three.	

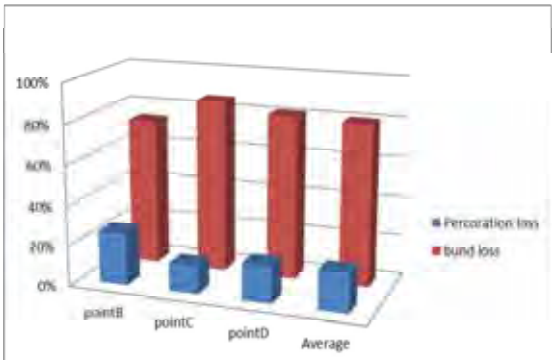


Fig.3-5-1-3 Component of seepage loss

[The second survey]

The survey results show the same tendency as the ones in the first survey. In summary, the leakage through ridges occupies 85% and the vertical percolation occupies 15% averagely.

Table 3-5-1-4 Calculated percolation value

date	site	weather	Percoration loss (mm/day)	bund loss (mm/day)	Total water loss in depth (mm/day)
21-Apr.	pointE	cloudy,rain	13.5	29.3	42.8
23-Apr.	pointF	cloudy	6.0	213.7	219.7
25-Apr.	pointG	cloudy	10.0	72.7	82.7
				Remark: each figure is on the average of three.	

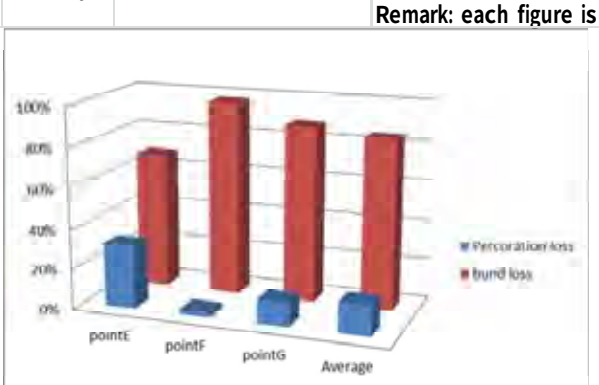


Fig.3-5-1-4 Component of seepage loss

Totally, the average vertical percolation loss is 13.6 mm/day and the leakage through ridges is 96.4 mm/day.

[Influence of rainfall to the leakage through ridges]

According to the survey results on 21st of April, the leakage quantity through ridges was very small. To this event, the rainfall was assumed to be the cause. The rainfall scale was 20mm during about 2 hours from PM 0 : 40 to PM 2 : 45, and was relatively intense according to the rainfall record. Rainfall itself affects the water level both in the cylinder and the paddy field equally, so that the factor that gives influence to the leakage through ridges is assumed to be the in-flow of rain water and ground water. It is understood that the increase caused by the rain/ground water flowing into the paddy field decreased the reduction level by the leakage through ridges.

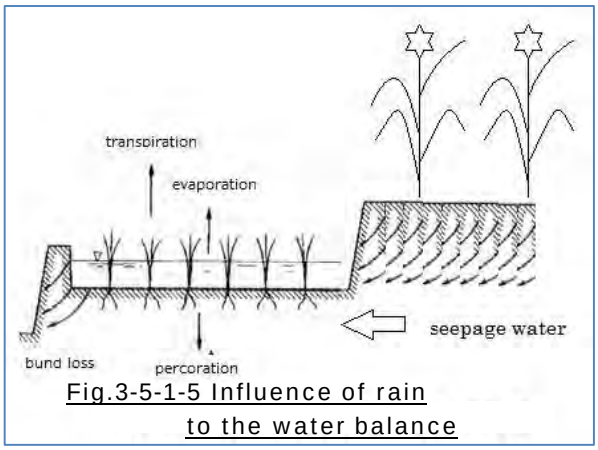


Fig.3-5-1-5 Influence of rain to the water balance

Following photos indicate the influence of rain. The water in the latter photo is more murky and suggests the in-flow of rain water.

Outlet of the paddy field (10:55)

Outlet of the paddy field (16:30)

3-5-2. Intake rate survey

(1) General

(a) Purpose of the survey

Intake rate shall be survey in the dry fields of command area and the suitable on-farm irrigation method shall be studied based on the survey result.

(b) Definition of the intake rate

ⅰ) Accumulated infiltration (D)

The accumulative infiltration (D) is the accumulative descent of water surface caused by infiltration into the ground. The following formula is applied to the relationship between the passing time (T)

and D based on the characteristics that the dots plotted on the complete logarithmic graph with time (T) on the lateral axis and D on the vertical axis fall on a line.

$$D=C \cdot T^{n}$$

Here T：passing time after the start of the test (min）
C：constant number（D's value at T=1min）
n：gradient of the line

ii) Intake rate (infiltration velocity) (I)

Intake rate is the indicator that shows the degree of infiltration and expressed by the following formula.

$$I=60 \cdot C \cdot n \cdot T^{n-1}$$

Here I：intake rate (mm/hr)
T：passing time after the start of the test (min）
n：gradient of the line

iii) Basic intake rate (I_b)

The observed value of intake rate becomes small by and by together with the time passing after the start of the test and finally reaches a constant value. This constant value is called "Basic Intake Rate" and is understood to represent the permeability level of the unsaturated soil layer. In reality, the value of the basic intake rate is given by the intake rate value D corresponding to the increase ratio of D becoming less than 10%. And the time (T) needed for the intake rate to reach the basic intake rate is expressed by the following formula. $T=600 \cdot (1-n)$

Then the basic intake rate is expressed as follows. $I_b=60 \cdot C \cdot n(600 \cdot (1-n))^{n-1}$ (mm/hr)

(c) Survey quantity and location

The survey locations are shown in (Fig.3-5-2-1). Point-D and point-E are the locations of reviewed tests to Point-A and Point-B of which basic intake rate values seemed to be too high. At the point-A and point-D, the test was carried out in the two conditions, one was the natural field condition and the other was the wet field condition.

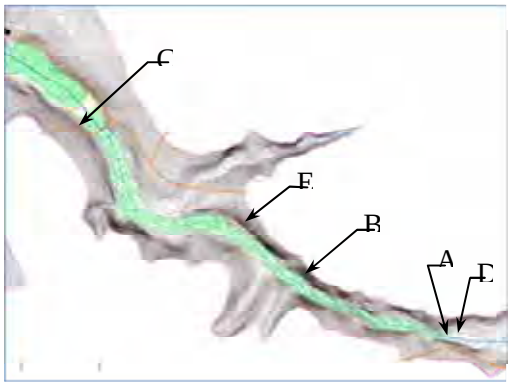


Fig. 3-5-2-1 Locations of Intake rate test

(d) Survey process and method

[Devices and equipments]

- steel cylinder; 3 pieces, φ15cm, H=35cm (with a scale on the inner surface)
- steel cylindrical frame for a buffering pond; 1 piece, φ58cm, H=35cm
- others; electronic scale×1, 500cc flask×1, 20ℓjerry can×4, water level×1, clinometer×1, stop watch×1, plastic sheet×1, funnel×1

[Process and method]

- Place the steel cylindrical frame on the ground surface and push it 15cm deep into the ground
- Place the steel cylinder at the center of the frame and push it 15cm deep into the ground
- Fill the steel cylindrical frame with water
- Cover the ground surface in the steel cylinder with the plastic sheet and pour water into the cylinder through the funnel
- Remove the plastic sheet and immediately after, scale reading is started at the interval of 1, 5, 10、15、20、25、30、40、50、60 minute.
- In case of the water level in the steel cylinder coming low, suitable amount of water is added by 500cc flask
- In case of Point-A and Point-D, the same process was repeated at the same place as the wet case.

Setting of the buffering pond

Installation of steel cylinder

Start of measurement

water for recovering the water surface

Measurement of water surface descent

3 times of testing at one lot

(2) Survey result

Table 3-5-2-1 Summary of the test results

Location/condition	Date	Plant/topography	Basic Intake Rate
A, natural condition	3/Apr.	Sweet potato／plane	580 mm/hr
A, wet condition	4/Apr.	Ditto	78 mm/hr
B, natural condition	8/Apr.	Sorghum／inclined(10°)	672 mm/hr
C, natural condition	12/Apr.	Feed crop／plane	75 mm/hr
D、natural condition	21/Apr.	Irish potato／plane	628 mm/hr
D, wet condition	22/Apr.	Ditto	490 mm/hr
E, natural condition	823/Apr.	Eggplant・vacant／plane	34 mm/hr

3/Apr. (natural condition：Point-A (upstream)：sweet potato：plane)

Basic Intake Rate is estimated to be I_b=580 mm/hr based on the observation.

The value of intake rate corresponding to increase ratio 10% is about 580 mm/hr (Table 3-5-2-2(1)).

Table 3-5-2-2 Observed intake rate(1)

T	D	I	rati
1	20	1029	
5	130	819	550%
10	220	742	69%
15	253	700	15%
20	313	672	24%
25	370	651	18%
30	500	634	35%
40	610	609	22%
50	700	590	15%
60	707.5	575	1%

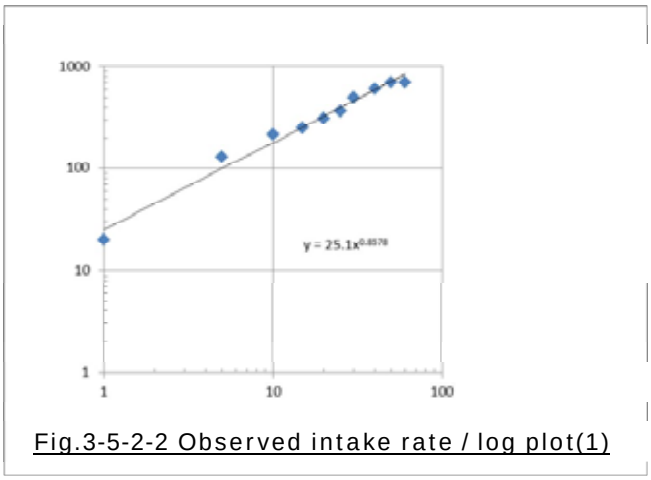


Fig.3-5-2-2 Observed intake rate / log plot(1)

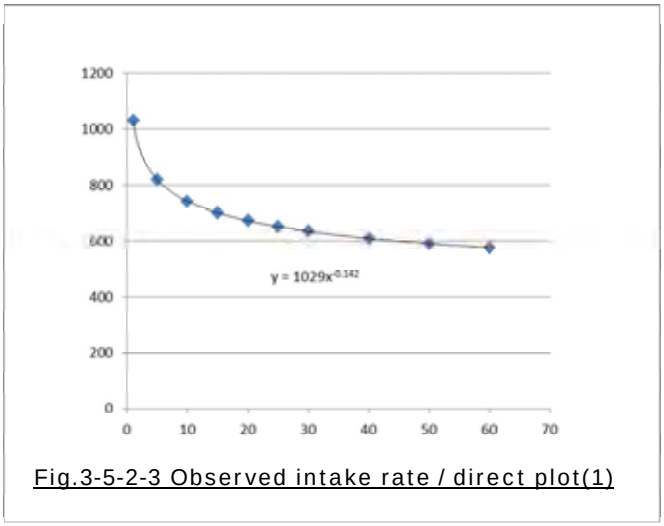


Fig.3-5-2-3 Observed intake rate / direct plot(1)

4/Apr. (wet condition：Point-A (upstream)：sweet potato：plane)

Basic Intake Rate is estimated to be I_b=78 mm/hr based on the observation.

The value of intake rate corresponding to increase ratio 10% is about 78 mm/hr (Table 3-5-2-2(2)).

Table 3-5-2-2 Observed intake rate(2)

T	D	I	ratio
1	15	457	
5	35	221	133.3%
10	55	162	57.1%
15	72.5	135	31.8%
20	85	118	17.2%
25	100	107	17.6%
30	140	98	40.0%
40	160	86	14.3%
50	185	78	15.6%
60	185	72	0.0%

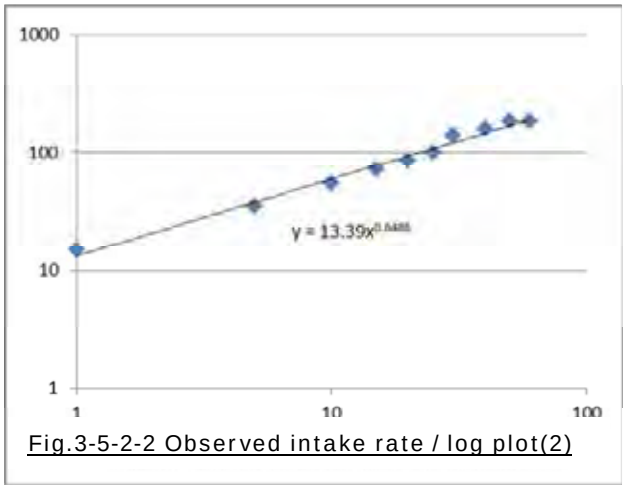


Fig.3-5-2-2 Observed intake rate / log plot(2)

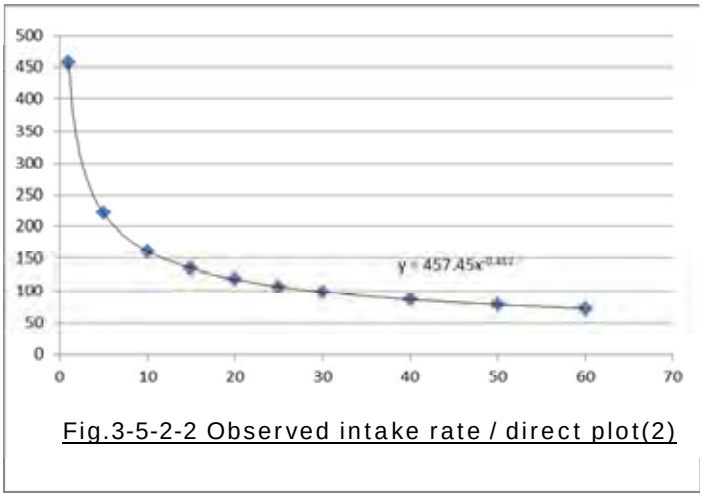


Fig.3-5-2-2 Observed intake rate / direct plot(2)

8/Apr. (natural condition：Point-B (midstream)：sorghum：inclined(10 °)

Basic Intake Rate is estimated to be I_b=672 mm/hr based on the observation.

The value of intake rate corresponding to increase ratio 10% is about 672 mm/hr (Table 3-5-2-2(3)).

Table 3-5-2-2 Observed intake rate(3)

T	D	I	ratio
1	30	1425	
5	130	1072	333%
10	198	948	52%
15	282	882	43%
20	359	838	28%
25	422	806	17%
30	492	780	17%
40	624	741	27%
50	747	713	20%
60	849	690	14%
70	944	672	11%
80	1044	656	11%

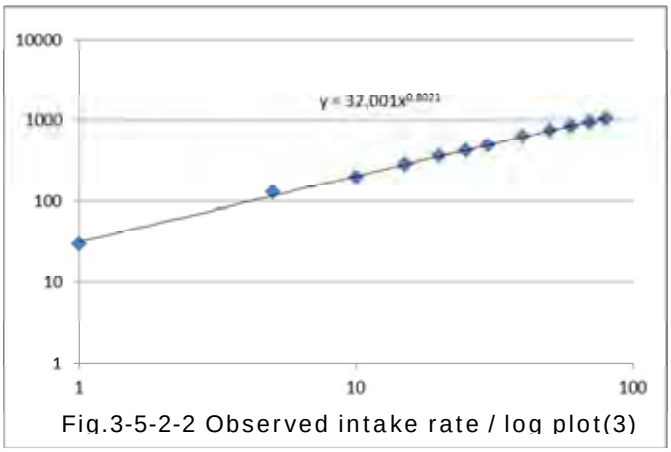


Fig.3-5-2-2 Observed intake rate / log plot(3)

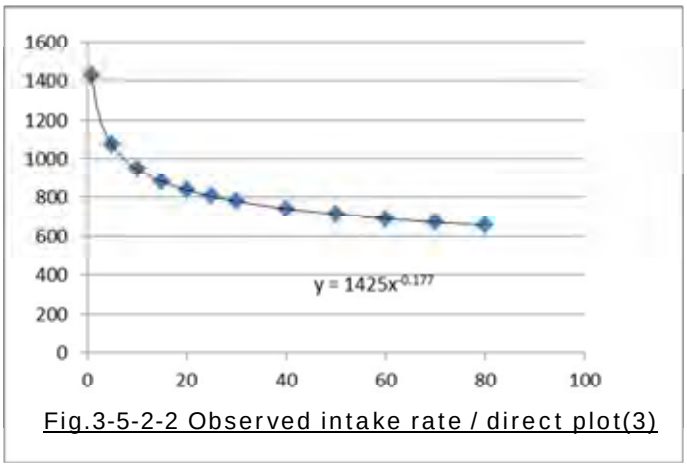


Fig.3-5-2-2 Observed intake rate / direct plot(3)

12/Apr. (natural condition：Point-C (downstream)：Reed canarygrass：plane)

Basic Intake Rate is estimated to be I_b=75 mm/hr based on the observation.

The value of intake rate corresponding to increase ratio 10% is about 75 mm/hr (Table 3-5-2-2(4)).

Table 3-5-2-2 Observed intake rate(4)

T	D	I	ratio
1	17.5	483.7	
5	32.5	222.4	86%
10	42.5	159.2	31%
15	62.5	130.9	47%
20	77.5	113.9	24%
25	85	102.3	10%
30	92.5	93.7	9%
40	110	81.5	19%
50	118.75	73.2	8%
60	132.5	67.0	12%

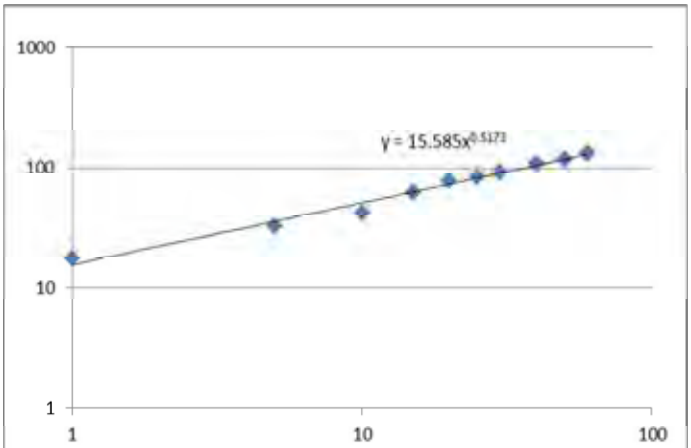


Fig.3-5-2-2 Observed intake rate / log plot(4)

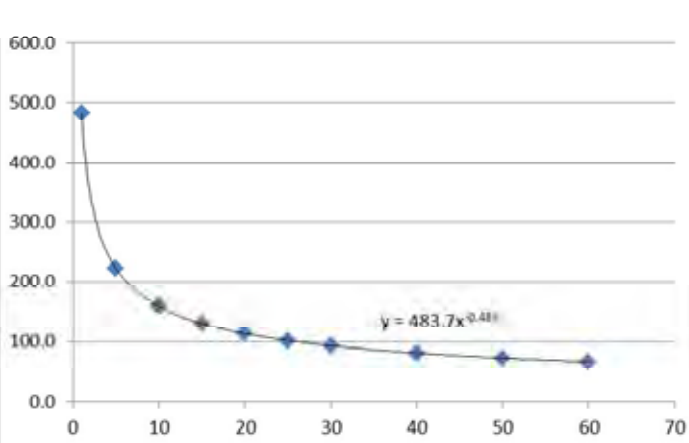


Fig.3-5-2-2 Observed intake rate / direct plot(4)

21/Apr. (natural condition：Point-C (upstream)：Irish potat：plane)

Basic Intake Rate is estimated to be I_b=628 mm/hr based on the observation.

The value of intake rate corresponding to increase ratio 10% is about 628mm/hr (Table 3-5-2-2(5)).

Table 3-5-2-2 Observed intake rate(5)

T	D	I	ratio
1	60	2664.4	
5	230	1509.8	283%
10	320	1182.2	39%
15	410	1024.6	28%
20	485	925.7	18%
25	550	855.6	13%
30	615	802.3	12%
40	727.5	724.8	18%
50	830	669.9	14%
60	912.5	628.2	10%

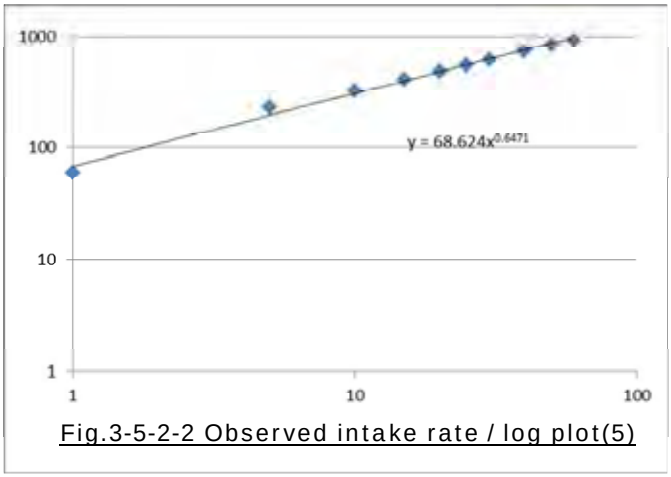


Fig.3-5-2-2 Observed intake rate / log plot(5)

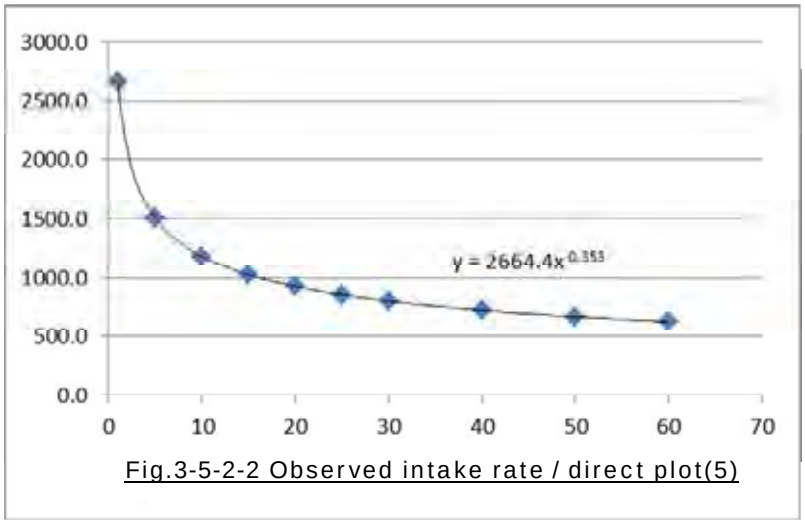


Fig.3-5-2-2 Observed intake rate / direct plot(5)

22/Apr. (wet condition：Point-D (upstream)：Irish potat：plane)

Basic Intake Rate is estimated to be I_b=490 mm/hr based on the observation.

The value of intake rate corresponding to increase ratio 10% is about 490mm/hr (Table 3-5-2-2(6)).

Table 3-5-2-2 Observed intake rate(6)

T	D	I	ratio
1	15	907.3	
5	72.5	708.3	383%
10	145	636.6	100%
15	215	598.1	48%
20	230	572.2	7%
25	295	552.9	28%
30	330	537.6	12%
40	390	514.3	18%
50	452.5	496.9	16%
60	455	483.2	1%

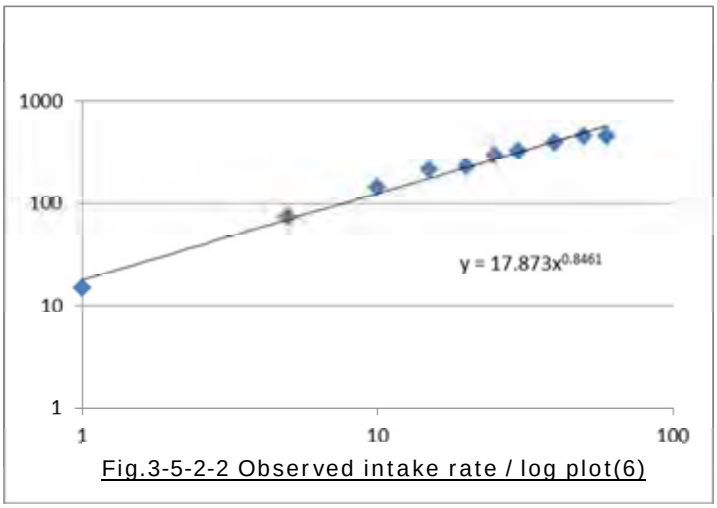


Fig.3-5-2-2 Observed intake rate / log plot(6)

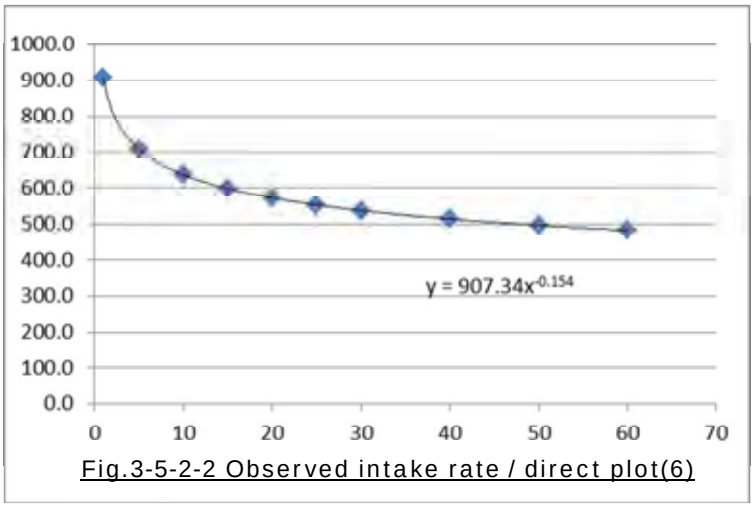


Fig.3-5-2-2 Observed intake rate / direct plot(6)

23/Apr. (natural condition：Point-E (midstream)：eggplant/vacant：plane)

Basic Intake Rate is estimated to be I_b=34 mm/hr based on the observation.

The value of intake rate corresponding to increase ratio 10% is about 34mm/hr (Table 3-5-2-2(7)).

Table 3-5-2-2 Observed intake rate(7)

T	D	I	ratio
1	2.5	101.6	
5	7.5	60.1	200%
10	12.5	47.9	67%
15	15	42.0	20%
20	20	38.2	33%
25	21	35.5	5%
30	22.5	33.5	7%
40	30	30.5	33%
50	37.5	28.3	25%
60	40	26.7	7%

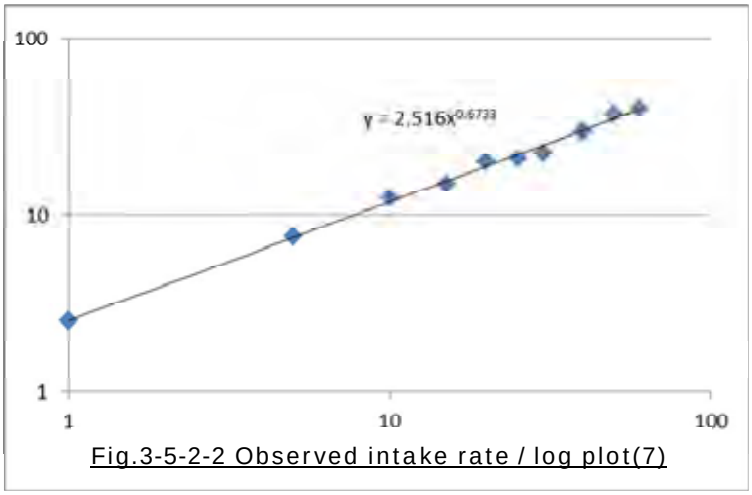


Fig.3-5-2-2 Observed intake rate / log plot(7)

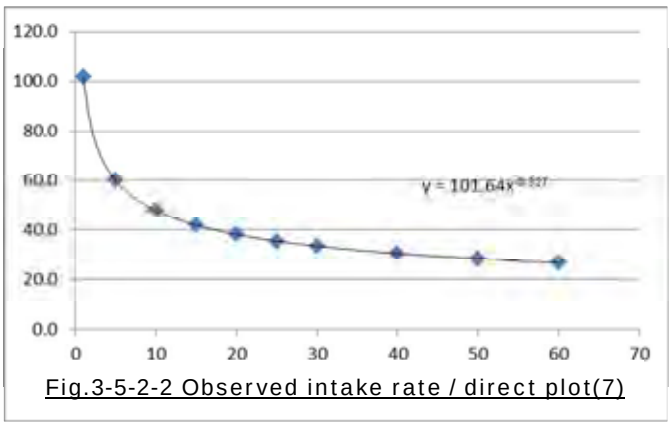


Fig.3-5-2-2 Observed intake rate / direct plot(7)

(3) Speculation

Intake Rate is the infiltration degree of the irrigation water or the rain water seepage into the ground under some given conditions, is expressed by mm/hr and considered to be an indicator of the permeability of unsaturated soil layers and to be an important factor on which the on-farm irrigation method or the suitable irrigation intensity is examined and decided in the dry field irrigation design. In U.S.A, it is said that in case of the basic intake rate being larger than 7.8 mm/hr, the surface irrigation method is not applicable due to the large loss of deep infiltration. In Japan, the intake rate is usually larger than this value (source; Irrigation and Drainage, P133, by Mr. Maruyama etc.), and the values shown as a standard value are less than 30mm/hr in every case (source; Dry Field Irrigation, refer to (Table 3-5-2-4)).

According to the survey results, all the obtained values are higher than 30mm/hr, and the values in the midstream and upstream area are very large showing the numeric with three figure refer to (table 3-5-2-3). Therefore, in this project, the on-farm irrigation methods such as the furrow irrigation method and sprinkler irrigation method are not applicable, and it would be necessary to apply the saving irrigation method in which the irrigation water shall be supplied directly and limitedly to and around the plant's root only.

Table 3-5-2-3 Basic intake Rate observed

	A (mm/hr)	B (mm/hr)	C (mm/hr)	D (mm/hr)	E (mm/hr)
Natural Condition	580	672	75	628	34
Wet condition	78	-	-	490	-

Table 3-5-2-4 Allowale irrigation intensity(mm/hr)

Soil	Plane field	Inclined field
Sandy	30	20
Loam	15	10
Clayey soil	10	7

3-6. Survey for water resources

3-6-1. Supplemental survey of hydrology

(1) Long-term movement in hydrological and meteorological fields

(a) Data collection

Table 3-6-1-1 Hydrometeorological data

Item	Station	Detail	Period	Reference
Rainfall	Kigali airport	Monthly	1998~2011	
	Kigali airport	Daily	1971~2009	From 2009 Report
	Kigali airport	Mon., 24 hours max	1971~2008	From 2009 Report
	Kibungo	Daily	1932~1993	From 2009 Report
	Kibungo	Monthly	2011	Not complete
	Gahororo	Daily	1960~1994	Not complete
Temperature	Kigali airport	Monthly max. min.	1998~2011	
	Kigali airport	Daily max. min.	1971~2008	From 2009 Report
	Kibungo	Daily max. min.	1973~1993	From 2009 Report
	Kibungo	Monthly max. min.	2011	Not complete
	Gahoror	Daily max. min.	1960~1994	Not complete
Sunshine	Kigali airport	Monthly	1998~2007	Not complete
	Kigali airport	Daily	1971~2008	From 2009 Report
	Kibungo	Daily	1990~1992	From 2009 Report
Humidity	Kigali airport	Monthly, mean	1998~2011	
	Kigali airport	Daily, mean	1971~2008	From 2009 Report
	Kibungo	Daily, mean	1990~1992	From 2009 Report
	Kibungo	Monthly, mean	2011	Not complete
Wind velocity	Kigali airport	Monthly, max.	1974~1993	From 2009 Report
	Kibungo	Daily, max.	1974~1991	From 2009 Report
Evaporation	Kigali airport	Daily accumulated	1971~1993	From 2009 Report
	Kibungo	Daily accumulated	1990~1993	From 2009 Report

(b) Long-term movement in hydrological and meteorological fields

ⅰ) Precipitation

Followings show the precipitation in Kigali airport for these 40 years, where the tendency of decrease appears clearly.

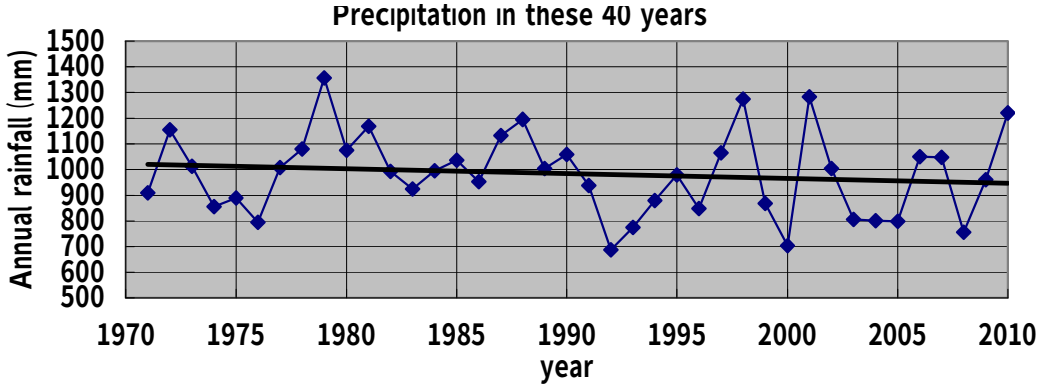


Fig. 3-6-1-1 Precipitation in these 40 years

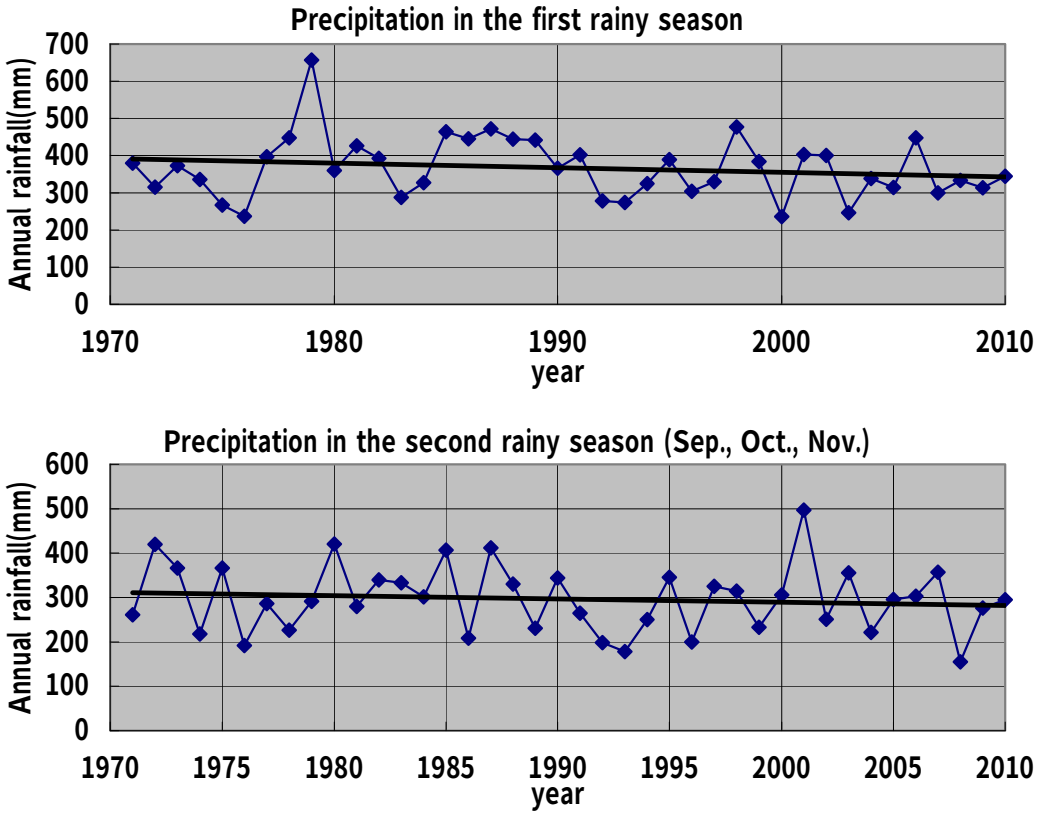


Fig. 3-6-1-2 Long-term weather patterns of precipitation in these 40 years

This tendency of decrease is mainly caused by the rainfall in the first rainy season (March, April, May) accelerating to decrease remarkably.

ii) Temperature

The following graph shows the annual mean value of the daily maximum temperature in these 40 years. Here the tendency of ascent is very clear by the fact that the annual mean value has risen by 1.5 ℃ in these 40 years. It would be said that the global warming phenomena appears remarkably in Rwanda.

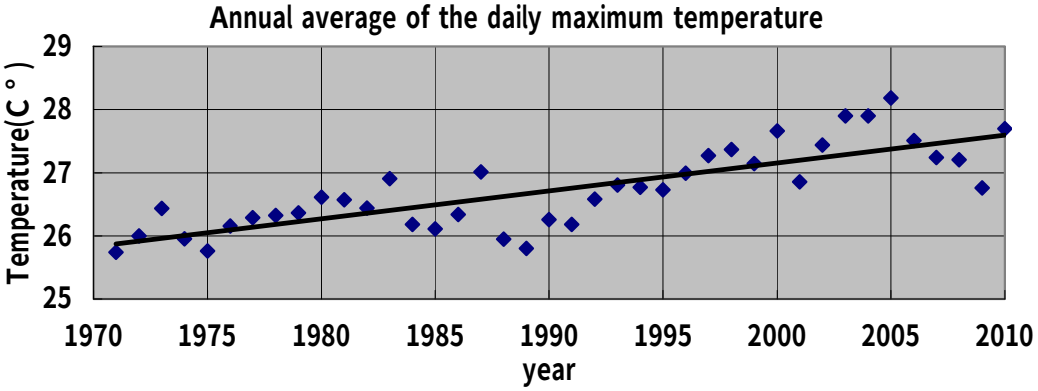


Fig. 3-6-1-3 Annual average of the daily maximum temperature

The following graph shows the annual mean value of the daily maximum temperature in these 40 years. Here the tendency of ascent is very clear by the fact that the annual mean value has risen by 1.5 ℃ in these 40 years. It would be said that the global warming phenomena appears remarkably in Rwanda(2) Rainfall and flow rate record at the dam site.

(a) Location, period and facilities

The locations of the rain gauge station and the flow rate recording station installed by Mr. Akihisa Nakano (MINAGRI irrigation advisor, JICA expert) are shown in the following topographical map. The recorded period is from 29th of March 2012 to 14th of April 2012 in rain's case, and from 21st of March 2012 to 10th of April 2012 in flow rate's case.

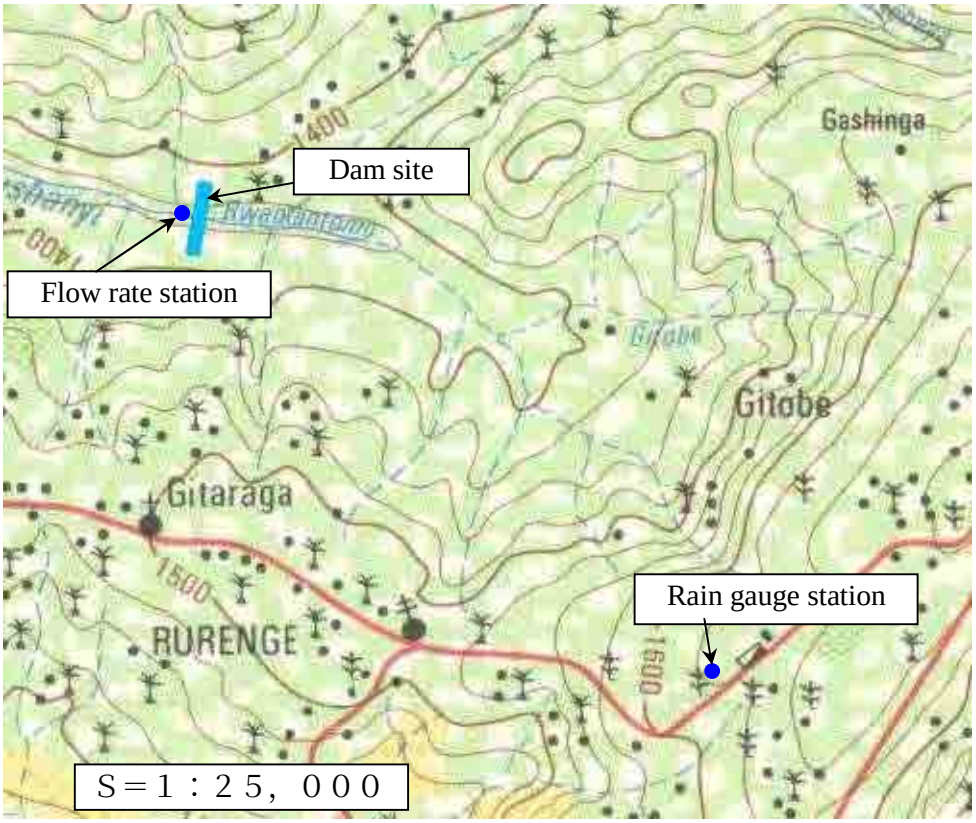


Fig. 3-6-1-4 Locations of the rain gauge station and the flow rate recording station

Rain gauge station

Flow rate recording station

3-6-2. Survey for water resources

(1) Field reconnaissance around the reservoir

(a) General

Date of the survey；6th and 7th of March, 2012

Participant；Mr. Nakano (MINAGRI advisor), Mr. Toku (Leader of the survey team), Mr.Hiki (survey team staffer), Mr. Jules, Mr. Fred, Mr. Yahaya

(b) Dam site

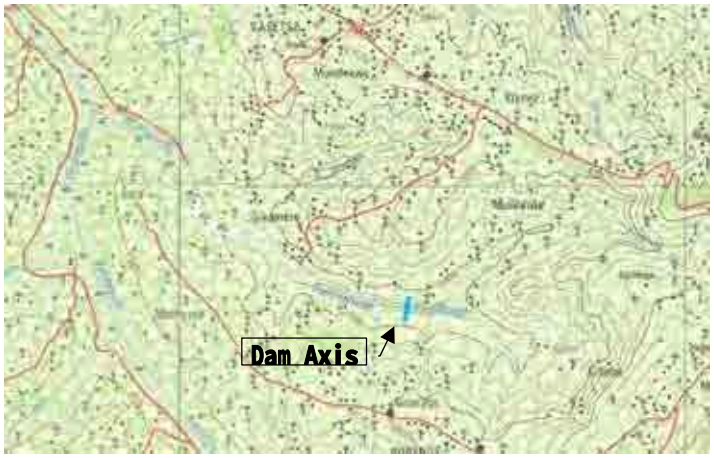


Fig. 3-6-2-1 Locations of the flow rate recording station

The dam site is located at the downstream of the confluence of small streams that originate from springs borne at the bottoms of the two fan-shaped eroded valleys. The shape of the valley at the upstream of the dam site is like a pan, and the left and right side slopes are gentle, so that the dam would become high accordingly to store a certain capacity of water in the reservoir.

The road on the left bank has been rehabilitated to have two lanes, that might be shifted to the mountain side according to the dam height.

Ditches for catching rain water and avoiding erosion of the land are excavated along contour lines on the hill slope of the right bank. They correspond to the land husbandry work to the gentle hill; and the steps observed on the photo above seem to be, perfect or not perfect it's a question, progressive terracing works. In addition, there is a cow house on the upper slope where three cows are bred by three men. Followings are the interview results.

- Families live in a house on the hill top following the government's policy.
- 70 litter of water is needed for cows a day.
- 70 litter of water is needed for three men a day.
- It is forbidden by the law to take cows to the river and let them drink water from the river.

(e) Chinese dam valley

A dam constructed under Chinese supporting exists in the adjacent valley. The water leakage from the discharge gate that was observed at the visit of 2010 has not yet repaired.

Along the road extending on the hill foot, the left bank of this valley, there are several hand pumps made by Chinese support; two of them are available now and their water quality is good.

Paddy fields are developed in the branch valley on the left bank; water source of them is springs.

There are many paddy fields with no cropping in this Chinese dam valley. It is said that the delay of the commission merchant coming to buy made farmers too late for selling the harvested rice, purchasing seeds and fertilizer, and planting rice in time.

At the confluence of the two rivers, the flow rate of the river from Chinese dam valley is predominant; as the result, the river flow from Ngoma-22 valley looks like having no velocity.

(f) Paddy fields in Ngoma-22 valley

In the Ngoma-22 valley, paddy fields extend about 3km long and about 70m wide averagely from the dam site to the confluence of the two rivers; total area is 20ha approximately. Water source is the river flowing down at the center of the valley and springs/ground water from both sides of the valley. The way of irrigation is the repetitive use of the river water where the river water is stopped by primitive weirs, led into paddy fields, and returned to the river from the notch on the path wall. One lot of the paddy field is averagely 20m×20m or so.

(g) Conditions downstream side from the confluence

The river meets the main river from through Gashonvi water shed about 2.5km downstream from the confluence point, and finally flows into the lake Bugesera. On the both side, 2.5km long, of and along the river, paddy fields extend. Here the irrigation water is led into the paddy fields by the check gate raising the water level in the river.

Raised water level by the check gate and the surrounding paddy fields

In Goshonvi area, from Goshonvi to Ruvuyu and from Goshonvi to Kamiranzovu, there extend paddy fields on the flat plain of the valley bottom. In the area toward the lake, paddy fields are developed till under the Gishike village; after that the flat plain is occupied by marshland and thickly grown papyrus. Development of marshlands are limited from the view point of environmental protection.

Paddy fields in Goshonvi area

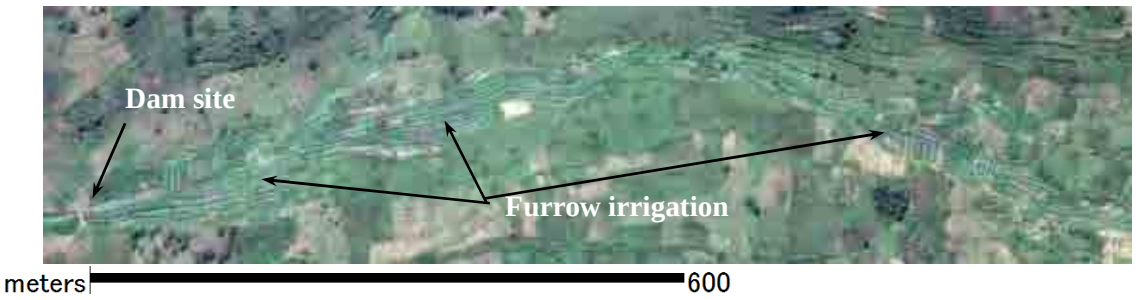
Marshland and thickly grown papyrus near Pepiniere

A reservoir in the inmost recesses of the Goshovi valley（dam height: about 20m, crest length:about 200m, affiliation: unknown）

(2) Current status survey of the river flow and the irrigation

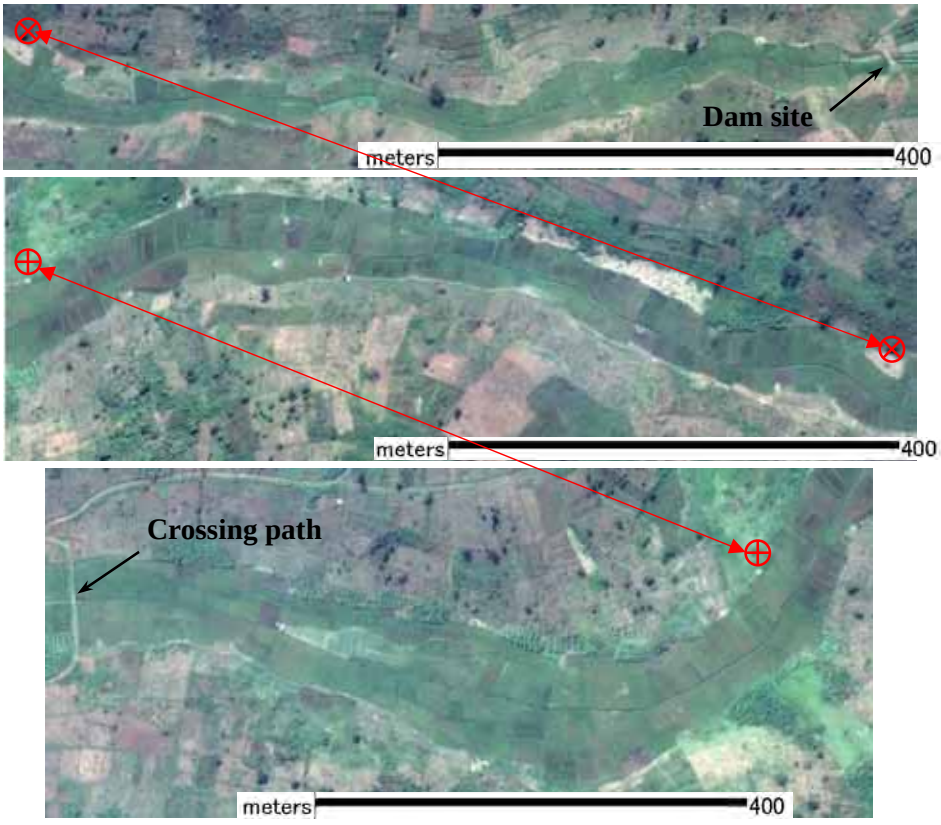
(a) Conditions in upstream area to the dam site

On the valley bottom in the upstream area extending 1km long, furrow irrigation is applied to the dry field by leading spring waters; and there is no river there. These creeks or furrow streams gather together and become the river for the first time at the dam site; in this meaning, it would be said that the dam site is located at the narrowest point of the valley.



(b) River flow conditions and irrigation performances in the downstream area.
(surveyed on 8th of April)

The river flows down repeating disappearing into the paddy fields and reappearing from the paddy fields. In case of the paddy field being not single, canals are provided on the hill side; it is also common for the irrigation water to be led along the inside of the path wall. At the time of 8th of April, all the paddy fields except for two lots are planted and the irrigation water covers more or less all the surface of the fields.



Downstream 50m, dam up and in-let mouth

Water way to the adjacent paddy field

Water repeats entering and returning between the river and the paddy fields.

Spring water is led to the paddy fields

Water way along the path wall, and to the adjacent paddy field through a tunnel

Lower water level in the water way than the field surface.

Dam up, and the water way to hill side

In-let mouth from the water way on the hillside

Water way repeating outside and inside

At the crossing path, the river is divided into three.

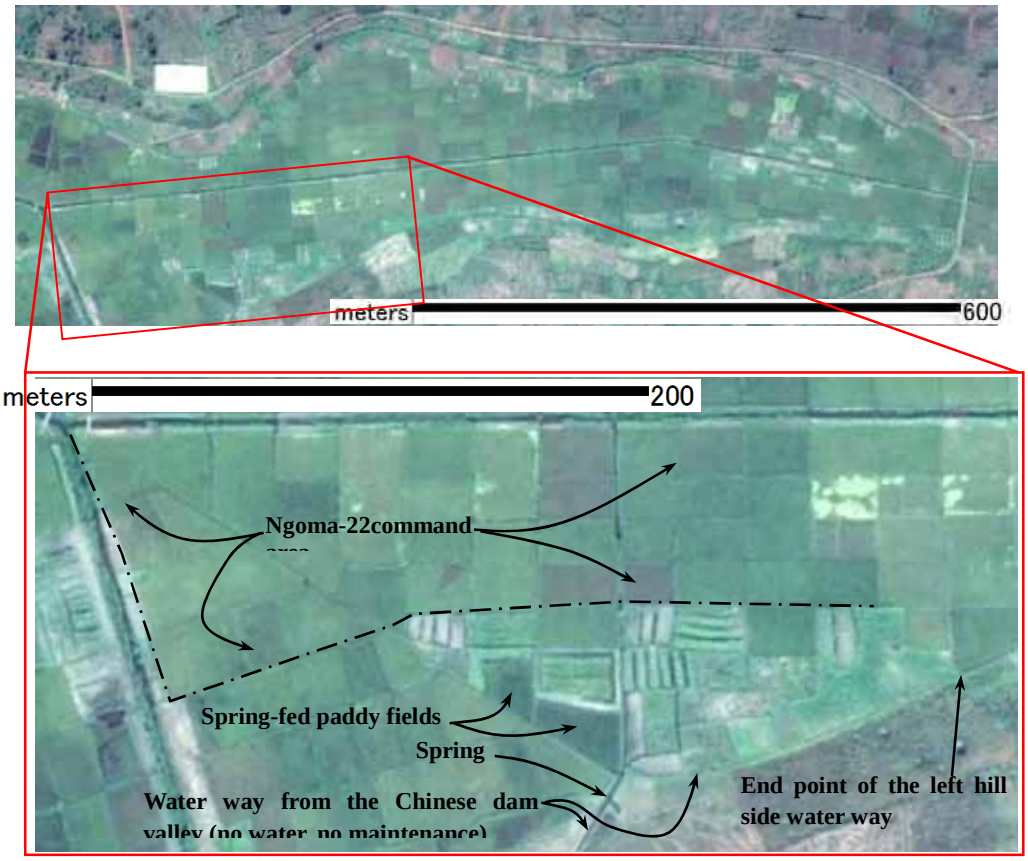
Water way on the left hill side

Main river

Water way on the right hill side

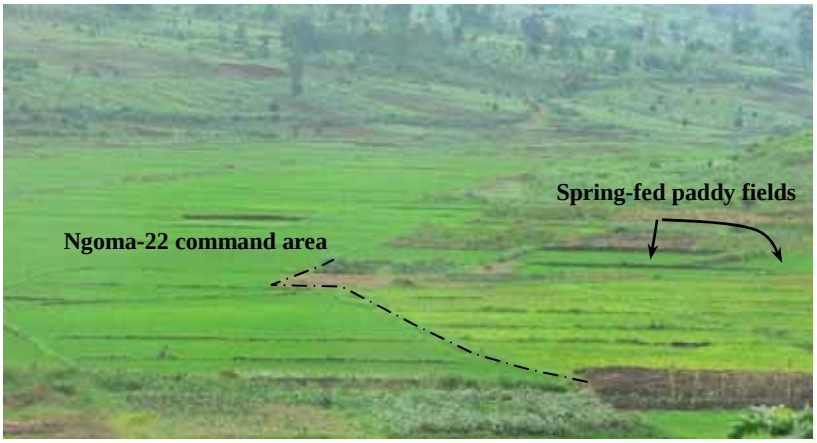
Dam up in the main river for leading water to the hill sides（70m upstream from the confluence）

End point of the left side water way（about 250m upstream from the confluence）



Spring at the hill

Left side；command area fed on the Chinese dam valley (no cropping)
Right side；Ngoma-22 command area（cropping）



(c) Result of river flow volume

The river flow quantity of Ngoma-22 at the junction direct upper classes observation point is included in approximately 70ℓ/sec in approximately a little over 3 times of the damsite spot observation flow quantity, wet season of May in the middle of April from the end of March, approximately two double

Table 3-6-2-1 Result of river flow volume

Name / Date	Meeting Piont (ℓ/sec)	Bridge (ℓ/sec)	X-section1 (ℓ/sec)	X-section2 (ℓ/sec)
25/3/2012	69.8	183		
1/4/2012	71.3	241		
8/4/2012	73.5	345		
19/4/2012	68.3	52		
25/4/2012	236	806		
1/5/2012	210	881	150	90
12/5/2012	218	158	196	172
20/05/2012	223	958	106	188

Location of observation point

(3) Spring survey

(a) General

Date of survey；7th of March, 2012（Field survey）, 12th of March (Supplemental survey)

Aim of the survey；Conformation of the surrounding conditions

Measurement of spring water quantity

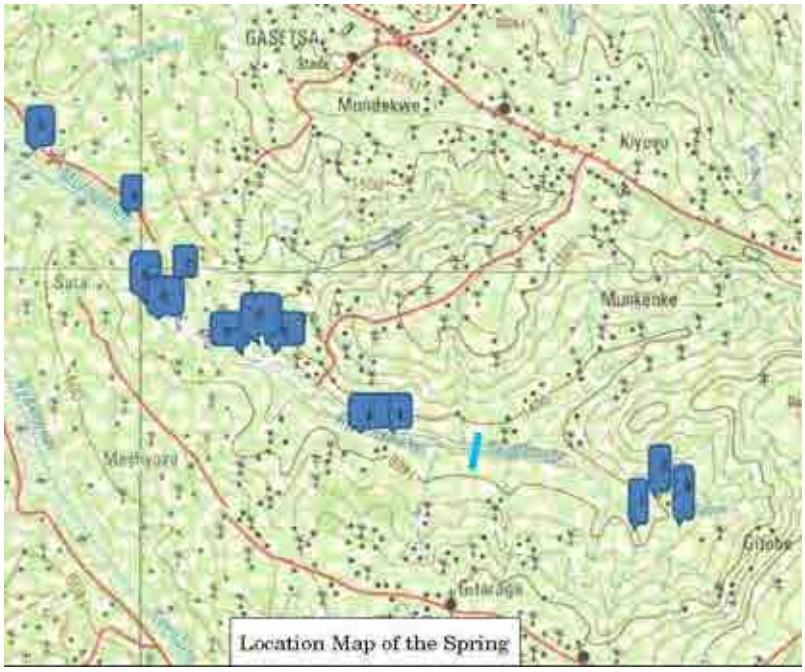


Fig. 3-6-2-2 Location of spring survey

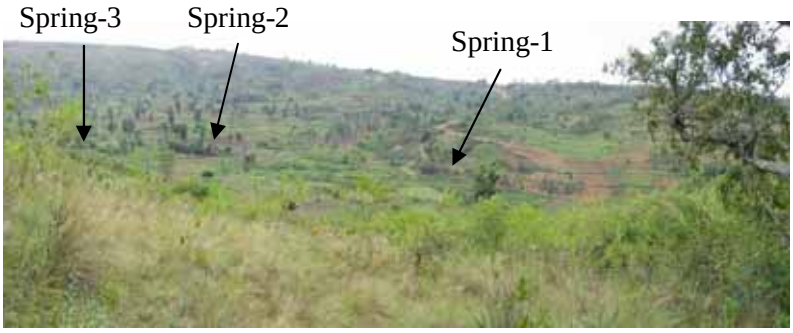
(b) Results of the field survey

Pursuing a stream upward at the dam site reaches a spring. There are many springs in the Ngoma-22 valley; through the site observations, there seems to be a common relationship between the existence of a spring and the landscape beyond the spring. That is to say, in many cases, there is a spring beyond which a fan-shaped eroded valley expands. The fan-shaped eroded valley is supposed to function as a water-gathering basin.

Spring-1

Spring-2

Spring-3



Spring-4

Spring-4’

Spring-5

Spring-5’

Spring-5’’

Spring-6

Spring-6’

Spring-7

Spring-7and the fan-shaped eroded valley

Spring-8

Spring-9

(c) Measurement of spring water quantity

ⅰ) Measurement method

ⅱ) Measurement result

Table 3-6-2-2 Measurement result of spring water quantity

Name / Date	Spring 1 (ℓ/sec)	Spring 6 (ℓ/sec)	Spring 7 (ℓ/sec)	Spring 8 (ℓ/sec)	Spring 9 (ℓ/sec)
12/3/2012	0.91	0.45	0.24	0.28	0.56
25/3/2012	1.00	0.43	0.26	0.29	0.56
1/4/2012	1.05	0.45	0.26	0.29	0.59
8/4/2012	1.00	0.50	0.30	0.27	0.63
19/4/2012	1.05	0.48	0.43	0.25	0.67
25/4/2012	1.67	0.81	0.77	0.30	1.11
1/5/2012	1.72	0.83	0.83	0.26	1.05
12/5/2012	1.72	1.00	1.00	0.28	1.02
20/05/2012	1.58	0.92	0.89	0.26	1.05

(4) Pumping Test

(a) Purpose of the Test

- To confirm the existence of an aquifer available for the water resource for irrigation use
- To grasp the available quantity of ground water pumped up from the aquifer

(b) Testing plan

ⅰ) Drilling of the Testing Well and its Location

One testing well is to be drilled newly as any existing well could not be found in the Ngoma-22 valley or on the surrounding hills in spite of the initial plan to carry out the pumping tests by using existing wells.

The location of the new well is selected on the slope of the left abutment, upstream of the dam site, (refer to the following map) considering the high possibility of the ground water table becoming high at the lower end of the valley-shaped landform, convenience of the pumped water being carried on to the canal, and the well excavation works in which the drilling machine must be transported to the testing point and installed.

Fig. 3-6-2-3 Location of pumping test

ii) Test Period

From the beginning of April to the beginning of May, about one month

iii) Contents of the Test

1) One (1) borehole drilling

Length; 30m (In case of the water depth in the drilled hole being not enough to conducting the pumping test, this depth shall be increased.)

Diameter; Suitable diameter for the installation of a casing pipe and conducting the pumping test

Memo of the drilled out materials; The Contractor shall submit the memo of the drilled out materials regarding the depth and their properties such as sand, clay, clay-gravel mixture every 2 meters' interval.

Casing pipe; The Contractor shall finish the borehole as an observation hole of the ground water table, so that the installed casing pipe shall be left in the hole.

2) Pumping Test

a) Preliminary Test

After setting all equipments and devices, the pumping equipment shall be calibrated at various pumping rates in order to ensure that all the equipment is properly functioning and to select the pumping rate for the subsequent step-drawdown test, the drawdown and yield shall be presumed throughout the test.

The pumping rate shall be modified according to the drawdown at the pumping borehole, and the preliminary pumping shall be continued at least four (4) hours.
The static water level in the borehole shall be measured carefully before any pumping, and the tests described below shall be started after the water level recovered to the original water level.

b) Step-drawdown/recovery Test

The borehole shall be pumped continuously at least three (3) increasing and two (2) decreasing discharge rates, maintaining each rate at a water level to be stable, but at least more than 180 minutes.

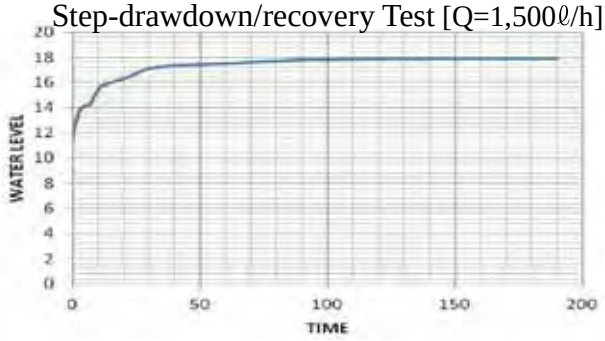
The pumping rate of each step shall be instructed by the Client based on the result of preliminary test.

For each pump discharge, the water level in the borehole shall be measured and recorded in the manner shown below;

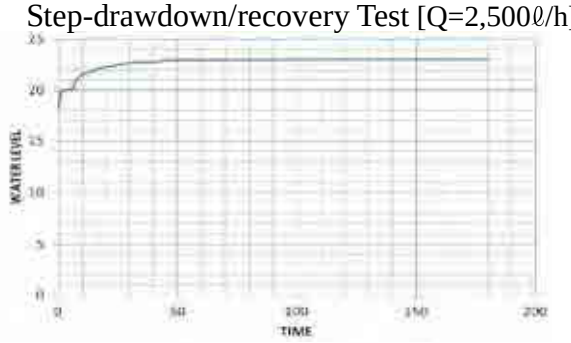
Period	Interval of reading
0 - 5 min.	30 sec.
5 - 15 min.	l min.
15 - 30 min.	5 min.
30 - 100 min.	10 min.
After 360 min.	30 min.

Test Result

Step-drawdown/recovery Test [Q=1,500ℓ/h]



Step-drawdown/recovery Test [Q=2,500ℓ/h]



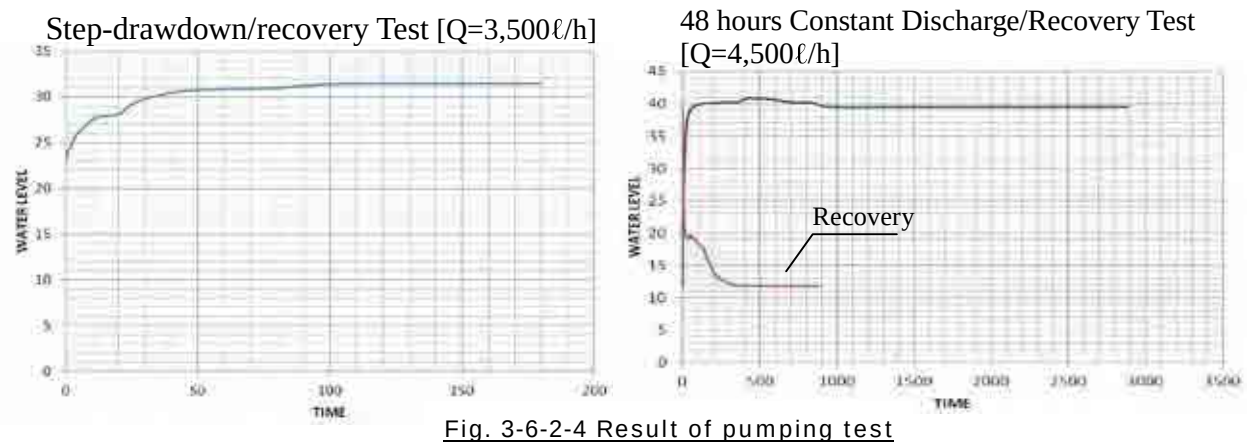


Fig. 3-6-2-4 Result of pumping test

c) Maximum Available Quantity by Pumping up

In case of the pumped up quantity being small, the water table in the well is kept high. This water descends together with the increase of pumped up quantity (refer to the figure below). This relationship is considered to be kept till the water table goes down to the aquifer's position. The maximum available quantity of pumped up water is assumed to be about 5,000 ℓ/hr as the aquifer's position is 46m to 48m deep (refer to the Borehole Diagram).

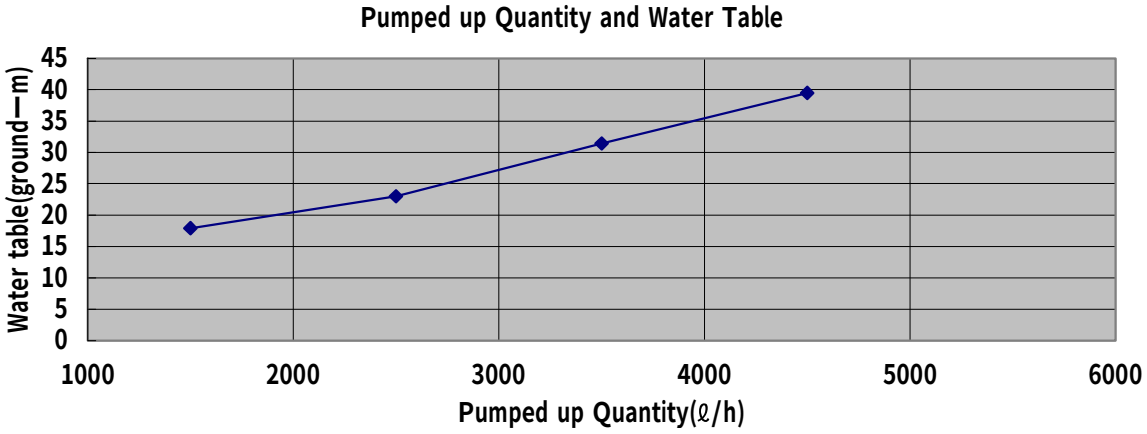


Fig. 3-6-2-5 Pumped up quqntity and water table

d) Hydro-geological conditions around the borehole

The proximate hydro-geological conditions around the borehole are illustrated as follows. The pumped up water is originated from the aquifer 46m to 48m deep that is composed of red-colored soil layer with sand.

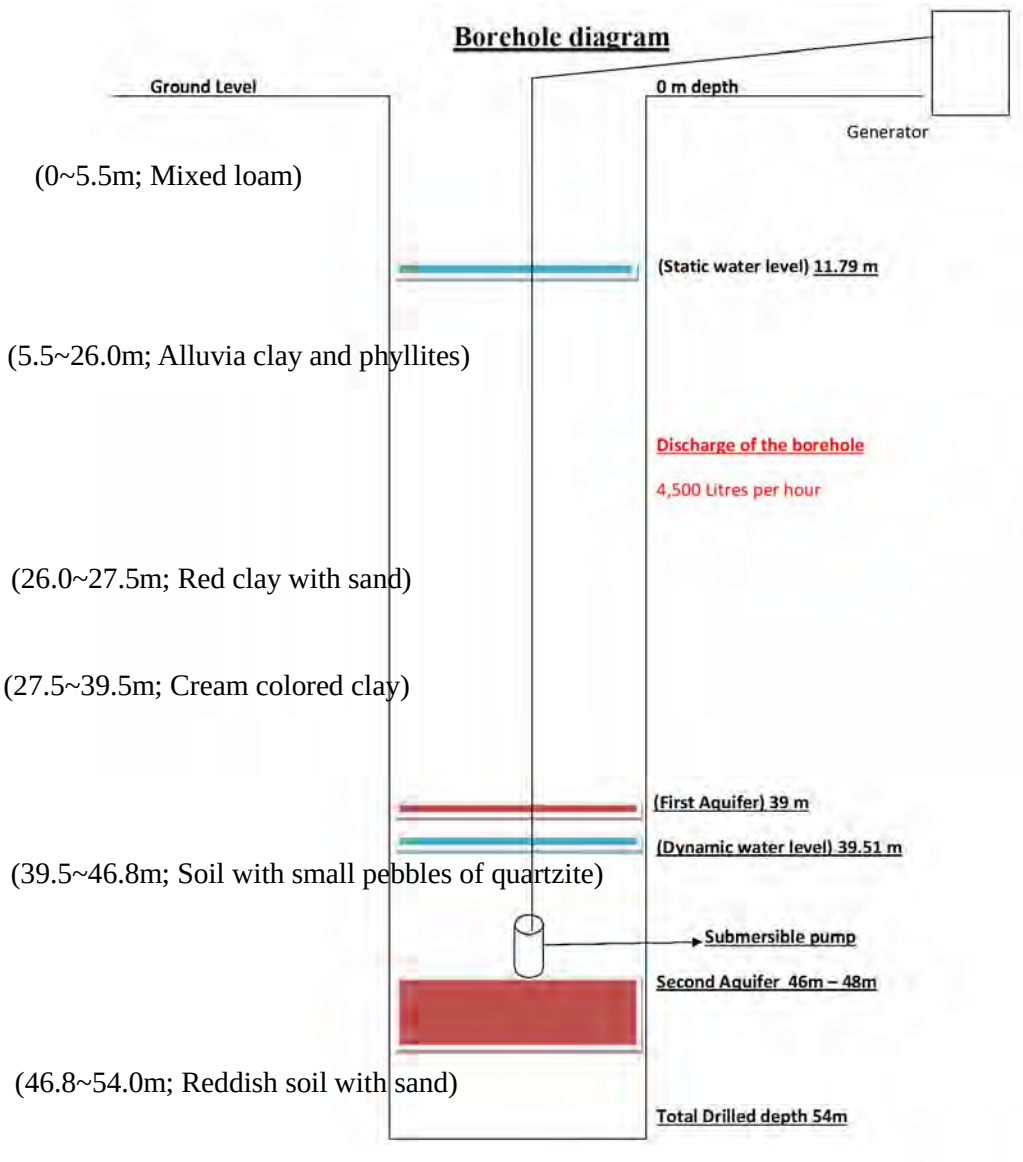


Fig. 3-6-2-6 Schematic hydrogeological test hole

Status of test hole drilling

Pumping test quantitative status

(5) Survey for the utilization possibility of ground water

(a) The dry valley

ⅰ) General

Date of survey；16th of March 2012 and 18th of March 2012

Surveyor；Mr. Toku, Mr. Hiki, Mr. Fred

Location；shown in the following map

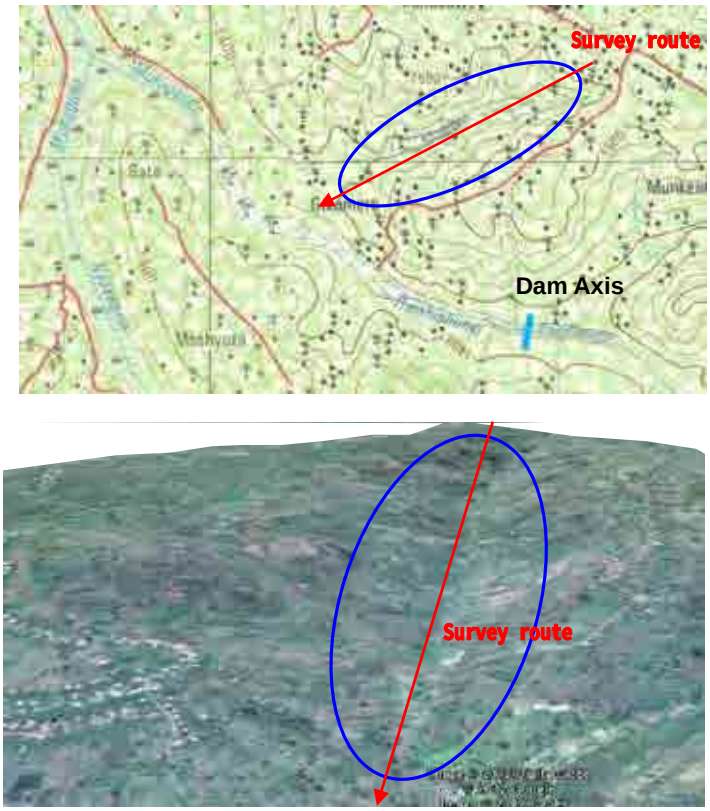


Fig. 3-6-2-7 Location of survey for the utilization possibility of ground water

ⅱ) Field survey

The banana plantation extends on the lower slope of the hill, there are ditches excavated at the interval of 25m or so to catch the rain water.

1 Distant view of the valley on the left branch valley slope

2 Ditches in the banana plantation

From on the hill foot, a branch valley is viewed at right in a distance. This is a fan-shaped eroded valley at the exit of which there lies a small hill that might be deposits from the valley or might survive from erosive actions. The downstream slope of this small hill is steep and the gap between the hill top and the downstream foot is about 5m. The ground surface at the downstream foot is wet; water surface may appear if excavated.

3 Distant view and the small hill

4 Swampy ground surface at the hill foot

Going down about 20m, water seeps out on the ditches' bottom excavated along the banana plantation and streams are borne; the reddish brown sediment on its bottom is assumed to be brought from iron bacteria. The width of the valley is narrow to be 15m or so.

5 Seeping out water in the ditches

6 Streams and sediment of iron bacteria

Going down a little more, a left branch valley with a fan-shaped eroded landscape appears. At its exit, a similar small hill lies; and at the foot of this hill, a spring appears.

7 Left branch valley in distance and a small hill

8 Spring at the foot of the small hill

At about 1km from the inmost recesses of the valley, the valley becomes wide to be about 50m. There the flow rate of the stream increases to be 0.2~0.3ℓ/sec. At the right side, a fan-shape eroded valley expands wide; the exit is closed by a similar small hill.

9 Widened valley and the stream

10 Deep branch valley and a small hill at its exit

Going down about 100m, the valley becomes narrow and the inclination of the valley bottom seems as if it were reversal. Here the flow rate is decreased through becoming an underground flow. After keeping this condition about 50m long, the inclination of the valley bottom becomes steep and the valley becomes wide; the flow rate recovers at the foot of the steep slope, and women and children gather for washing and drawing water for drinking. The flow rate is approximately 0.5ℓ/sec.

11 Narrow valley and the gentle inclination

12 Water drawing spot on the slope foot

In Test Pit-1 excavated beside the water drawing spot, water surface appeared at 70cm below the ground level that corresponds to the water level in the stream.

13 Water level in Test Pit-1

At about 40m downstream from here, the valley width becomes narrow again and the inclination of the valley bottom becomes very gentle. This topographical characteristic that the inclination of the valley bottom becomes very gentle at the narrow valley and becomes steep at the widened point is assumed to be made by the sedimentation transported by repeated small scale floods with a gentle flow down speed. In Test Pit-2 which was excavated at about 50m downstream from Test Pit-1, ground water appeared at 60cm below the ground surface.

14 Step-like feature at the narrow valley

15 Water table in Test Pit-2

At about 50m downstream from Test Pit-2, Test Pit-3 was excavated on the left side slope about 2.5m high beyond the valley bottom. Water table did not appear in this test pit.

16 Narrow valley where TP-2 and TP-3 were excavated

17 TP-3

At about 1.5km from the inmost recesses of the valley, the valley becomes widened and a branch valley appears at the right bank side. This branch valley is deep and has a fan-shaped eroded feature. On the ascending way to this branch valley, outcrops of clay stone are observed. At the foot of this branch valley, there appears a small spring with water quantity of about 0.001ℓ/sec.

18 Outcrop of clay stone

19 Spring at the foot of the branch valley

From here the valley is widened and flat toward the exit. On the way toward the exit, a washing yard appears and the stream sometimes flows down in a artificial water way for irrigation. But the stream

disappears after the water drawing spot at about 300m from the exit. The exit of the valley is narrow and composed of a small hill on which a road goes across. The road surface is not swampy, dry.

20 Washing yard

21 Artificial water way（Q=about 1ℓ/sec）

22 Small scale eroded valley at the left side

23 A deep valley at the right side, before the exit

24 The last water drawing spot(Q 0.09ℓ/sec)

25 Road going across the valley exit

Fig. 3-6-2-8 Survey route

iii) Prospect

There is a characteristic relationship between the longitudinal inclination of the valley bottom and the valley width. The longitudinal inclination is gentle at the narrow valley and is steep at the end of narrow valley, i.e. at the beginning of the wide valley. The widened valley itself is flat but longitudinally steeper than the narrow valley portion. Such combination of topographical features is repeated three or four times; and the stream goes underground and disappears completely at the last narrow portion, i.e. the exit of the valley. Such step-like longitudinal features are assumed to be formed as a result of soils transported by repeated small scale floods being left at the narrowed portion. The sediment is composed of silty clay to sandy clay; the water table here is shallow to be about 60cm to 70cm below the ground surface, and ground water appears during the excavation work of the test pit, so that the horizontal flowability of ground water is supposed to be relatively high. Therefore, there would be a high potential of utilizing ground water as a water resource for irrigation.

The origin of the stream, that is observed all along the valley bottom but disappears at its exit, is springs. The field survey on 18th of March after the interference of rain on 16th of March observed spring waters increased by 3 or 4 times; but there is no atmosphere of the flood rushing out, that would be the result of the topographical characteristics above. Therefore, the utilization way of water resources here would be as follows.

- Floods are stored in a small reservoir as the source of ground water.
- Surface water is led into a canal.
- Ground water is gathered by a stopper-like underground structure and taken out through a pipe.

The structure's profile would be as follows.

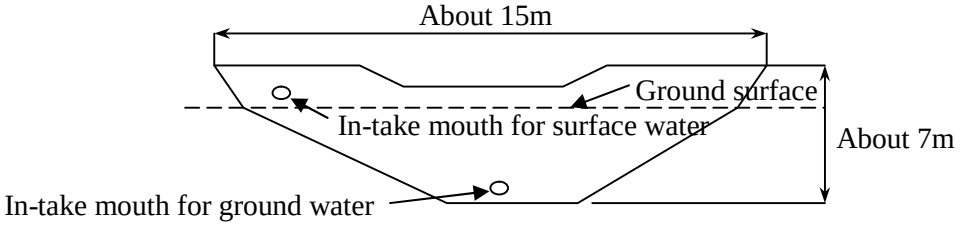


Fig. 3-6-2-9 Semi-underground dam profile

(b) Fan-shaped eroded valley

ⅰ) General

Through the field survey for springs, the connection between springs and the topographical characteristics of the fan-shaped eroded valley beyond them came to the surface and the valley's function as a basin for gathering ground water was assumed to be the origin of the spring. Based on this assumption, field surveys were conducted aiming to find springs or streams in the valley's basin or to confirm the existing of shallow ground water by a test pit excavation. The locations of this field survey are as shown below.

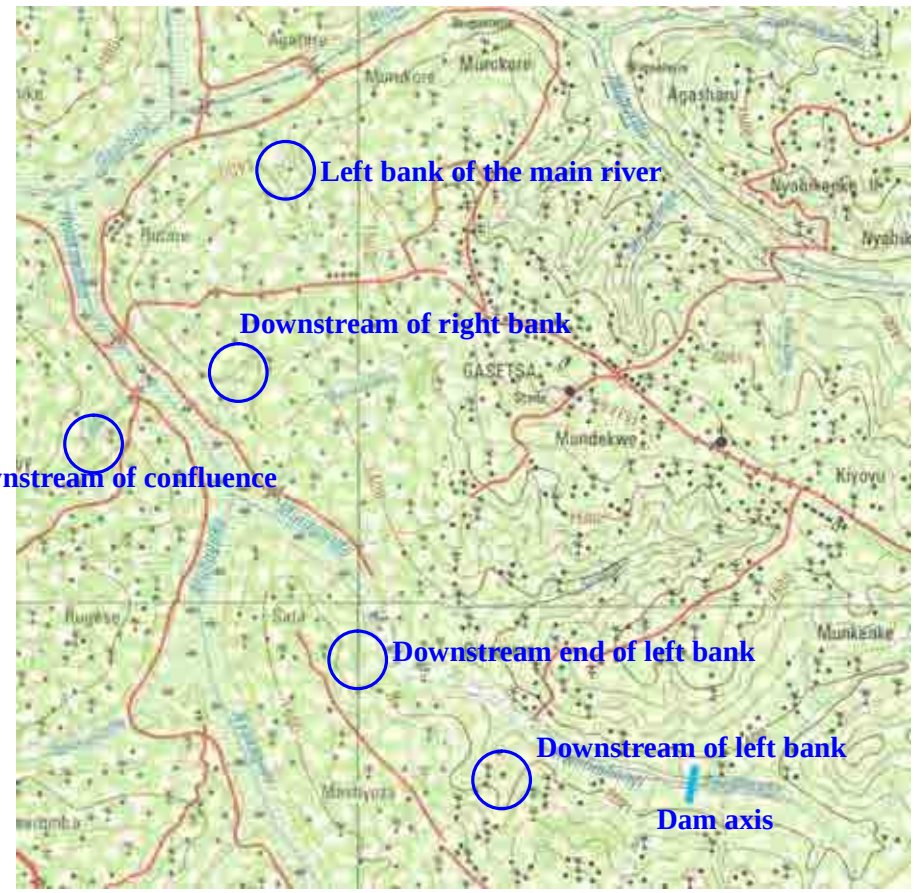


Fig. 3-6-2-10 Location of test pit excavation

ⅱ) Downstream end of the left bank（surveyed on 24th of March）

A small scale but clear fan-shaped eroded valley extends in the site though the eroded valley is not clearly shown in the topographical map with the scale of 1:50,000. The center of the valley is extruded and this extrusion divides the valley into two independent branch valleys. There were any streams or springs so that a test pit excavation was carried out on a basin of the right valley.

Eroded shape of the right valley

The test wall changed its color from reddish brown to brownish grey at the depth of 0.8m and the brownish grey portion continued till meeting the highly weathered clay stone at the depth of 1.6m. These upper portions are assumed to be deposited soils because of hard and angular gravels (φ=5cm~30cm) contained. The test pit was excavated till 1.7 m deep; ground water did not appear. In addition, a thin lateritic gravel layer about 10cm thick was ling at the depth of 0.4m.

Test pit

iii) Downstream of left bank（surveyed on 25th of March）

Here also, a terrace extrudes at the center and divides the valley into two independent valleys. The left valley has the plantation of sorghums as a main crop, on the other hand the right valley is covered by banana plantations. The left valley has a flat terrace that may function as a basin for gathering ground water. The right valley is sharply and deeply eroded and does not have such a terrace.

There not existed any stream or spring, so that a test pit was excavated on the terrace of the left valley.

The test pit was excavated to the depth of 4.9m; but ground water did not appear. The test pit wall showed reddish brown and was composed of uniform sandy clay with small quartz gravels, so that this layer was assumed to be residual soil of highly weathered granite.

Left valley

Right valley

Test pit excavation（D=4.9m）

iv) Downstream of right bank
（surveyed on 1st of April）

After entering through the valley exit, flat land continues, no stream.

At about 200m from the exit, a small stream appears.

Proceeding more 50m, the land becomes swampy.

Many springs beyond the swampy land

Spring in the inmost recesses of the valley

v) Downstream of confluence
（surveyed on 1st of April）

After ascending the slope of the exit, the valley becomes flat and gentle.

At about 200m from the exit, a small stream appears.

At about 300m from the exit, a spring appears. (Q=about 2ℓ/sec)

Surrounding ground is like a marshland.

At about 400m from the exit, valley becomes narrow and steep. After ascending this slope, a spring appears.

Toward the inmost recesses of the valley, banana plantations extend.

vi) Left bank of the main river（surveyed on 1st of April）

The exit of the valley is an open space where sorghums are planted. At the event of heavy rain, it is said that a small amount of murky waters comes out of the exit; but a water way or a ditch does not exist. At about 200m from the exit, the valley becomes narrow and the valley bottom has a gentle ascending slope. The valley bottom is wet and seems like water appearing soon; but the ground keeps such condition endlessly. It is said that at the inmost recesses of the valley, a spring appears after a heavy rain but soon disappears.

vii) Potential to the utilization of ground water in fan-shaped eroded valleys

The fan-shaped eroded valley with a catchment area larger than some level is needed for the springs existing in the valley.

Table 3-6-2-3 Potential to the utilization of ground water in fan-shaped eroded valleys

Location	Potential
Downstream end of the left bank	Positive, but pumping facilities or horizontal drillings are needed.
Downstream of left bank	Positive, but pumping facilities or horizontal drillings are needed.
Downstream of right bank	Positive, a simple underground cum head work structure makes it possible to utilize surface water and ground water.
Downstream of confluence	Positive, a simple underground cum head work structure makes it possible to utilize surface water and ground water.
Left bank of the main river	Positive, but pumping facilities or horizontal drillings are needed.

3-6-3. Survey for water resources

(1) Domestic water

(a) General

Date of survey；9th of March 2012～10th of March 2012

Surveyor; Mr. Toku, Mr. Hiki, Mr. Fred、 Mr. Yahaya

Survey area；Kawalondo Sector， Remera Sector

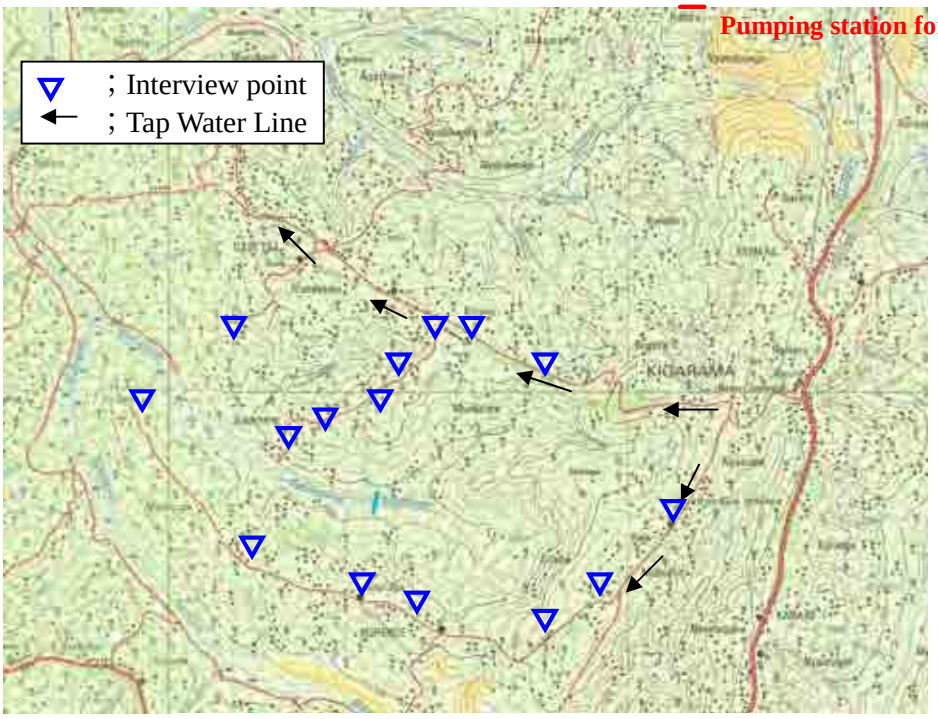


Fig. 3-6-3-1 Interview point for domestic water

(b) Pumping station for tap water

- Implementation；1988, (Rehabilitation in 2008 under the RED CROSS support)
- Water source；Spring (no treatment)
- Capacity；6～7ℓ／sec， 24hours operation
  （Electric pump ; capacity 22~24m3/hour， lifting height about 250m）
- Maintenance；EWSA (Energy, Water and Sanitation Authority)
- Water fee；10~20 RWF (consumer→tap owner)， 10RWF(tap owner→EWSA)
- Covering range；Kwaronzo Sector， Remera Sector， Luramira Sector

(c) Water consumption

Water consumption per one adult is averagely one jerry can with capacity of 23ℓ. In children's case, it is a little lower. In case of cows, it is also one jerry can; but it seems to be different depending on the grow-up stage and each character. In some cases of adult cows, two jerry cans are needed.

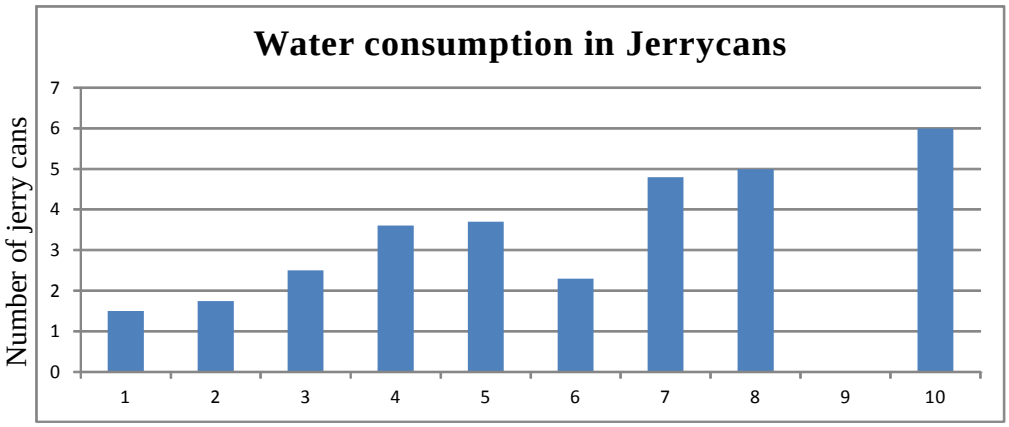


Fig. 3-6-3-2 Water consumption in jerrycans

Table 3-6-3-1 Water consumption and family size in jerrycans

N0 of Cans / Family Size	1	2	3	4	5	6	7	Average
1	1	1						1.5
2	1	3						1.75
3		6	1		1			2.5
4		3	6	2	3			3.6
5		1	7		3	1		3.7
6		2	3	1				2.3
7		1		2		2	1	4.8
8			1		1		1	5
9								
10						1		6

(d) Source of domestic water

64% of households among 56 interviewed get the domestic water from springs. The reasons are that a long distance of transportation is needed due to the water tap interval being too long or the water line extending only on the main road, and that the water fee is a heavy economical load to each household.

	Number	Percentage
Spring Water	36	64%
Tap Water	20	36%
Total	**56**	**100%**

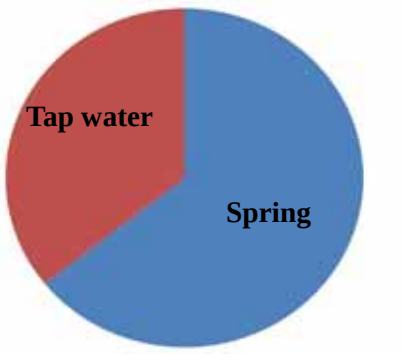


Fig. 3-6-3-3 Source of domestic water

(e) Washing place

44% of households among 56 interviewed do the washing at the springs. It would be necessary to consider the conservation of existing springs or preparation of water drawing place at the time of canal/reservoir construction.

	Number	Percentage
Spring	25	44
Home	31	56
Total	**56**	**100**

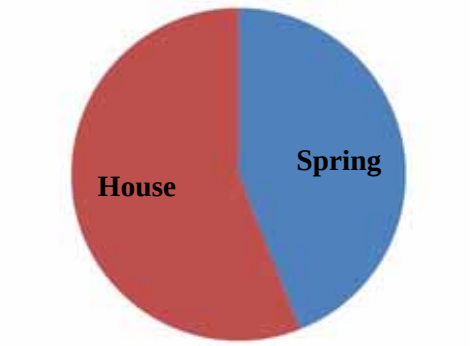


Fig. 3-6-3-4 Washing place

(2) Irrigation water

53% of the farmers among 38 interviewed are not satisfied with irrigation water conditions. Most of these farmers said that the insufficient period ranged from June to August where they conducted two times of cropping a year, the first; from February to June, the second; from August to December.

	Number	Percentage
Enough	18	47
Not enough	20	53
Total	**38**	**100**

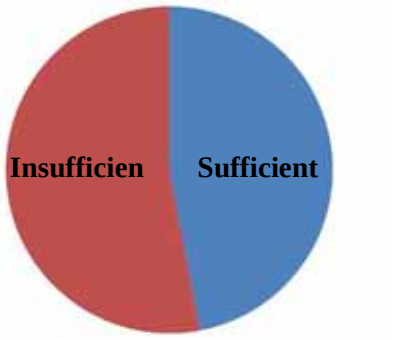


Fig. 3-6-3-5 Irrigation water

The insufficient conditions from June to July are caused by the fact that they need water for nursery they begin to plant. In terms of the insufficiency in August, it might be solved to shift the start of cropping from August to September. To this question, they answered the start of cropping in August was to avoid the bad influence of low temperature in the rainy season.

3-7. Command area survey

3-7-1. Field survey in the supposed command area

(1) Land utilization condition

(a) General

Date of survey；14th of April 2012

Surveyor；Mr. Hiki

Location, Naming；shown as follows

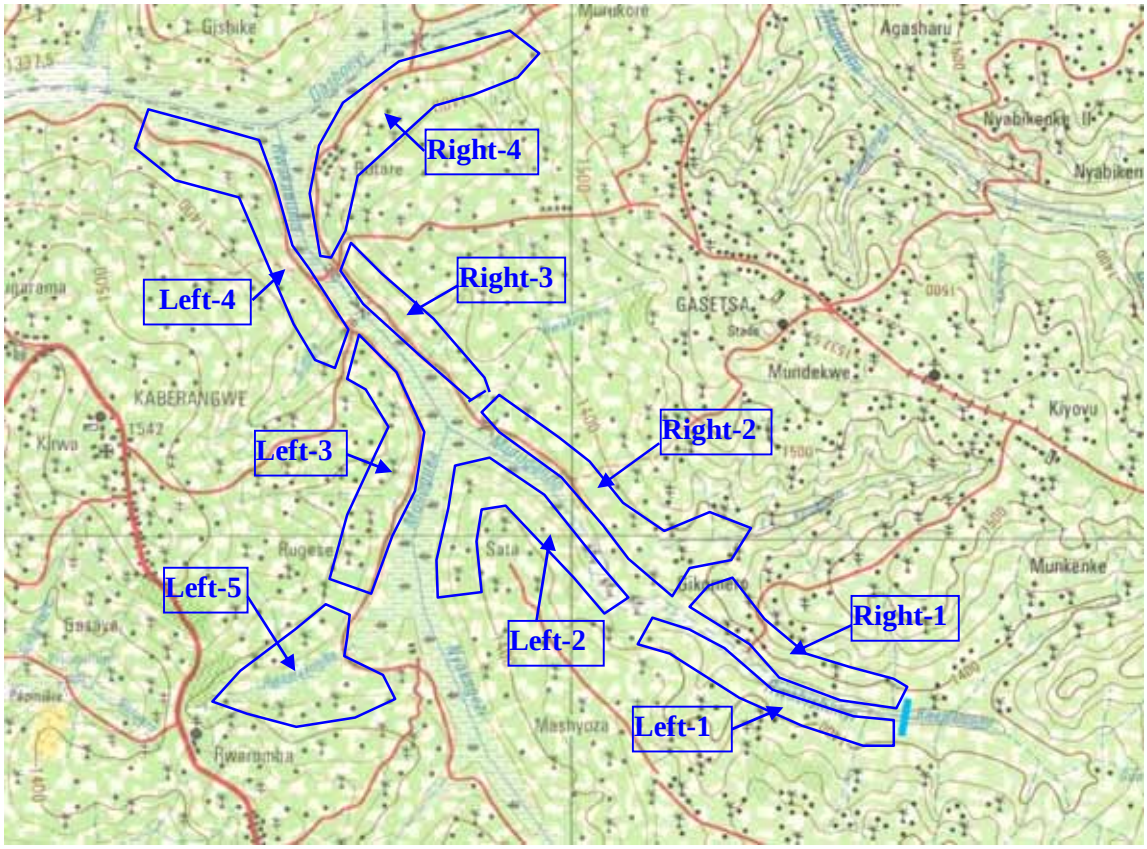


Fig. 3-7-1-1 Field survey in the supposed command area

(b) Survey result

ⅰ) Left-1

Table 3-7-1-1 Survey result of Left-1

Zone	Crops	Reference
Upstream area	Sorghum mainly, Beans	Gentle slopes with about 15 ° inclination rise up from the river bed. Progressive terracings are observed
Central area	Sorghum, Beans, Potatoes, Cassava, Pasture	Lower slopes have the inclination of about 25 °. Upper slopes: 10 °~15 °. Progressive terracings are observed. Mixture plantation of Cassava and Beans
Downstream area	Sorghum, Beans, Banana, Potatoes, Backo (limited)	Fan-shaped eroded valley, Banana plantation on slopes and the valley bottom. Dry fields on the terrain are covered by lateritic gravels. The density of land husbandry works is low.

Sorghum and Beans on the gentle

Dry field covered by lateritic gravels, mix planting of Cassava and Beans

Banana plantation on the valley slopes and valley bottoms

ii) Left-2

Table 3-7-1-2 Survey result of Left-2

Zone	Crops	Reference
Upstream area	Sorghum, Beans, Banana, Potatoes, Pasture, Cabbage(limited)	Fan-shaped eroded valley, lower portion: 10 ° ~15 ° Upper portion: steep, no land husbandry works
Central area	Banana, Sorghum, Potatoes, Beans	Mix planting of Banana~Sorghum, Banana~Potatoes~Beans. Weed lands, no land husbandry works and steep slopes are observed.
Downstream area	Sorghum, Beans, Banana	Lower slopes: 15 ° ~20 ° , Upper slopes: 10 ° ~15 ° . Fruit trees and pasture are observed in /around the village on the hill top. Progressive terracings are observed.

Pasture and Banana plantation

Mix planting of Banana, potatoes and Beans

iii) Left-3

Table 3-7-1-3 Survey result of Left-3

Zone	Crops	Reference
Upstream area	Sorghum, Beans	Gentle slopes: about 15 ° Land husbandry works。
Central area	Sorghum, Beans, Banana, Cassava	Dry fields extend wide between paddy fields and the hill foot
Downstream area		

Sorghum and Beans on gentle slopes

Wide dry fields toward the paddy field, Sorghum, Cassava and Cabbage

iv) Left-4

Table 3-7-1-4 Survey result of Left-4

Crops	Reference
Sorghum, Beans, Banana	Banana plantation becomes predominant in downstream areas.

Beans, Sorghum, Banana

v) Right-1

Table 3-7-1-5 Survey result of Right-1

Zone	Crops	Reference
Upstream area	Sorghum(6)：Beans(4)。	Slopes with inclination of 15 ° ± rise from the river bed. Upper portion: 10 ° ± Progressive terracing works are seen.
Central area	Sorghum, Beans on steep slopes	Lower slopes: 20 ° ~25 ° Upper slopes: gentle density of land husbandry works is low.
Downstream area	Sorghum, Beans, Banana, Pasture	Gentle slopes of 10 ° ~15 ° Progressive terracing works are seen.

Sorghum, Beans, Progressive terracing works

Beans are predominant on steep slopes.

Sorghum, Beans (gentle slopes on the exit of dry valley)

vi)Right-2

Table 3-7-1-6 Survey result of Right-2

Zone	Crops	Reference
Upstream area	Banana, sorghum, Pasture	Slopes: 10 ° ~15 ° Progressive terracing works are seen.
Central area	Banana, Sorghum, Beans	Slopes: 10 ° ~15 ° Progressive terracing works are seen.
Downstream area	Banana, Sorghum, Beans	Slopes: 10 ° ~15 ° , Upper: 15~20 ° Progressive terracing works are seen.

Sorghum, Beans, Banana

viii) Right-3

Table 3-7-1-7 Survey result of Right-3

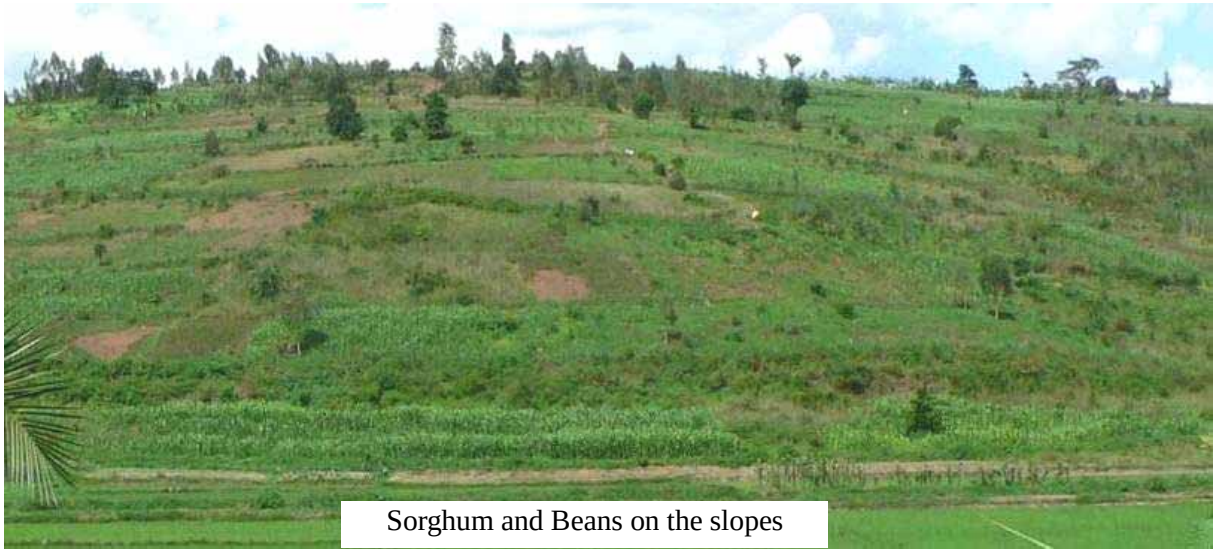
Crops	Reference
Sorghum, Beans	Tall trees and weed lands are seen.

Tall trees, Sorghum and Beans are mixed.

ix) Rigth-4

Table 3-7-1-8 Survey result of Right-4

Crops	Reference
Sorghum, Beans	Banana plantation in the valley Vegetables are planted on the dry fields between the hill foot and the paddy fields near Gashonvi watershed.



Sorghum and Beans on the slopes

Sorghum around the valley exit and banana in the valley

Vegetables on the plain along the hill foot

ix) Rwamakombe valley

Table 3-7-1-9 Survey result of Rwamakombe valley

Crops	Reference
Sorghum, Beans, Banana, Rice	Weed lands are predominant in the valley bottom. Slopes and hill top area are cultivated; Sorghum, Banana, Beans are planted.

Rwamakombe valley

From the exit valley, there are many places on the moor.

Paddy field on the valley bottom, Sorghum on the slopes,

Mix planting of Banana~Beans~ potatoes

(c) Summarization of the field survey

Crops planted are composed of Sorghum at first, Beans and Banana at second. Banana plantations are observed in many cases around the villages on the hill top or on the slopes and bottoms of valleys. Cassava and Potatoes are planted on the dry fields without top soils. Cabbage and Backo are also planted but its area is limited. Maize sometimes appears in the Sorghum area but Maize plantation can not be seen. Mix plantation is also conducted but the mix planting itself is not predominant though all kinds of mixture of crops, such as Sorghum and Beans, Sorghum and Maize, Banana and Sorghum, Banana and Beans, Banana and Potatoes, Banana and Beans and potatoes, are observed.

In addition, progressive terracing works are seen on most slopes of the right bank side, but their density is decreased on the steep slopes. On the other hand, there appear frequently the slopes with low density of progressive terracing works or without progressive terracing works on the left bank side.

(3) Site conditions of topography, etc.

(a) Topography

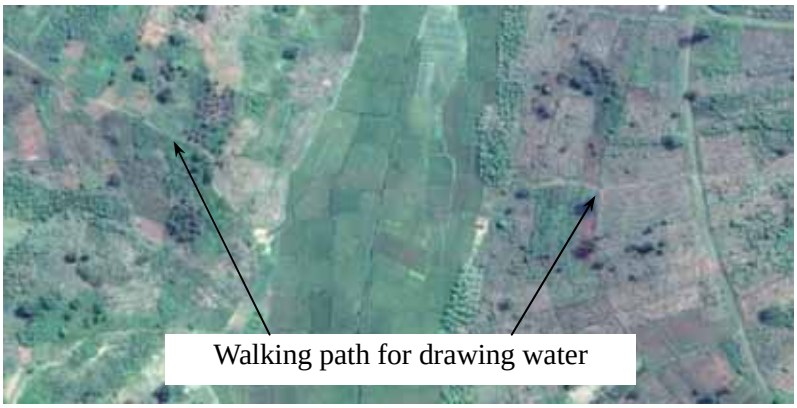
In Ngoma-22's valley, the lower portions of the hill slopes are steep with the inclination of about 20 degree including the maximum inclination of about 25 degree except the gentle slopes at the valley mouths or the end of hills. The height of such steep slopes is about 20m from the river bed. The upper portion of the slopes is gentle with the inclination of about 10 to 15 degree. Progressive terracing works covers slope surfaces widely, it is a question if perfect or not perfect, but these works do not provide flat farmlands. It would be desirable to provide such steep slopes with the radical terracing works, which are higher level works of land husbandry than the progressive terracing works, considering the effectiveness of irrigated agriculture.

Steep slopes on the right side hill, lower portion

Sorghum plantation on steep slopes on left side hill

(b) Cultivation road, Road for operation and maintenance

At this stage, there is any kind of road except for the walking path for villagers drawing drinking water from the springs. Farmlands extend on the hill slopes tightly without spaces among them. Cultivation roads should be provided from the view point of the rationalization of farming works and the progress of productivity in future. And also the roads for operation and maintenance of canals and its appurtenant facilities are needed. It would be a big challenge to formulate these roads under the agreement of land owners.



3-7-2. Field Survey of Reservoir Area

Field survey was conducted at reservoir area in order to confirm the current status of land use. The results of field survey are summarized as follows:

(1) Outline of field survey

Date of survey: May 28, 2012

Reservoir area: 14.96 ha (FWS 1,390.60m)

Location of reservoir: Refer to (Fig. 3-7-2-1)

Fig. 3-7-2-1 Location of Reservoir

(2) Results of Field Survey

The results of field survey of reservoir area are summarized as follows:

- Reservoir area consists of flat and sloping ground, and its area ratio is 1:2,
  (Flat ground: Slope ground = 1 : 2 = 5 ha : 10 ha, Total: 15 ha)

- Acreage under cultivation is 70 % both flat and sloping ground,
  (Cultivated flat ground: 5 ha * 70 % = 3.5 ha, Cultivated slope ground: 10 ha * 70 % = 7.0 ha, Total cultivated area: 10.5 ha)
- In flat ground, a creek is developed as irrigation canal by firmer, but check gate and other canal appurtenant facilities are not provided,
- In flat ground, sweet potato, cabbage, carrot, tomato, etc. are cultivated,
- In sloping ground, sorghum, maize, cassava, beans, etc. are cultivated,
- According to the interview held on another day, farmland in flat ground is subdivided into blocks, and farmers cultivate crops only in rainy season. In addition, famers who occupied each block don't have ownership.

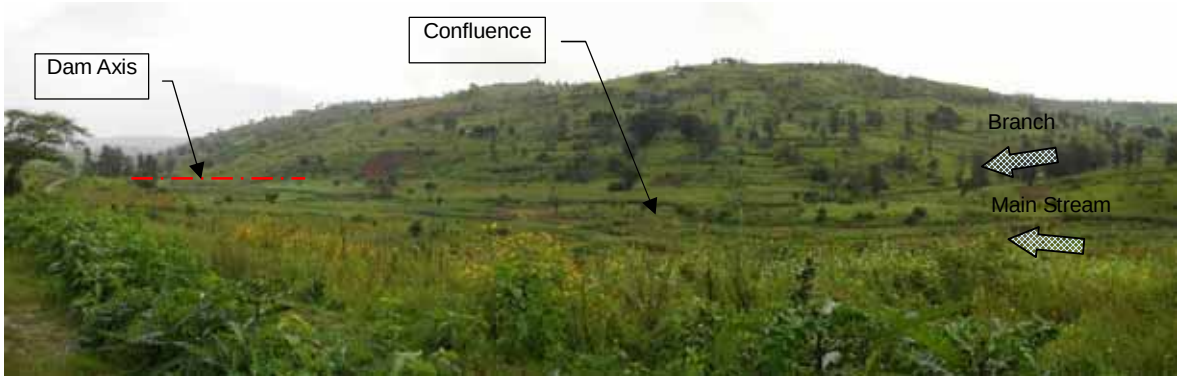
Acreage under cultivation in reservoir area identified through field survey is summarized as shown in (Table 3-7-2-1).

Table 3-7-2-1 Acreage under Cultivation in Reservoir area

Landform	Crop	Area (Approx.)
Flat Area	Sweet Potato	2.45 ha (70 %)
	Cabbage	0.70 ha (20 %)
	Carrot	0.18 ha (5 %)
	Tomato	0.18 ha (5 %)
	Sub-total	3.50 ha (100 %)
Slope Area	Sorghum	4.90 ha (70 %)
	Maize	1.05 ha (15 %)
	Cassava	0.70 ha (10 %)
	Beans	0.35 ha (5 %)
	Sub-total	7.00 ha (100 %)
Total		10.50 ha -

Photo Record: Panoramic View of Reservoir Area (May 28, '12)

View from Left Bank at Upstream to Reservoir Area



View from left Bank at Midway Point to Reservoir Area

View from Left Bank at Dam Axis to Reservoir Area

Photo Record: General View – Flat Area (May 28, '12)


General View in Flat Area (Left: Sweet Potato, Right: Sweet Potato)


General View in Flat Area (Left: Cabbage, Right: Carrot & Sweet Potato)


General View in Flat Area (Left: Cabbage, Right: Chinese Chive)

Photo Record: General View – Slope Area (May 28, '12)


General View in Flat Area (Left: Sorghum, Maize & Cassava, Right: Sorghum)


General View in Flat Area (Left: Sorghum, Right: Sorghum & Maize)


General View in Flat Area (Left: Sorghum, Right: Beans)

3-7-3. Topographical survey

The topographical surveys were carried out under the purpose of obtaining the fundamental topographic information necessary for the irrigation design. These survey works, of which contents are shown below, were sublet to the local survey firm.

Table 3-7-3-1 Topographical survey

Item	Quantity
Installation of Bench Mark	1 L.S
Plane survey(1:1000)	0.7 km^2
Longitudinal survey on the dam axis	180 m
Land-use map	0.7 km^2
Report(drawings as the achievement of the works, TBM coordination)	1 L.S

The main achievements of the works are shown as follows for reference.

In addition, circumstances around bench marks in Rwanda and the way of solving this issue in the Ngoma-22 valley are as follows.

Lack of bench marks in Rwanda

Almost all the bench marks that were once put up in place in Rwanda were destroyed during the chaos brought from genocide in 1994 to 1995. There exists no bench mark near the dam site and the nearest and the only one bench mark is the one in the roundabout of the road junction in Kayonza, that is about 60km far from the dam site.

Reliability/accuracy of the elevation measured by GPS

The accuracy level of the elevation measured by GPS is very low due to the lack of satellites that covers Rwanda, so that the elevation is not decided based on GPS measurement in Rwanda.

Elevation decision method applied in Rwanda (MINAGRI) these days

The material that has the highest reliability in terms of elevations is the topographical map with 1/50,000 scale. INAGRI has the elevation data of 10m grids that cover the whole country and is able to produce the topographical map by drawing contour lines based on these data; but the topographical map achieved is modified according to the elevation in the 1/500,000 scale topographical map.

Setting up the bench mark in the dam site

At first the dam axis line was drawn in the 1/500,000 scale topographical map. Then x-y coordination was read out to the intersection point of the extended line of dam axis and the contour line with EL.1400m. This intersection point was rebuilt at the site as the bench mark and the elevation of which was declared to be EL. 1400m.

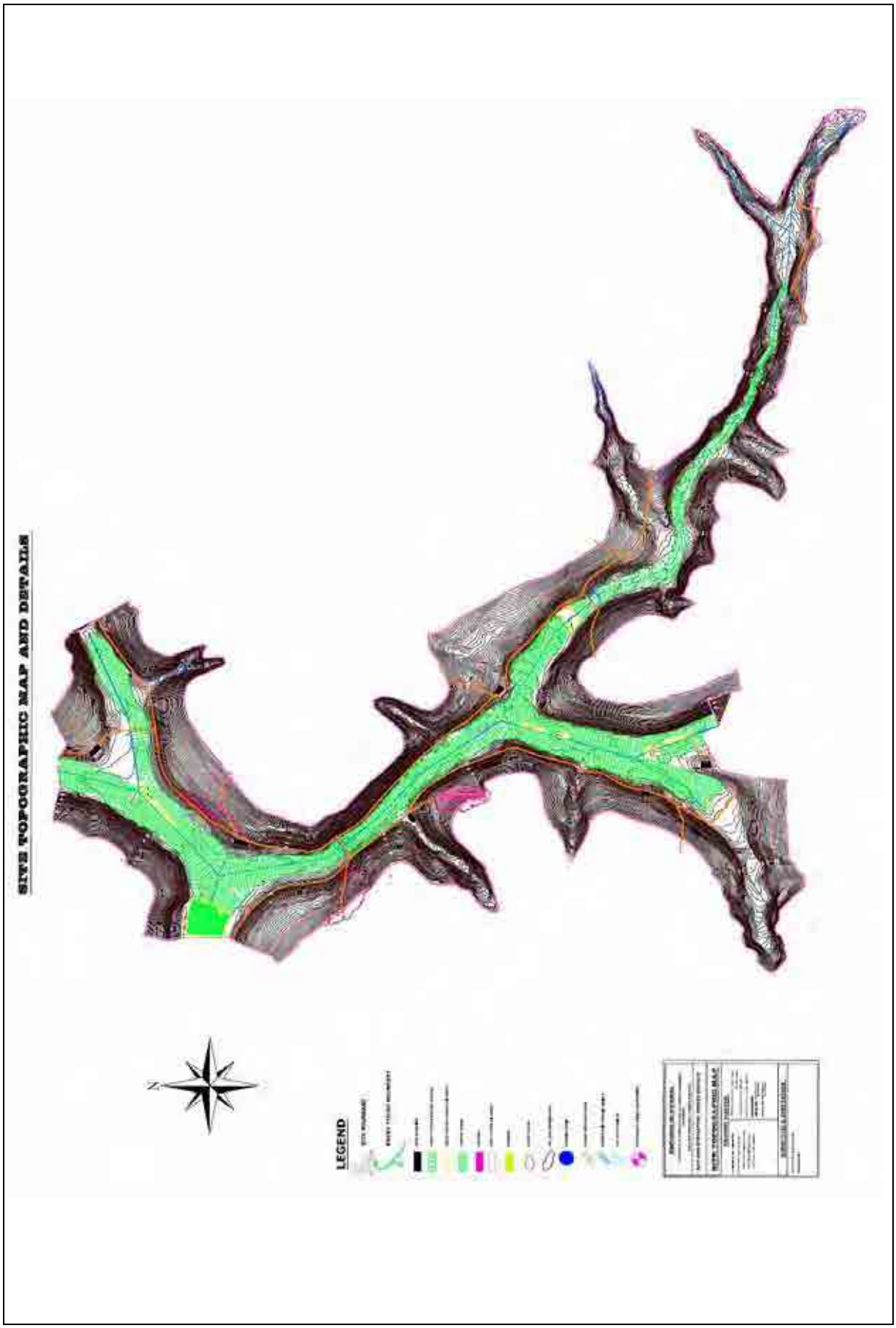


Fig. 3-7-3-1 Plane surveying

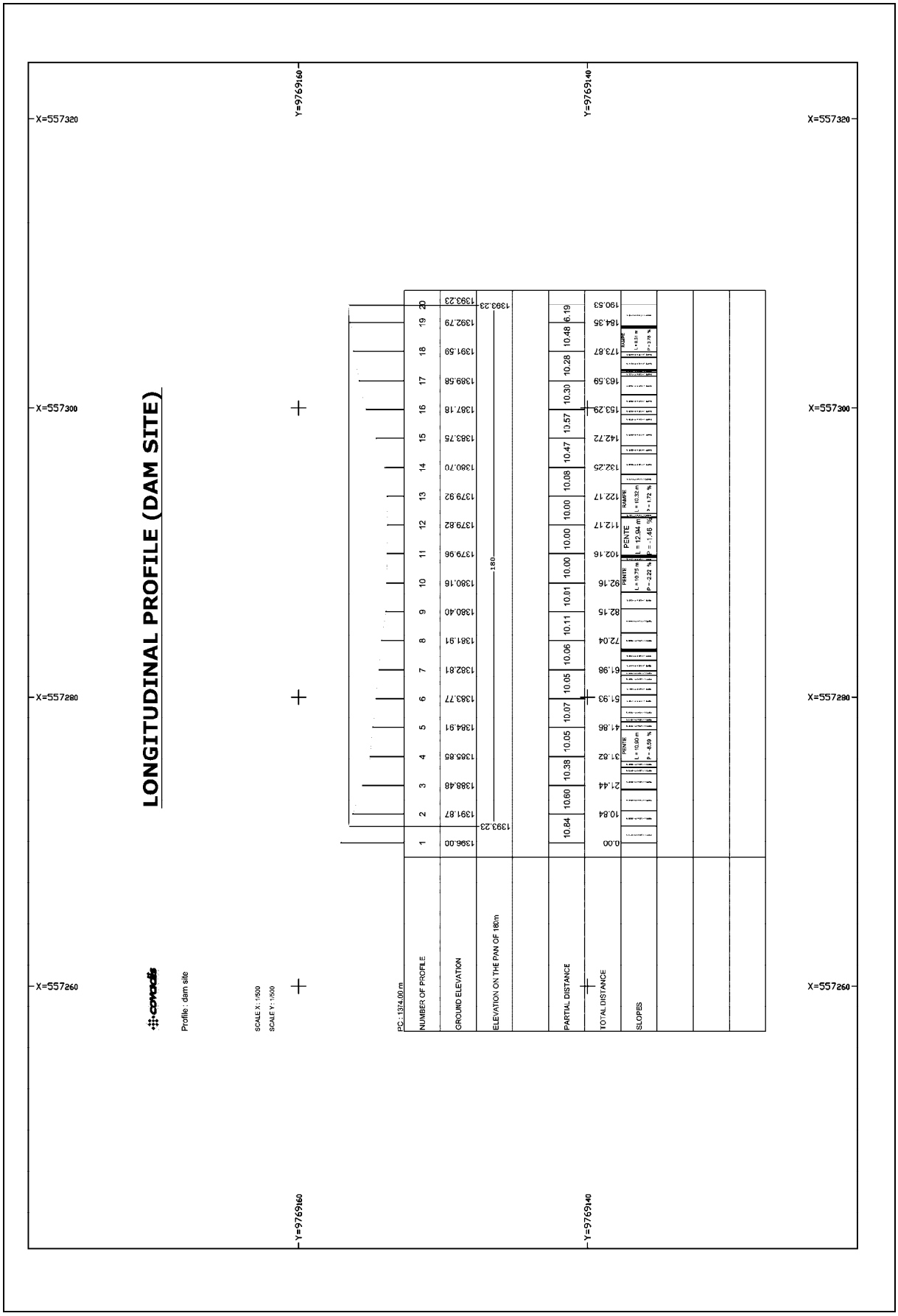


Fig. 3-7-3-2 Longitudinal axis of dam

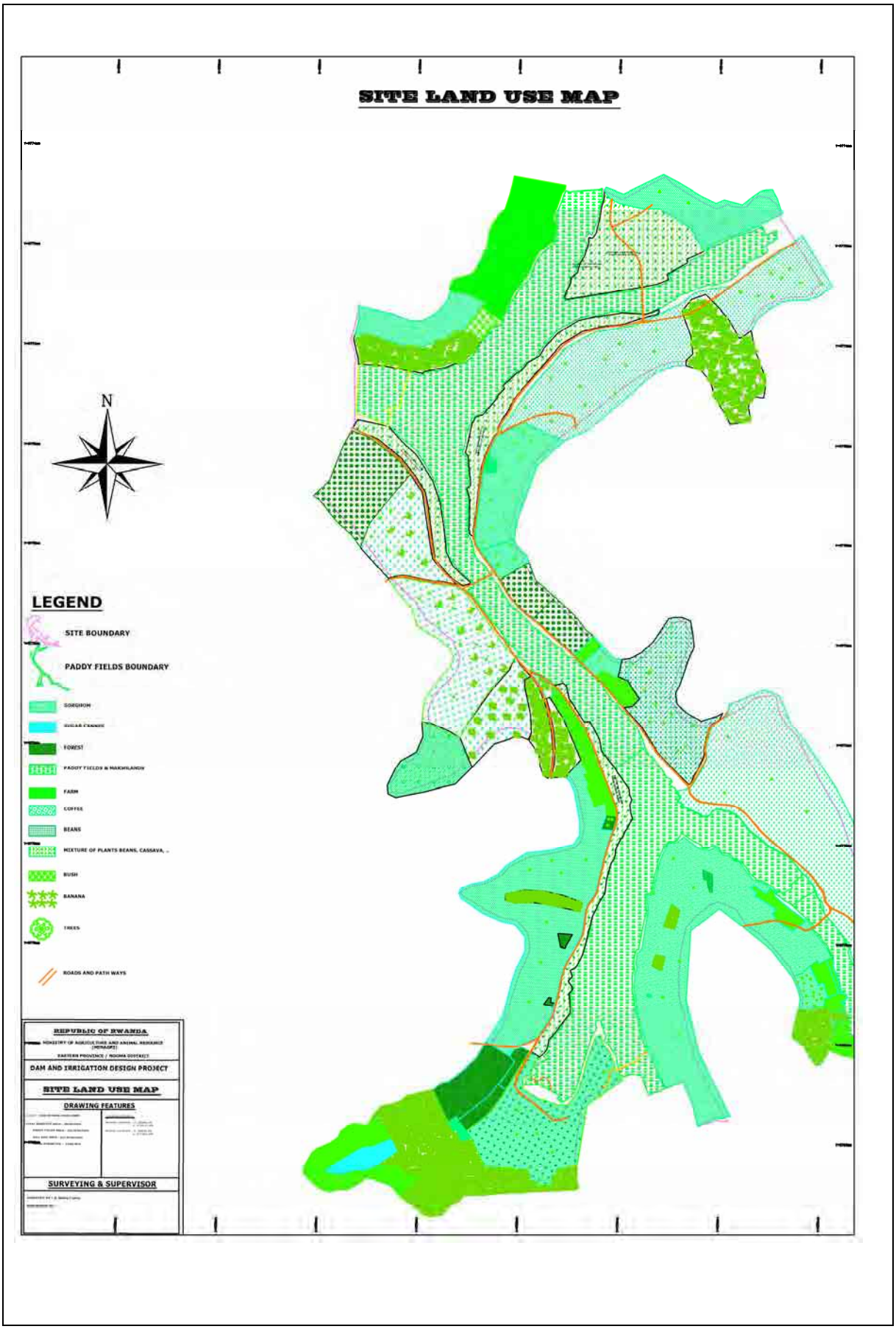


Fig. 3-7-3-3 Current state land-use map(1/2) - downstream side

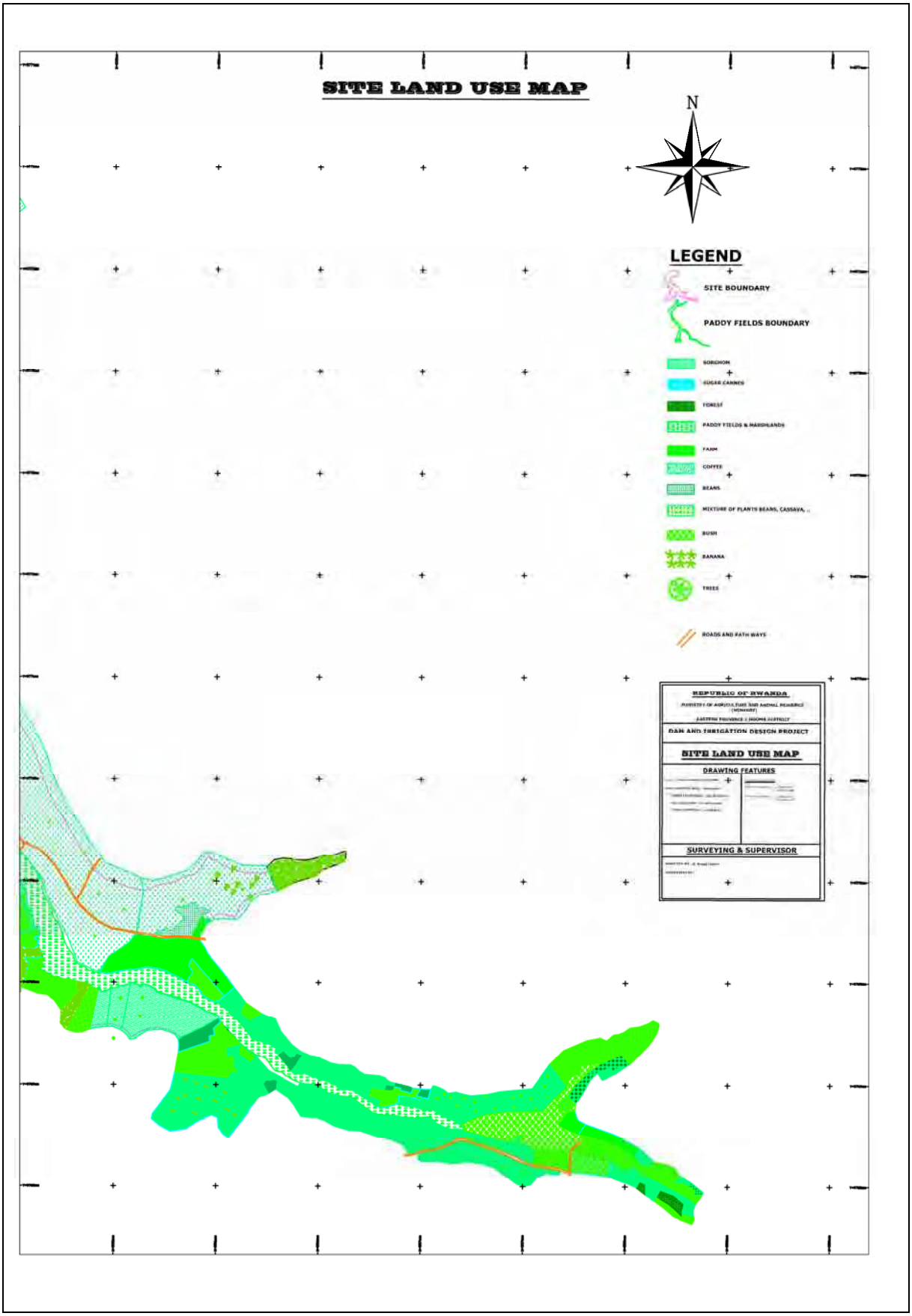


Fig. 3-7-3-4 Current state land-use map(2/2) - upperstream side

3-8. Laws and institutions on water users associations

In Rwanda, Minister's ordinance (No.50 of 12/12/2011) was promulgated in December 12th 2011while in the Ministry of Agriculture and Animal Resources a gazette on the establishment of Water Users Association: WUA（No.011/11.30 of 23/11/2011）was issued. WUAs Support Unit was organized in this ministry aiming at enacting this law smoothly into effect, and it started the activities from December 2011. The organization and functions of WUA is illustrated as follows:

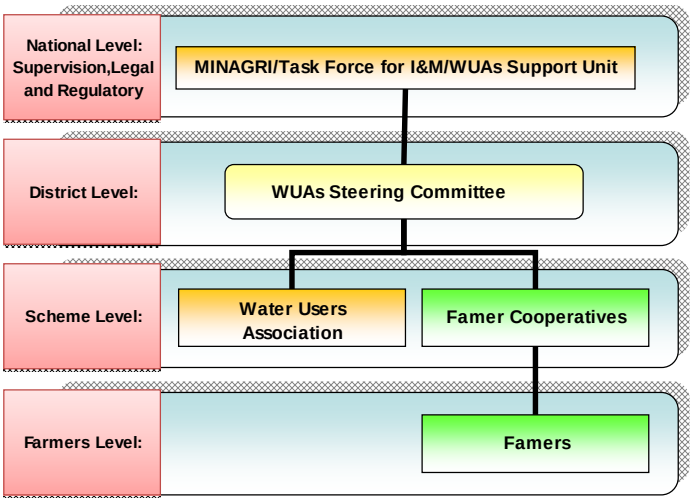


Fig. 3-8-1 Organigram of organizations related to Water Users Association

Source）: Ministry of Agriculture and Animal Resources

In the minister's ordinance, organization of WUA for managing irrigation facilities is stated in its clauses of articles, in which a framework is stipulated where WUA's steering committees established in each district provide technical support for WUAs. It is also stipulated in it that WUA's steering committees manage water fee collected from the members of WUAs for operation and maintenance / repair of irrigation facilities.

Outline of the act on water user's association（2enacted in December 2011）

- WUA is to be organized for all the irrigation schemes in Rwanda.
- This act is applied to the existing and scheduled irrigation facilities constructed by the government.
- WUA should equitably and equally be managed.
- WUA must realize equitable water distribution.

Source）: Ministry of Agriculture and Animal Resources

WUA's Support Unit has a schedule of establishing 25 WUAs in this year, and for this purpose the fiscal budget amounting to 58,697,000 RWF （97,020US$）has been provided. As to the budget for the next fiscal year, it was put under session in the Ministry of Agriculture and Animal resources.

Scheduled activity plan for WUA 's Support Unit (outline) is shown in (Table 3-8-1).

Table 3-8-1 Bar-chart of the scheduled activities of WUA Support Unit

	予算 (RWF)	Dec	Jan	Feb	Mar	Apr	May	Jun
Establishment of WUA	13,228,950							
Documentation		■						
Organization of constitutive general assenbli			■	■				
Preparation of WUAs bylaws			■	■				
Trainining and capacity buildi	20,789,850							
Trainining of WUAs leaders			■	■	■	■	■	
Trainining of WUAs members				■	■	■		
Information and Communicati	3,779,700		■	■	■	■		
Staff Training	2,000,000			■	■	■		
Meeting and Workshops	7,559,400	■	■	■	■	■	■	■
Plan of Actions	1,889,850	■	■	■	■	■	■	■
Studies	7,559,400						■	
Monitoring and Evaluation	1,889,850		■					■
Total	58,697,000							

Source）: Ministry of Agriculture and Animal Resources

3-9. Current state of WUA

The Study Team visited and observed WUAs currently organized and managed in Rwanda to analyze present state of their management and operation / maintenance.

Case 1 and Case 2 give the state of WUA organized in the dam facilities. Case 3 shows an example of WUA that manages, operates and maintains a diversion work. All these cases are useful as examples of management, operation and maintenance of facilities bb WUAs to establish future plan of utilizing facilities.

3-9-1. Case 1: Ntende Dam, Kiliba Dam（Rwagitima area, Gatsibo-District）[2]

(1) Current situation of facilities

Ntende Dam: Embankment height 4.5m, Storage area 64ha, Gross storage volume 700 thousand m^3, Beneficiary area 575ha, number of beneficiary farmers 3,015psn.

Kiliba Dam: Gross storage volume 400 thousand m^3

(2) State of management for facilities and activities/ management of WUAs

Organization system: WUA consists of a manager and 12 staff. a staff is assigned to each zone and there are 10 zones, the rest 2 staff are responsible for these 2 dams. The rate of affiliating the organization has reached 100%.

Collection of water fee: collecting tariff of 750RWF/ person/ year, but it has been changed into 200RWF/a. Rate of collecting tariff has reached 100%.

(3) Supporting system

Receiving training service from RSSP (Rural Sector Support Project) and also continuously receiving support on he management and O/M even after the construction of the facilities.

[2] source：excerpt from site observation memo at Ntende Dam, Kiliba Dam Ntende ダム、Kiliba ダム（Rwagitima area）on March 22nd2012JICAby Mr. Suuzuki technical adviser of JICA, Mr. Nakano, JICA expert and Hioki, Team member, Sanyu Consultants

(4) Particularly notable matters

Alteration of cropping period; Cropping of rice is practiced on 509 ha out of the total field of 575ha.

Water gates are managed in open use from early morning to daytime during dry season after January.

Planned cropping calendar was put into practice about 3 months earlier than what was recommended by Ministry of Agriculture and Animal Resources（Feb～Jun）based on the study result by RSSP. (It is considered that the reason of earlier action was a result of delayed cropping preparation in the previous cropping season and the cropping was inevitably skipped) (Intake gate of kiliba Dam was under repairing and later renewed).

Such an alteration in cropping period is evaluated a a progressive challenge and its objective is considered to cope with water deficiency and to aim water saving.

(5) Irrigation in rotation

The irrigation perimeter is divided into two wards, A and B, where irrigation is practiced in each ward every two days.

3-9-2. **Case 2:** Chinese Dam（Ngoma District）[3]

(1) Outline of the scheme

The water source is a dam constructed by China in 1987. During the period just after the construction, WUA was organized under the instruction of Chinese technical staff. Rice seed was also supplied from China and it seemed that all the cropping process from cultivation to post-harvest treatment had been instructed from Chinese technical instruction. After the harvest, rice was polished and stored in a processing and treatment facility in Rwamagana, and this facility is still now put under operation. The project was smoothly managed under the technical instruction by China during the period from 1987 to 1994, but all beneficial farmers abandoned their cultivation as a result of the dispute in 1994. Settlement was performed by local administration since 2000 and rice cropping was again launched. However, a part of the canal needs repair, and また WUA organization does not function though already established.

(2) Current situation of facilities[4]

Watershed area: 29.4k ㎡, Length of the crest of the embankment: 157.8m, Gross storage volume: 400 thousand m^3（estimated）, Width of the embankment crest 4.5m

Construction of this dam was started in 1985, completed in 1987.

(3) Current management of WUA

Organized system: no more organized

Collection of water fee: not collected

State of regular meetings: not held

Treatment for board members: no allowance is paid to them

(4) Current facility management

Gates are operated by the request of beneficiary farmers. There is a rule by which WUA pays allowances to the gate keepers but actually no allowance has been paid. O/M of the canal is voluntarily kept by beneficiary farmers.

(5) Supporting system

Such services as training on paddy cultivation or on facility management are not provided.

[3]Study on Chinese Dam by Hioki (Sanyu Consultants)

3-9-3. **Case 3:** Inkingi Y'Ubunhizi Cooperative（Bugesera District）

(1) Outline of the scheme

Farmers n this area have traditionally cultivated banana, coffee, sorghum etc on the slope of hilly area, and in 2003the land was developed through a Marshland Development Project by World Food Program（hereinafter referred to as WFP）. Crop cultivation in wetland could not be practiced before this project due to poor drainage, rice cultivation has been introduced since drainage/ irrigation canals have been constructed by WFP.

(2) Current situation of facilities

Water diversion work (4 sites), total length of canals: 3.6km, beneficiary area 32ha

(3) Current management of WUA

Organized system: 4 sites of diversion work was constructed in 2011 by the project called PAPSTA (Support Project for the Strategic Plan for the Transformation of Agriculture) then WUA was established in August in the same year. Organizing activities of WUA was performed mainly in dry-season (August~ October and January~ mid March). Board staff of WUA consists of a president and 16 board members, 9 groups of water users groups per each diversion work have been organized, and 4 members are engaged in the operation of gates per each diversion work.

- Collection of water fee: though it has been planned to collect 500RWF/ season / person, or 1000RWF/ year（two seasons）, but actual collection has not yet started.
- State of regular meetings: hey are performed about once in a week only during dry-season. In these meetings, gate operation is mutually consulted (no minutes has been provided).
- Treatment for board members: No allowance has so far been paid to board members.

(4) Current facility management

Farmers themselves are voluntarily engaged in gate operation and O/M of canals.

(5) Supporting system

Such services as training on paddy cultivation or on facility management are not provided.

(6) Rotation practice in irrigation

Management of gates is decided in the water distribution meetings held once a week where consultation with gate keepers are made reflecting the state of farm practices on each parcel of rice field. Since the consultations used to continue since WUA was initially established, no dispute/ struggle has ever taken place.

Diversion work

main canal (downstream)

Water intake

Secondary canal

Source: JICA study Team

3-9-4. Evaluation of WUA and proposal

Current state of each WUA has been evaluated as follows that was visited and observed this time.

Table 3-9-4-1 Evaluation of the state of WUA

	Case 1	Case 2	Case 3
Organization/ management			
Organization system	○	△	○
Water fee collection	◎	×	×
Practice of regular meetings	Not known	△	○
Treatment of board members	×	×	×
Facilities			
Facility management	○	△	○
Supporting system			
Provision of training	○	×	×
Organized instruction	○	×	×
Integrated evaluation	A	C	B

Note: ◎ perfectly (100%) performed, ○ favorably performed, ∆ performed though hazard exists, × not performed. A: Excellent, B: Fairly good, and C: With problem（Source: JICA study team）

In the case 2, The fact that the irrigation facilities of thedam constructed in 1985 does not favorably function is the cause of not smoothly managed WUA activities. According to the result of hearing from villagers, the facilities had favorably been utilized at the period of completing dam construction and WUA had functioned at that time.

In the case 3, though the facilities have newly been constructed, lack of training or of sustainable continuation of instructions serves as constraining factor in organizing WUA and also in developing its activities.

It has been basic principle in Rwanda that once irrigation facilities are constructed by projects, O/M activities for the constructed facilities are handed over to the beneficiary farmers. Also, through the enactment of the act on WUA realized recently, it is decided to obligately estblish WUA for the constructed irrigation facilities. Yet, cases are sometimes observed that even though WUAs were organized, support does not necessarily follow up, suggesting the necessity of sustainable instructions for effective O/M of the facilities and also for susained effective utilization thereof.

Sector and Cell offices play wide roles including management of irrigation scheme and techniques of farming in the model area of “Ngoma22” in this Project, but futhermore, such wider instructions as promotion of organization and know-how of organizational management is required. In other words, beneficiary farmers share common recognition that irrigation water is a target resource to be commonly managed, thereby envisaging creation a WUA in which all of them participate. To this end, it is considered necessary from the planning stage of a project to reflect desire of stakeholders in the project, and it ia also important to deepen understanding of local inhabitants toward water management.

3-10. Other types of farmers’ organizations

There have been various types of farmers’ organizations in Rwanda, including traditional and customary mutual-assistance organizations, collaboration groups, saving and solidarity circles, cooperatives, unionized groups, cooperative federation etc. In villages, the village chiefs take initiative to organize a group activity (Umganda) that offers voluntary activities including road

cleaning/ repair work, weeding, maintenance of canals etc. Similarly, a group activity in which individual members of an inhabitant's group raise money to offer the collected money to the member in turn to appropriate it for unexpected expenditure or maintenance of house building, so to speak an activity of alternate raise and help. In such a way, traditional mutual-help systems are still in function in rural areas in Rwanda, and such traditional activities serve as an advantage in establishing farmers7 organizations.

Representative traditional farmer's group activities are mentioned below:

3-10-1. Umganda : inhabitan ' s voluntary labor offering towards public works

Umganda stems from voluntary labor offering activities on public works still sustained in rural media from ancient times, and the inhabitant's participation therein has almost been deemed as forced public obligation. Its contents of activities are mostly originated from sector's or inhabitants' ideas. They can present their opinions in an assembly held at every Umganda. participants of the assembly debate relevance of proposed opinions, and once an opinion is judged relevant as an activity worth tackling as the entire community, it will be announced as the content of the activity to be approached in the coming schedule.

As a rule, an adylt family member was attended from each household, and if absent from it the absentee household pays 500Frw to the Sector office that is to be spent as expense for Umganda (purchasing materials of construction work).

3-10-2. Ubudehe : Mutual help orgaization of neighbor inhabtants

Ubudehe is a mutual help organization that still remains as ancient custom, one Ubudehe exists per Cell. This is kept for the purpose of joint practices of crop cultivation.

3-10-3. Gacaca : an informal method of reconciliation

In villages, a reconciliation procedure called acaca existed. This has been practiced in local commuities before the dispute, and actually utilized as a part in judging dispute crimes (confined to light offence cases) that recently took place. However, this is not currently functioning any more.

3-10-4. Ibmina : so to speak raise money and lend it to the needy member (an informal financing institution)

This is a type of finance practiced in villages. A group of inhabitants for the financial purpose raises money among its members and the collected money is loaned in turn for spending to unepected expenditures or repair of residences etc, and this activity has widely been developed. As a scale of raising/funding, 5~10 farm households raise the amount of 200 Rwf per week.