Appendix 5

Soil and Water Conservation

APPENDIX 5

SOIL AND WATER CONSERVATION

Table of Contents

List of Tables

List of Figures

APPENDIX 5

SOIL AND WATER CONSERVATION

CHAPTER 1 INTRODUCTION

This appendix is mainly focusing on the preliminary estimate of the present potential soil erosion and on assessment of the Master Plan from the view point of its contribution toward the soil loss reduction. For this, the review of secondary data and information and field reconnaissance in the Study Area were conducted, and findings of the present condition were summarized, including the outcomes computed by GIS for the examination on the soil erosion status in the Study Area.

CHAPTER 2 PRESENT CONDITION OF THE STUDY AREA

2.1 Risk of Soil Erosion and Slope Failure

2.1.1 Overview of the Study Area

Field reconnaissance was conducted to have a better grasp of the existing condition of the Study Area. Main findings are shown in **Table 2.1.1**, and the overviews of the Study Area are as follows.

In the Study area, the Magat River system seriously suffered more from sedimentation than the Cagayan and Addalam River systems (**Figure 2.1.1**). Denuded or deteriorated areas exist in various places in the upper Magat River Watershed especially in the watersheds of the Santa Fe and Santa Cruz river systems. Possible sources of sediment discharge with high density were observed on the following areas/cases:

- Slope failures or landslips, and erosion of their terraces,
- Hill slope erosion developing on denuded lands, including gullies and rills,
- Debris or immature debris flow, and
- Bank erosion.

Among the above, most of the slope failures and landslips were reportedly triggered by the 1990 earthquake (Killer Earthquake).

As regards the Matuno River, one of the left tributaries of the Magat River, the exact area of principal source of sediment discharge was not identified during the field reconnaissance. However, the condition of the river sedimentation implies that the upper watershed is highly degraded.

Moderate sedimentation was observed during the reconnaissance in the watersheds of the Ibulao and Alimit Rivers flowing down in the left mountain range of the Magat reservoir. Per field reconnaissance, the source of sediment discharge to both rivers seems to originate from:

- Natural disasters in upper watersheds, due to steep topography, and
- Sheet and gully/rill erosion in middle – lower watersheds.

Likewise, the Addalam and Cagayan River systems have slight to moderate sedimentation as a whole. Vegetation in the mountainous areas extending over the right bank of the Cagayan River (Sierra Madre Mountains) is relatively rich. Although a few forests exist in the hill areas along the Addalam/Cagayan Rivers and their tributaries, soil erosion such as gullies and rills is limited. The principal sediment source of these watersheds seem to be: sheet erosion in hill areas covered by grass/grazing land or agricultural land, bank erosion of rivers and their tributaries, and degraded areas observed occasionally in the Abaca River and Casignan River Watersheds (uppermost watershed of the Cagayan River).

2.1.2 Preliminary Estimate of Potential Soil Erosion

As part of the analyses of the present natural conditions of the Study area, GIS analysis was applied for assessment of potential soil erosion. Following is the methodology and outcome of the analysis.

(1) Methodology

1) Model Applied

The Universal Soil Loss Equation (USLE) model developed by Wishmeier,W.H. and Smith, D.D. (1998) was applied to estimate the potential soil erosion. USLE model is widely used for predicting a long-time average soil loss from sheet and rill erosion from specific field areas. This model computes the soil loss for a given site as the product of five major parameters (e.g. rainfall, soil, slope, crop, and practice), and those values can be expressed numerically at a particular location.

The USLE equation is as follows:

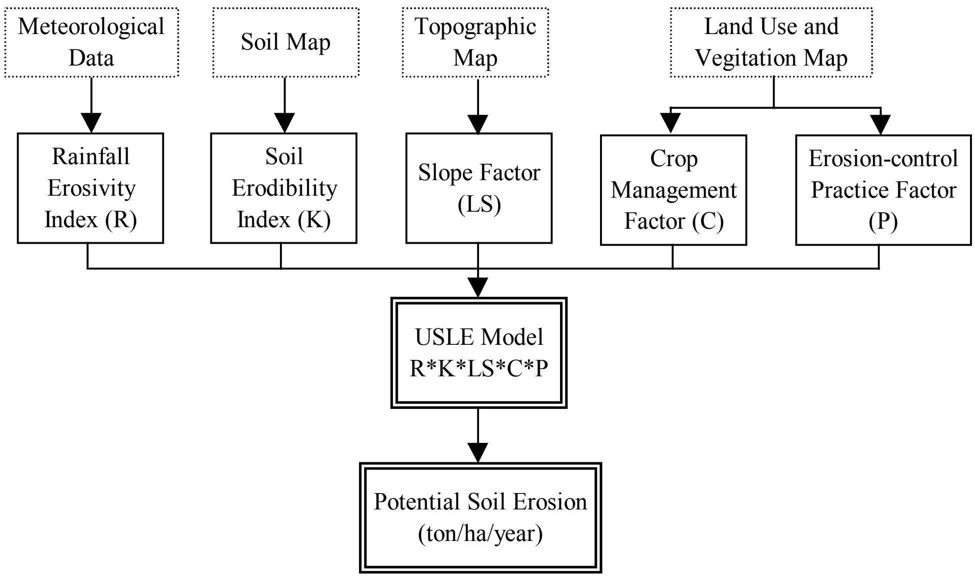
$$E_{denu} = R \times K \times LS \times C \times P$$

where E_{denu}: Mean annual soil loss（t/ha/year）
R：Rainfall erosivity index
K：Soil erodibility index
LS：Slope factor
C：Crop management factor
P：Erosion-control practice factor

The parameters of USLE equation are to be set up in accordance with the data obtained from site survey or measurement in order to meet quantitative estimate of soil loss. However surveyed or measured data are very limited in the Study Area. The quantitative soil loss computed by USLE model in the Study is provisional because of the premise that secondary/literature information is employed for establishing several parameters, and calculated outcomes are used for relative assessment and evaluation in the Study, as presented in the subsequent Chapter 3.

2) Flow of the Analysis

The flow of the assessment using the USLE model is illustrated below:



Flow of Analysis on Potential Soil Erosion

3) Parameters

The parameters for the USLE model were determined from various sources, and processed by GIS. The following describes conditions and setting up of respective parameters.

a. Rainfall Erosivity Index (R)

Rainfall erosivity index (R) was computed by the following equation.

$$R = 0.276 \times P \times I_{30} / 100.0$$

where P : Annual rainfall (mm/year)
I_{30} : Maximum 30-minutes rainfall intensity (mm/hr)

Daily rainfall records at 20 rainfall stations (**Table 2.1.2**) were used for computing annual rainfall (P mm/year) and the maximum 30-minutes rainfall intensity (I_{30} mm/hr). R was computed in such a way that:

i) A 50-year probable daily rainfall was computed for each of the rainfall stations by using Iwai method;

ii) Then, the maximum 30-minutes rainfall intensity was computed for each rainfall stations by using the following Monobe equation with a 50-year probable daily rainfall intensity:

$$r_t = \frac{R_{24}}{24}(24/t)^{2/3}$$

where: r_t :Mean rainfall intensity in t hours (mm/hr)
t: Duration of rainfall or time of flood flow concentration (hr)
R_{24}: Rainfall for 24hours (mm)、
$R_{24}/24$: Mean rainfall intensity per hour

Daily rainfall intensity formula is as follows;

$$I_N^{24}=R_N^{24}\cdot\beta_N=I_N^{24}\cdot\left(\frac{a'}{t+b}\right)=\frac{a}{t+b}$$

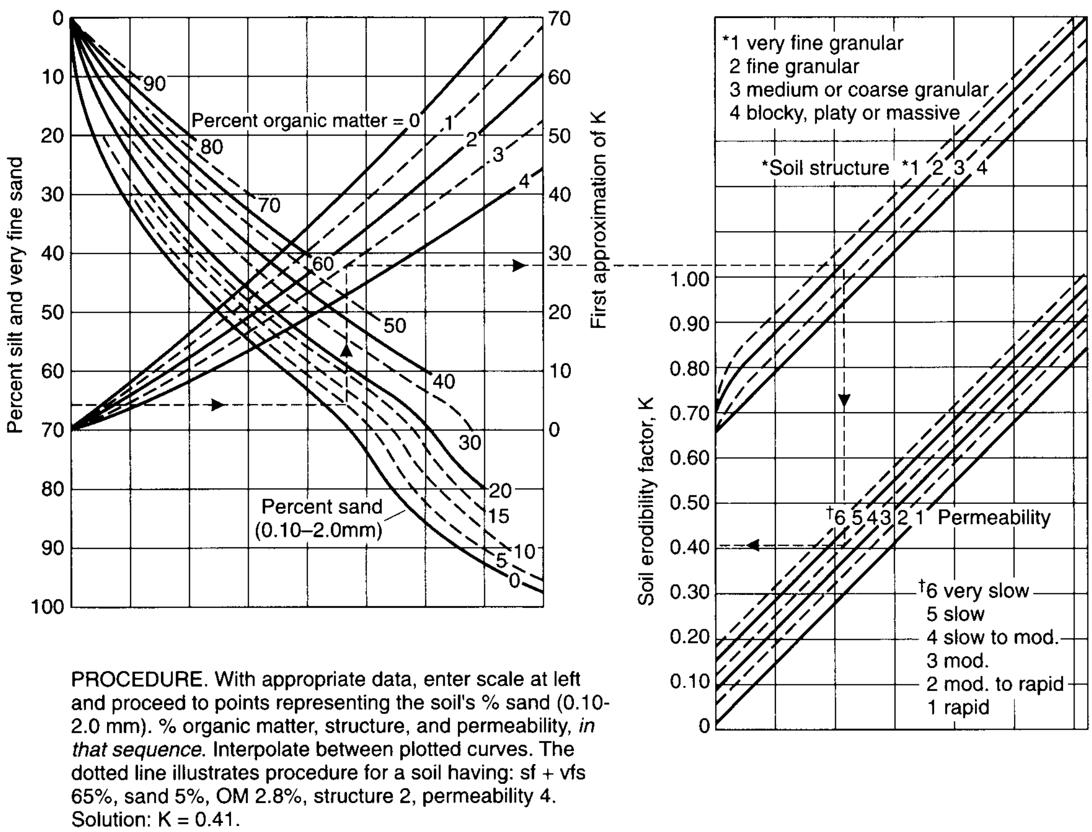
where: I_{24}: Formula of daily rainfall intensity (mm/24hr)
β_N: Coefficient of characteristic

iii) Using the annual rainfall and the 30-minutes rainfall intensity computed for each rainfall station, point Rs were computed for the 20 rainfall stations (**Table 2.1.2**); and

iv) The point Rs were converted to the areal ones for the whole Study Area using Tiessen weighted-average method.

b. Soil Erodibility Index (K)

The following nomograph was used for computing K value of soil erodibility in the Study Area:



Method for Estimating Soil Erodibility Index[1]

For applying this method, the physical property of soils is required as input data such as the percentage of sand, clay and silt for each soil category. Since no soil survey has been conducted in the Study, K value of each soil types was estimated in such a way that:

[1] Figure 3.1, Soil Erosion & Conservation, Second Edition, R.P.C Morgan

i) Soil types occurring in the Study Area were quoted from the soils map on a scale of 1:250,000 prepared by DENR;

ii) Percentage of silt and very fine sand and the percentage of organic matter and other necessary data such as grain size distribution for each of soil type and structure in the Study Area, were cited from the result of the soil survey carried out by The Feasibility Study on the Flood Control Project for the Lower Cagayan River (JICA) and that of the soil survey in Thailand (**Tables 2.1.3 and 2.1.4**); and

iii) K value for each soil type was computed using the nomograph mentioned above.

c. Slope Factor (LS)

The slope factor (LS) reflecting the topographic (length-slope) factor was computed with the following continuous form of equation, which was developed for computation of the LS factor to incorporate the impact of flow convergence being represented by upslope contributing area of a target cell in grid-based approach under GIS analysis [2]:

$$LS = (m+1) \times (A_r / l)^m \times (\sin b_r / b)^n$$

where, A_r: length of upper area of target cell (m) / unit length of cell (m)
b_r: slope of a target cell derived from digitized topographic map with a scale of 1:50,000 (degree)
l (const.): 22.1m
b (const.): 0.0896
m (const.): 0.4
n (const.): 0.7

d. Crop Management Factor (C)

Crop management factors (C) were assumed with reference to those proposed by Morgan, and were determined as shown in **Table 2.1.5** for the respective vegetative covers derived from the satellite image analysis (**Appendix 1**).

e. Erosion-control Practice Factor (P)

Erosion-control practice factor (P) represents the degree and effectiveness of countermeasures against soil erosion. Wischmeiter and Smith (1978) proposed this factor based on their field survey regarding sediment discharge by soil type. Assuming that no soil conservation work has been provided in the Study Area in general, this factor was selected as P=1.0.

(2) Potential Soil Erosion in the Study Area

The result of the estimation of potential soil erosion in the Study Area is shown in **Figure 2.1.2**. The following table shows the estimated potential soil erosion and total areas of excessive erosion in each of the Magat, Addalam and Cagayan River Basins. The term "Excessive Erosion" refers to the soil erosion potential classes of 4, 5 and 6 as explained in the subsequent Section 3.2.3.

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[2] Moore and Burch et. al, 1996

Estimated Present Potential Soil Erosion and Total Areas of Excessive Erosion in Each Basin

Basin	Area (km^2)	Volume (m^3/year)	Erosion Potential (mm/Year)	Area of Excessive Erosion (km^2) (Classes 4, 5 and 6)	Percentage Area of Excessive Erosion (%)
Addalam R. B.	1,147.741	930,000	0.811		
Cagayan R. B.	3,421.627	5,253,000	1.535	428.716	12.5
Magat R. B.	4,176.630	8,673,000	2.077	1018.141	24.4

Based on the average annual erosion rate the micro watersheds are classified into classes 1,2,3,4,5 and 6. The classes follow 1 mm increments of the average annual erosion rate.

The above table implies that the condition of soil erosion is most severe in the Magat River Basin with a soil erosion potential figure of 2.077 mm/year. Estimated potential soil erosion by Sub-watershed indicates that the area affected by severe erosion is spread over 24% of its basin area (**Table 2.1.6**). **Figure 2.1.1** shows that the Sub-watersheds in the upper reaches of the Magat River basin (Basin M) such as the upstream reaches of the Ibulao, Alimit, Matuno, Santa Cruz, and the Santa Fe Rivers and their tributories are particularly threatened by excessive soil loss requiring urgent soil conservation work. In the Cagayan River basin (Basin C) excessive soil erosion is seen in the basins of the Dibuluan, Dabubu and the Ngilinan Rivers. Soil erosion in the Addalam River basin (Basin A) is moderate.

The values of the factors influencing potential erosion in the areas of excessive erosion indicate that the governing factors in the Magat River basin and in the Cagayan River basin are the slope factor and the rainfall erosivity factor suggesting that slope stability measures should be adopted in those areas. While in the Addalam River basin the slope factor is less and soil erosion potential is moderate.

2.1.3 Landslip

(1) Mapping of Landslip

In the Study, land slip areas were identified using SPOT Panchromatic images covering the Study Area. In order to map the identified areas, 1/50,000 NAMRIA Maps were used.

Multitemporal satellite imagery with sufficient spatial resolution and stereo capability such as SPOT images can be used to make an inventory of previous landslips. The spatial resolution required for the recognition of landslip features is about 10m at smallest. Given the spatial resolution requirement, SPOT HRV-P (Panchromatic mode) imagery can be used with its 10m resolution. Multitemporal satellite imagery also can be used to map factors that are related to the occurrence of landslips such as lithology, faults, slope, vegetation and landuse and the temporal changes in these factors. These can be used within a GIS in combination with a landslips inventory map for landslips hazard assessment.

In this Study, a mosaic of SPOT Panchromatic images covering the watershed was developed using the following six full scenes.

Date	Cloud Cover	Path/Row
1998.03.08	Less than 30%	K303-J317
1999.02.18	Less than 30%	K303-J318
2000.08.13	Less than 30%	K304-J317
2000.09.10	Less than 30%	K304-J318
1999.09.05	Less than 30%	K305-J317
2000.06.08	Less than 30%	K305-J318

These images with a ground resolution of 10 meters enabled the identification of the details of the landslip areas. A conventional manual method of interpretation was adopted. The scars of the land surfaces that are depicted conspicuously on the places of the landslips on the images where there are no vegetation and fresh rocks are exposed help to identify the landslips. The scars of the larger landslips are evident in this manner. The ones of the smaller slips cannot be detected in this way. However, although the small landslips may not be seen individually, the overall rough appearance of a slope can suggest that mass movement has occurred. These can be confirmed by the examination of geological maps of a scale such as 1:50,000 or larger, for the presence of rock types and/or formations that are susceptible to landslips. An examination of the stream traces can also show deflections of the bed course due to landslips. If tectonically controlled stream segments can be separated the deflections due to slips or slumps can become evident. The identified areas were marked on hard copy printouts of the SPOT panchromatic images prepared at a scale of 1:50,000.

On the site, landslips were identified by typical features that signify their occurrence. The superficial anomalies that were observed on-site were placed into perspective by understanding the overall structural geology of the study area. After the landslip areas were identified on the hard copy printouts of the SPOT panchromatic images they were verified with the available ground truth information that was collected during the field reconnaissance survey and were delineated on the 1:50,000 topographic maps. Processing of the images was done using ER Mapper image processing software.

The landslip areas that were delineated on the topographic sheets were then digitized. The digital data of the landslips areas were then integrated into the GIS to be used together with the other spatial data in the GIS analysis.

(2) Distribution of Landslips

Figure 2.1.3 shows the distribution of landslip areas identified using SPOT satellite images of 1998 to 2000 covering the watershed. The identified landslip areas are excessive in the Magat River basin (Basin M) and are concentrated in the upstream areas of the Ibulao, Matuno, Santa Cruz and Santa Fe River basins. It is expected that these areas would be a considerably large source of sediment discharge requiring appropriate urgent remedial measures.

The identified landslip areas in the Cagayan River basin (Basin C) are much less and could be found in the upper reaches of the Dibuluan and Ngilinan Rivers. The landslip areas in the Addalam River basin (Basin A) are few. They are mostly dispersed in the uppermost basins of the Addalam River.

2.1.4 Sediment Transportation

(1) Sedimentation in Magat Dam Reservoir

The sedimentation in the reservoir of the Magat dam is serious. The dead space of the reservoir was originally 300 million m^3. Due to increased sediment discharge from the upper basin, the dead space of the reservoir has been significantly reduced to 116.4 million m^3 for 17 years (from 1982 to 1998) according to a report on sedimentation survey in the Magat reservoir as shown below.

Sedimentation in the Reservoir of the Magat Dam[3]

(Unit: million m^3)

Year	Accumulated Sediment Volume	Annual Sediment Rate	Remarks
1982	7.4	-	Completion of dam
1984	22.0	7.3	
1989	49.0	5.4	Earthquake in 1990
1995	179.0	21.7	
2000	213.8	6.7	

A series of the survey revealed that:

i) An annual sedimentation rate was drastically increased after the 1990 earthquake;

ii) The annual sedimentation rate between 1982 and 1989 is 5.9 million m^3, while the one between 1989 and 1995 was 21.7 million m^3;

iii) The last survey in 2000 implies that increased annual sedimentation rate by the earthquake tend to be settled to the previous level. This seems to be somehow arbitrary in its interpretation whether upsurge of sediment load caused of the earthquake has really settled down or not, whether a huge volume sediment deposited in the river system would not be carried into the Magat reservoir with flood discharge or not.

iv) To be assured of the trend of sedimentation, further survey is required.

(2) Sedimentation and Sediment Transport in the River System

There are no data monitored continuously nor periodically regarding the sediment discharge to or the sedimentation in the river systems in the Study Area. However, some information to be suggestive of the status of river sedimentation and its transport has been obtained, especially in upper watershed of the Magat River.

During the field reconnaissance, it was observed that the Cabanglasan bridge crossing the Cabanglasan River has been choked up with sediment. This bridge was constructed in 1993 under the 1990's earthquake disaster restoration project, and the clearance of the bridge designed by the project was 6.1 m from the river bed up to the bottom of the beam. According to PENRO Nueva Vizcaya, riverbed of the Magat River and its tributaries has risen considerably after the 1990 earthquake as shown in the following table.

[3] The Feasibility Study on the Flood Control Project for the Lower Cagayan River (JICA), 2002

Transition of Channel Cross Section of Magat River and its Tributaries

(Unit: ft)

River Name	Measured Point	1960*1		1999*2	
		Width	Depth	Width	Depth
Matuno River	San Leonald, Bambang	36	16	84	10
Marang River	Santa Clara, Aritao	20	11	29	5
Imugan River	Baan, Kayapa	20	18	30	6
Cabanglasan River	Cabanglasan, Kayapa	30	18	77	8
Magat River	Maddiangat, Quezon	92	22	128	14

Remark *1: Interview data to local people by PENRO
*2: Measurement data by PENRO
Source: PENRO Nueva Vizcaya

The sedimentation of the Santa Fe River is also serious. The river bed at the Santa Fe bridge of Route 5 reaches about 1.5 m below the bottom of the beam at present. This bridge was constructed in the latter 1980s with designed clearance of 6.5 m and at present the depth of sedimentation is about 5 m. On the other hand, Municipal Public Work and Design Office (MPDO) Santa Fe is compelled to dredge the upstream and downstream channel of the bridge twice or more times a year. According to the officials of MPDO, 10 days or more are required for one dredging work in this stretch of 300 ~ 400 m for 800 ~ 1,500 m^3 or more. The dredging work began in 1993, and two other stretches of the Santa Fe River are also dredged in similar frequency (the Baliling bridge of Route 5, and midway stretch between Santa Fe and Baliling bridges).

Further information was that the MPDO officials stated that the sediment discharge from upper watershed increased drastically after the 1990 earthquake. However, it is, because of insignificant volume of dredging work in Santa Fe River, unclear whether or not the sediment load from upper watershed exceeds sediment run off to lower river even at present. To understand the status of sediment discharge to and its transport in the river system, continuous and periodical investigation is required.

2.2 Structural Soil and Water Conservation Measures

Existing structures for soil and water conservation in the Study Area are listed in **Tables 2.2.1-2.2.4**, and are summarized below, based on the available data gathered from concerned PENROs and CENROs.

Summary of Existing Structures for Soil Conservation in the Study Area*1

(Unit: Sites)

Province	Check Dam				Other Structures*2			Total
	Serviceable or existing	Damaged	Unknown	Subtotal	Serviceable or existing	Damaged	Subtotal	
N. Vizcaya	13	6	0	19	1	0	1	20
Quirino	4	0	1	5	0	3	3	8
Ifugao	13	5	0	18	9	1	10	28
Isabela	1	0	0	1	1	0	1	2
Total	31	11	1	43	11	4	15	58

*1: Structures installed by DENR only
*2: Other structures include retaining wall, riprap, revetment, impounding dam, etc.

More than 80% of the structures installed within the Study Area is located in the provinces of Nueva Vizcaya and Ifugao. This implies that these provinces are apt to suffer from the soil erosion or other sediment disaster caused by steep topography and heavy devastation.

In Nueva Vizcaya province, most of the structures for soil conservation have been constructed in: i) the Casignan River Watershed (upper watershed of the Cagayan River); ii) the Kasibu River Watershed (upper watershed of the Addalam River); and iii) along some sections of Route 5 from Aritao till Santa Fe (left tributaries of the Santa Fe River).

In Ifugao province, 15 out of 28 sites are located in the Lamut River Basin and seven sites are in the Alimit River Basin.

Generally, 48 out of a total of 58 sites constructed are stone masonry types and the rest are loose rock or gabion types (**Tables 2.2.1-2.2.4**).

Aside from such civil structures, retaining walls and side ditches constructed by communities are occasionally observed on the provincial road between Banaue and Mayoyao. In addition, there are unique cases where the slopes of rice terrace are protected by stone masonry along this section.

2.3 Rural Infrastructures and Transportation

2.3.1 Road and Transportation

(1) Road Networks

Roads in this country are classified into three categories from the functional viewpoint: i) national road traversing inter-provinces; ii) secondary-national or provincial road running within a province; and iii) municipal or barangay road connecting villages in local area. From physical conditions, these are classified into asphalt road, concrete road, gravel road, and earth road.

Two national roads run in the Study Area. One is Route 5 and the other is Route 4. Route 5 with asphalt concrete pavement starts from Manila, and runs from southwest to northeast in Nueva Vizcaya province within the Study Area. This route, being one of the trunk roads of the country, is fairly good in condition and is playing an important role in country‘s economy.

Route 4, branching off from Route 5 at Bagabag town of Nueva Vizcaya Province, runs northwest towards Mountain Province through Ifugao Province. Its concrete surfaced section between Bagabag and Lagawe is fair in condition. The condition of its section between Lagawe and Banaue is somewhat poor since some portions of this section has graveled or earthen surface. Moreover, due to steep topography, the alignment of this section is swinging and steep, and also slope failures/landslips or its traces are occasionally observed along the road.

The surface of the provincial roads in the Study Area is concreted or graveled on the whole, and asphalt-paved provincial roads are very limited. All-weather type provincial roads run: along the towns of Bagabag, Solano, Bayombong, Bambang, Aritao, Dupax del Norte, Dupax del Sur, etc. in the province of Nueva Vizcaya; around Lamut and Lagawe in Ifugao Province; Diffun to Nagtipunan in Quirino; and most of the provincial roads in Isabela Province within the Study Area. In the Cordillera Central Mountain areas such as Mayoyao in Ifugao, Santa Fe and Kayapa in Nueva Vizcaya, however, the condition of the provincial road is rough because certain sections are earthen ones, and is unlikely passable to vehicles during the wet season. In Quirino Province, the provincial road traversing Sierra Madre Mountains from Abbag in Quirino to Aurora Province is disconnected at the Cagayan River, where a bridge is under construction.

The current service condition of barangay roads varies widely in each municipality and barangay within the Study Area. The following table shows the case of Quirino Province, as an example, that the service level in the municipality of Nagtipunan is much lower than the other municipalities. It is suggestive that, in Nagtipunan which is a mountainous area, the accessibility to national/provincial roads or center-town of municipality considerably lags behind other municipalities in its development.

Service Condition of Barangay Roads by Municipality in Quirino within the Study Area

Municipality	Area*1 (km^2)	Service Condition of Barangay Road							
		Concrete		Gravel		Earth		Total	
		Length*2 (km)	Rate ($km/10km^2$)	Length*2 (km)	Rate ($km/10km^2$)	Length*2 (km)	Rate ($km/10km^2$)	Length*2 (km)	Rate ($km/10km^2$)
Diffun	306.2	0.7	0.0	86.7	2.8	54.8	1.8	142.1	4.6
Cabarroguis	182.2	1.4	0.1	62.1	3.4	132.5	7.3	196.0	10.8
Aglipay	240.8	6.7	0.3	35.3	1.4	24.4	1.0	66.4	2.7
Maddela	652.3	5.8	0.1	190.7	2.9	165.3	2.5	361.8	5.5
Nagtipunan	1607.4	0.0	0.0	53.3	0.3	27.8	0.2	81.1	0.5

Source *1: Brief Provincial Profile, Province of Quirino
*2: Inventory of Barangay Roads and Bridges as of June 30, 2001, DPWH Quirino

In the case of Ifugao Province, 91 barangays out of 149 within the Study Area have all-weather roads, however about 30 % are quite inaccessible by vehicle as shown below.

Number of Accessible Barangays by Municipality in Ifugao within Study Area

Municipality	No. of Barangays	Accessible by Motor Vehicles		
		All Weather	Dry Season Only	Inaccessible
Aguinaldo	9	4	3	2
Asipulo	9	3	3	3
Banaue	18	12	2	4
Hingyon	12	5	1	6
Hungduan	9	3	1	5
Kiangan	14	10	1	3
Lagawe	20	5	2	8
Lamut	18	16	2	0
Alfonso Lista	1	1	0	0
Mayoyao	27	12	1	14
Tinoc	12	0	3	9
Total	149	71	19	54

Source: Accessibility Profiles/Status as of July 1999, PPDO Ifugao

In the Upper Cagayan River basin, particularly in the Casecnan Watershed, the road is surfaced with either gravel or earth. This is maintained as an all-weather road and it provides accessibility from Carranglan, Nueva Ecija Province to dams at Casecnan giving the local or indigenous people ease in transporting their products out from their area to the lowland.

(2) Public Transport

Between Metro Manila and Aparri town located at estuary of the Cagayan River, long- or middle-distance buses using Route 5 run some round trips a day including night trips. For inter-town or internal town transportation, jeepneys, mini-buses, and tricycles (motor cycle combination) are widely used in the Study Area. These transport facilities are provided by private companies or individuals. Only the above-mentioned types of land transportation and other kinds of wheeled vehicles ply over the area. There is no railway ever provided within the Study Area.

An airport exists in the Study Area and it is located at Lantap, Bagabag, Nueva Vizcaya. A private company serves a propeller airliner three round trips a week between Bagabag and Manila.

Water transportation is not a major one in the Study Area except in Abbag, Maddela, Quirino and Jones, Isabela where a small barge is used to ferry people and vehicles in crossing the Cagayan River.

2.3.2 River Structures

(1) Flood Control Structures

No systematic flood control structures are observed in the Study Area except for some sporadic protection works. The bank protection works are occasionally observed in the main Magat, Cagayan, and Addalam Rivers and in their tributaries to protect adjacent residential areas, trunk roads and bridges, and agricultural land. However, the areas protected with those facilities are very limited. Some spur dikes with revetments also exist in the upper Magat River near Bambang town and near Santa Fe Bridge on Route 5. Structures constructed under the previous flood control projects in Nueva Vizcaya and Quirino Provinces within the Study Area, are listed in **Tables 2.3.1** and **2.3.2**, respectively.

(2) Dams

In the Study Area, there is one reservoir type dam and two run-of-river type weirs. The reservoir type one is the Magat dam, and the weirs are called the Pelaway and the Taan weirs.

The Magat dam is located on the boundary of Ifugao and Isabela Provinces, having dual functions for irrigation and for hydroelectric power generation. It was completed and became functional in 1982, and has been operated since then by NIA and NPC for irrigation and hydroelectric power generation, respectively. In the design, it has basically no flood control capacity. Practically, however, it is likely contributing to flood peak reduction. The principal features of the dam are as follows[4]:

- Height of dam : 114 m
- Crest length of dam : 4,160 m
- Storage capacity at full supply level : 1.08 billion m^3
- Irrigation area by dam : 95,000 ha
- Total power capacity : 540 MW

The Pelaway and Taan weirs are located at the Abaca and Taan Rivers, respectively, both of which are tributaries of the upper Cagayan River in Nueva Vizcaya Province. The weirs have the purposes of diverting water through trans-basin tunnels from the Cagayan River basin in Region 2 to the Pantabangan River basin in Nueva Ecija Province for irrigation and for hydroelectric power generation. The designed principal features of the Taan and Pelaway weirs are as follows:

- Height of Taan weir : 25 m
- Crest length of Taan weir : 200 m
- Height of Pelaway weir : 25 m
- Crest length of Pelaway weir : 200 m
- Target irrigation area : 35,000 ha
- Power capacity : 150 MW

BOT (Built, Operate and Transfer) system is applied for the Casecnan Project which includes those weirs and trans-basin tunnels, a powerhouse, and access roads toward and within the project area.

[4] The Feasibility Study on the Flood Control Project for the Lower Cagayan River (JICA)

CHAPTER 3 EXPECTATION OF SOIL LOSS REDUCTION BY THE MASTER PLAN

3.1 Contribution of the Master Plan to Soil Erosion Control

Various components and activities are formulated and proposed in the Master Plan. Among these, land use plan, planting/agronomic method, and some of technical operations proposed are major components/activities that will considerably contribute to mitigate potential soil erosion in the Study Area.

(1) Proposed Land Use Plan

The table below shows the summary of future land use plan, excluding A&D and Civil Reservation areas, proposed by the Master Plan. The present forest areas of approximate 400,000 ha (Category 1 to 5 of the table) will be protected/maintained, and the area of approximate 110,000 ha will be additionally reforested and canopied as man made forest or agroforestry. Total area canopied by forest in future will be 1.3 times larger than that of the present, and 77% of the management area or 58 % of the Study Area would be covered by the forest in future whereas 60% or 45 % is respectively covered at present. These land-use alteration is considered to be main contribution to soil loss reduction.

On the other hand, agricultural land would increase from 54,000 ha at present to 66,000 ha along with population growth. However, according to the concept of the Master Plan, agricultural activity on the steeper slope will be strictly restricted, and be shifted to the lands on the gentle slope. This concept will cancel out the increment of potential soil erosion resulted from expansion of agricultural land.

Alteration of Land Use

(Unit: ha)

Category	Present	Future			Gain/Loss
	Total	*(Future PA)*	*(Future FL)*	Total	
1.Old growth forest	148,000	*(125,700)*	*(22,300)*	148,000	0
2.Mossy forest	7,300	*(7,200)*	*(60)*	7,300	0
3.Residual forest	216,900	*(128,700)*	*(88,200)*	216,900	0
4.Sub-marginal forest	23,300	*(8,600)*	*(14,700)*	23,300	0
5.Pine forest	600	*(500)*	*(100)*	600	0
6.Reproduction brush	84,000	*(8,000)*	*(0)*	8,000	-76,000
7.Other plantation	9,800	*(1,000)*	*(8,800)*	9,800	0
8.Grass land	104,900	*(0)*	*(0)*	0	-104,900
9.Agricultural land	53,800	*(10,300)*	*(56,000)*	66,300	+12,500
10.Man made forest	0	*(46,400)*	*(31,200)*	77,600	+77,600
11.Agroforestry area	0	*(10,500)*	*(23,200)*	33,700	+33,700
12. Silvopastral area	0	*(0)*	*(57,100)*	57,100	+57,100
13. Others*	12,100	*(2,200)*	*(9,900)*	12,100	0
Total	660,700	*(349,100)*	*(311,560)*	660,700	

*: Bare/rocky land, Built-up area, Water body, and Unidentified.
PA: Protected Areas
FL: Forestland

(2) Planting/Agronomic Method

The following planting/agronomic methods proposed in the Master Plan will contribute to soil loss reduction.

i) Assisted Natural Regeneration (ANR): enhancement of rapid succession of the residual forest such as enrichment planting, gap planting and thinning.

ii) Agroforestry: practical devices such as alley cropping, contour hedgerow planting, and inter-planting of fruit/firewood tree.

iii) Silvipasture: practical devices such as hedgerow fodder planting.

iv) Agriculture: practical devices such as contour farming, in-row tillage, improved fallow system for idle land, and terracing.

(3) Other Technical Operations

Such proposed harvesting methods as selective cutting and small-scale harvesting, and such fire protection as controlled burning and no-fire bonus scheme, will be indirectly effective for reducing the risk of soil erosion.

3.2 Relative Assessment of Soil Loss Reduction

3.2.1 Approach and Method

In order to estimate the effectiveness of the Master Plan for reducing potential soil loss, and to contribute to prioritizing the sub-watersheds for implementation of the Master Plan, assessment of soil loss reduction was studied. For this, the estimation of potential soil erosion on the future condition was carried out preliminarily. The same method was employed as explained in **Section 2.1.2** in this appendix, namely USLE model. The expected effectiveness of the Master Plan was expected and assessed in line with the following approach.

i) The base of the expectation is to recalculate the potential soil erosion using USLE model, where the goal of the Master Plan would be realized.

ii) The parameters composing USLE equation were examined based on the concept and activities proposed by the Master Plan, and some of the factors were changed for recalculation.

iii) The GIS analysis was applied to recalculate the expected soil loss reduction that would show the future status on potential soil erosion in the Study Area.

iv) The factors used in this recalculation as well as in the previous calculation are provisional ones. The surveyed/measured data in the Study Area for discussing and setting the factors are very limited, and there is no choice but to introduce the secondary/literature information for assumption of the factors. Therefore, the effectiveness of the Master Plan toward the soil loss reduction was relatively assessed on the sub-watershed basis by the reduction rate rather than by the expected reduction volume itself.

3.2.2 Condition for Recalculation

For estimation of the future potential soil erosion, the factors composing USLE equation were settled as follows, based on the concept and activities of the Master Plan.

(1) Crop Management Factor (C)

C-factor was examined mainly based on the future land-use plan proposed by the Master Plan.

The conditions to be considered for determination of C-factor for recalculation are as follows.

i) Reproduction brush in the future Protected Areas and Forestlands is proposed to be reforested or to be used for agroforestry and silvipasture with the different slope gradients.

ii) Grass land in the future Protected Areas and Forestlands is proposed to be reforested or to be used for silvipasture and agriculture with the different slope gradients.

iii) A part of agricultural land in the future Protected Areas and Forestlands is proposed to be reforested or to be used for agroforestry according to the slope gradient category.

iv) Other land use and vegetation in any land classification are not considered to be changed by implementation of the Mater Plan.

Considering above, the tables below show the C-factors applied for recalculation on the future condition.

C-factor Applied in the Future Protected Areas

Present Land Use & Vegetation	Proposed Land Use & Vegetation	Applied Factor	Slope (%)	Application Basis
Reproduction Brush	Man Made Forest (50%)	0.002	>50	Forest (assumed)
	Man Made Forest	0.002	30 - 50	Forest (assumed)
	Agroforestry	0.003	<30	Forest (assumed)
Grass Land	Man Made Forest	0.002	>30	Forest (assumed)
	Agricultural Land	0.250	<30	Average of rice and maize[*1]
Agricultural Land	Man Made Forest	0.002	>30	Forest (assumed)

Note: C-factors applied to any other land use/vegetation are same as shown in **Table 2.1.5**.
*1: Maize of high productivity with conventional tillage

C-factor Applied in the Future Forestlands

Present Land Use & Vegetation	Proposed Land Use & Vegetation	Applied Factor	Slope (%)	Application Basis
Reproduction Brush	Man Made Forest	0.002	>30	Forest (assumed)
	Agroforestry	0.003	18 - 30	Forest (assumed)
	Silvopastral	0.010	<18	Savanna or grass in good condition
Grass Land	Man Made Forest	0.002	>50	Forest (assumed)
	Silvopastral	0.010	18 - 50	Savanna or grass in good condition
	Agricultural Land	0.250	<18	Average of rice and maize*1
Agricultural Land	Man Made Forest	0.002	>50	Forest (assumed)
	Agroforestry	0.003	30 - 50	Forest (assumed)

Note: C-factors applied to any other land use/vegetation are same as shown in **Table 2.1.5**.
*1: Maize of high productivity with conventional tillage

(2) Erosion-control Practice Factor (P)

P-factor is mainly dependent on the practical device of tree-planting/cropping such as contouring and terracing. For recalculation, it was assumed that contouring practice would be introduced into the agricultural land developed anew. This assumption can be applied to a part of grass land in future National Parks and Forestlands according to the future land-use plan in the Master Plan. In due consideration of actual application rate of contouring practice in future, P-factor was determined as follows for recalculation.

i) New agricultural land developed in grass land on the slope less than 18% in the future National Parks and Forestlands; P=0.80

ii) New agricultural land developed in grass land on the slope between 18% to 30% in the future National Parks; P=0.95

iii) Any other land; P=1.0 (not changed)

(3) Slope Factor (LS)

Contribution of change of LS-factor toward soil loss reduction is generally produced by mechanical or structural measures. Although such measures are somewhat suggested in the Master Plan, this effect would be insignificant because of budgetary limitation and less intensive. Therefore, improvement of LS-factor was considered to be negligible, and this factor was not changed for recalculation.

(4) Other Factors (K and R)

Since there was no programs in the Master Plan with regard to soil amendment or other measures to reduce the soil erodibility, the same K-factor as the previous calculation was applied.

Rainfall erosivity index (R) was not changed for recalculation.

3.2.3 Effectiveness of Soil Loss Reduction

(1) Index for Assessment of Effectiveness

Various indexes are supposed for the assessment of effectiveness of soil loss reduction. For employing relative assessment of effectiveness in soil loss reduction, the following indexes were attempted and discussed on sub-watersheds basis, in case of achieving the goal of the Master Plan.

Index for Relative Assessment

Index			Description
1.	Mass reduction	m^3/yr	This index is to assess the effectiveness from the view point of impact reduction of sediment load toward the downstream of a calculated sub-watershed (off-site impact reduction). The mass reduction of soil loss volume between the present and the future cases is directly compared based on the outcomes calculated by USLE model. The index is explained by "VP minus VF". The watershed that gains larger mass reduction is assessed as one that would gain higher effectiveness from the Master Plan. This index is valid when the parameters applied to and outcomes calculated by the model are precise. In the Study, several parameters are assumed for USLE calculation in accordance with the secondary/literature information, and this index therefore, as remains at indicative level.
2.	Volume reduction rate	%	Although this index is to assess the effectiveness from the same view point as mass reduction, uncertainty due to the assumption of the parameters can be eliminated. The index is a volume reduction rate (percentage) from the present to the future, and explained by "(VP-VF)/VP". The watershed which gains larger percentage is assessed as one which will gain more effectiveness from the Master Plan. However, for example, the case of the watershed with "VP=10 and VF=6" of reduction rate of 40% is assessed to be equivalent to the case with "VP=100 and VF=60". The influence of the area (A) of the sub-watersheds can not be reflected.
3.	Erodible layer reduction	mm/year	This index is to assess the effectiveness from the view point of soil loss preventability within a calculated sub-watershed or at a calculated land itself (on-site impact reduction). The index is a deference of the potential erodible layer between the present and the future, and explained by "(VP-VF)/A". The watershed that gains larger difference is assessed as one that will gain more effectiveness from the Master Plan. However, application of the watershed area to "A" shows a tendency to attenuate the effectiveness from the Master Plan.

VP: Volume of soil loss at present
VF: Volume of soil loss in future

Among the above indexes, mass reduction and erodible layer reduction was employed for relative assessment of the effectiveness.

(2) Assessment of Effectiveness of Soil Loss Reduction

1) Estimated Future Potential Soil Erosion

Figure 3.2.1 spatially shows the future potential soil erosion in the basin on the sub-watershed basis. From this figure the condition of the estimated future potential soil erosion after realizing the goal of the Master Plan can be seen. It shows how the excessive erosion in the basin can be controlled.

The table below shows the estimated future potential soil erosion and total areas of excessive erosion based on the concept and activities proposed by the master plan.

Estimated Future Potential Soil Erosion and Total Areas of Excessive Erosion in Each Basin

Basin	Area (km^2)	Volume (m^3/year)	Erosion Potential (mm/Year)	Area of Excessive Erosion (km^2) (Classes 4, 5 and 6)	Percentage Area of Excessive Erosion (%)
Addalam R. B.	1,147.741	796,000	0.694	-	-
Cagayan R. B.	3,421.627	4,545,000	1.328	382.987	11.2
Magat R. B.	4,176.630	4,498,000	1.077	75.998	1.8

Source: JICA Study Team

Table 3.2.1 shows the recalculated future potential soil erosion. The comparison between the present and the future shows a considerable reduction of soil loss especially in the Magat River basin. This indicates that the proposed rehabilitation plan of development of man made forest and agroforestry in the Magat River basin would remarkably contribute to the soil loss control.

In the Magat River basin, average potential soil potential will be reduced from 2.077 mm/year to 1.077 mm/year, and the area exposed to excessive erosion will be reduced from 24.4% of the basin area to 1.8%. In the Cagayan river basin the erosion potential will be reduced from 1.535 mm/year to 1.328 mm/year and the area exposed to excessive erosion will be reduced from 12.5% of the basin area to 11.2 % of the basin area. This result shows that the land use plan and activities proposed by the Master Plan will contribute to reduction of the soil loss in the Study Area.

2) Assessment of Effectiveness

Table 3.2.2 shows the contrast of the potential soil erosion between the present and the future. These outcomes are explained on the changed land use basis due to the implementation of the Master Plan, and summarized below.

Nos. of Sub-watersheds in Each River Basin by Each Effectiveness Class (changed use basis)

Basin	Class 7	Class 6	Class 5	Class 4	Class 3	Class 2	Class 1	Total
Addalam	1	1	1	3	1	11	0	18
Cagayan	9	6	9	5	6	17	2	54
Magat	12	2	6	11	9	21	0	61
Total	22	9	16	19	16	49	2	133

Note: Classes are divided by the following criteria of effectiveness as erodible layer reduction.
Class 7: 5mm/yr~ Class 6: 4~5mm/yr Class 5: 3~4mm/yr Class 4: 2~3mm/yr
Class 3: 1~2mm/yr Class 2: -0.2~1mm/yr Class 1: ~-0.2mm/yr

The sixty-six (66) sub-watersheds (almost 50 % of all the sub-watersheds) are ranked in the Class 4 or upper classes. Among these, the 31 sub-watersheds concentrate in the uppermost areas of Alimit, Ibulao, and Santa Cruze Rivers in the Magat River basin, as well as 29 sub-watersheds are distributed from Nagtipunan up to the boundary between Quirino and Aurora Provinces within the Cagayan River Basin.

In contrast with these two basins, the effectiveness of soil loss reduction by the Master Plan is not significant in the Addalam River basin, since land use status in this basin will not changed drastically in future. Topographically due to the gentle slope in the Addalam River basin comparing with two other basins, the rehabilitation plan of reforestation and agroforestry with wide range or gathered-together area will not be introduced aggressively and intensively according to the concept of land-use plan development.

CHAPTER 4 RECOMMENDATION

4.1 Soil Erosion Control Measures

Vegetative measures are proposed in the Master Plan as main part for the rehabilitation and restoration of devastation of the Study Area, and proposed components and activities will realize the soil loss reduction and sustainable use of resources in the Study Area. In addition, mechanical/structural measures as well as vegetative measures would be effective from the view point both of soil erosion control and of sediment disaster prevention. In the Study, mechanical/structural measures are not formulated nor integrated into the Master Plan because of little data/information and limited field reconnaissance. In this regard, it is recommendable that the following measures be introduced or formulated with the further data collection and analysis, intensive field investigation and detailed study.

i) Especially in the agricultural land on the slope more than 18%, construction of waterways are recommendable. The purpose of waterways is to convey surface runoff at a non-erosive velocity to a suitable disposal point. The waterways should be composed of diversion channels, terrace channels and grass waterways.

ii) Contour bunds are recommendable in the agricultural land on the slope less than 18%. The contour bunds are earth banks of approximate 0.2 m height, installed along the contour to act as a barrier to surface runoff, to form a water storage area on their upslope side, and to break up a slope into segments for reducing the runoff velocity.

iii) It seems that bank erosion of the river system observed occasionally in the Study Area is playing as one of the main sources of sediment discharge. And agricultural lands along the rivers/streams look threatened with or damaged by bank erosion. When new agricultural lands will be developed along the rivers/streams under the activities of the Master Plan, adequate consideration should be paid, and such protection works as revetment and spur dike be done if necessary from the view point of farm land conservation.

iv) Collapsed areas are concentrated in the upstream areas of Ibulao, Matuno, Santa Cruz, and Santa Fe watersheds in the Magat River basin. It is, because of no available data/information, unclear whether or not the areas are under the slope of stable grade, and whether or not the further sediment disaster would occur. Therefore, detailed investigation and study are required, and slope stabilization works or hillside works should be applied if necessary, not only for the prevention of the sediment disaster but also for reduction of sediment discharge by point source control.

v) Sabo works are one of the major structural measures for decrement or prevention of sediment discharge to downstream. In the Feasibility Study on the Flood Control Project for the Lower Cagayan River (JICA), sabo works plan is recommended as watershed conservation plan in the preliminary level. This preliminary plan consists of the construction of 26 sabo dams within the Magat Dam catchment area, and aims at storing sediment volume of 225 million m^3 by each dam height of 25m. Although further investigation and detailed study are required, this preliminary plan should be incorporated when an erosion and sediment control plan with structural measures would be formulated in the Study Area.

4.2 Accessibility Improvement for Rural Area

The result of field study suggests that accessibility to rural/mountainous areas is considerably poor. Easy transportation of the product from Man Made forest or Agroforestry out to the lowlands is prerequisite for making a contribution to stabilize livelihood of upland people mentioned as a principle of the Master Plan. Therefore, accessibility improvement such as a barangay road construction should be planned and implemented for rural/mountainous areas, in due consideration that infrastructure developed newly would not be additional sources of sediment discharge.

Tables

Table 2.1.1 Main Findings of Field Reconnaissance in the Study Area (1/2)

River	Main Findings	Date
Marang River and Benay River	a. Sedimentation and bank erosion are observed near the confluence of Magat River. b. Although traces of rills and gullies are often observed on the hillslopes along the rivers, erosion progress seems dormant because surface of traces have been covered by grass or bush. c. Hillside failures or landslides are limited. d. It is therefore expected that main source of sediment discharge to Marang and Benay River is sheet erosion from and initial rill / gully erosion process in (burnt-) grazing area.	24 April 2001
Santa Fe River	a. Heavy sediment is observed in this river system. At the Santa Fe Bridge of Route 5, the riverbed reaches 1.5 m below the beam of the bridge (original design height of pier is 6.5 m). b. Main sources of sediment discharge seem: - Many land collapses caused by Killer Earthquake in 1990, - Erosion of traces of land collapses, and - Erosion of steep slopes denuded by logging.	24 April 2001 and 8 May 2001
Santa Cruz River	a. As well as Santa Fe River, this river system also suffers from heavy sedimentation. Small scale but many land collapses and gullies are observed along the Santa Cruz River and on cut-slopes of existing road. b. Cabanglasan River Basin is one of the most devastated watershed of Santa Cruz River system. Existing bridge (original design height of pier is 6.1 m) is almost choked with sediment. c. According to hearing to local people carried out by PENRO N. Vizcaya in 1999, it was reported that in 1960 width of water surface of this river was 30 ft and that depth was 18 ft at Cabanglasan. However, in 1999, PENRO N.V. measured the width of 77 ft and the depth of 8 ft at the same location. This indicates severity of aggradation of the riverbed. d. All possible source of sediment discharge to this river can be observed with high density, i.e.: - Hillslope erosion including gullies and rills, - Landslides or slope failures, - Debris or immature debris flow, and - Bank erosion e. Upper watershed of Imugan River which is a tributary of Santa Cruz River system seems well managed by the Kalahan Educational Foundation through its local fund. Local community has a regulation to ensure sustainable land use. However, according to DENR and local people, lower Imugan River seems to be highly devastated similar to Cabanglasan River.	24 April and 8 May 2001
Magat Reservoir and Magat River	a. Most of mountain ranges surrounding Magat Reservoir are covered by grass land or (burnt-) grazing land. NIA, one of dam administrators, is striving to reforest surroundings, however it was not successful due to limited finance. b. Although forest areas are observed on the hilltops of right-bank mountain ranges of Magat River from Bagabag to Bayombong, some parts of these ranges are covered by grass land or (burnt-) grazing land, and small-scale land collapses are found occasionally. c. Bank erosion is observed at the stretch from Bambang to Santa Fe of Magat River. Besides, there are gullies on the hillslope of left-bank mountain range located in the south of Aritao.	25 April 2001

Table 2.1.1 Main Findings of Field Reconnaissance in the Study Area (2/2)

River	Main Findings	Date
Ibulao and Alimit River	a. Moderate sedimentation is observed in both rivers. b. In the upper watersheds of these rivers, hillside collapses due to steep topography are found occasionally. Similarly, along the roads both existing and under construction, cut-slope failures and rock falls are observed frequently. c. Local communities installed such civil structures for soil and water control as soil retaining work and channel work along existing road. Besides, there is a unique case where the steps of rice terrace are protected by stone masonry. d. Regarding middle-lower watersheds of both rivers, topography is rather gentle, and hillside failure or landslide is very limited. e. In middle- lower watersheds, small bushes are somewhat scattered along the streams / valleys. Few forests exist. Watersheds are covered almost by grass and shifting cultivation lands, and gullies can be sometime observed on hillslopes of grass lands. f. It seems therefore that sediment discharge to both rivers is mainly caused by: - Natural or factitious disasters in upper watersheds; and - Sheet and gully erosion in middle - lower watersheds.	26 April and 10 May 2001
Middle Cagayan River (Angadanan - Nagtipunan)	a. Banks in some stretches of Cagayan River are eroded, and small-scale erosions (rills?) are sometimes found on the hills along the river. However, conspicuous sedimentation is not observed in the river. b. An area along the river in Nagtipunan assumes a look of devastated lands. It is probable that some zones with similar feature are distributed in the watershed. c. Besides, some of tributaries of Cagayan River have deposition of boulders with ϕ 300 mm or more.	27 April and 3 May 2001
Upper Cagayan River (Watershed of Casecnan Dam)	a. Although mountainous areas near the boundary of Study area are covered by virgin or secondary forest, hillslopes along Abaca and Casignan River are moderately devastated. Gullies and land collapses are often observed. b. Site road for construction of Casecnan Dam suffers from cut slope failures. Some of these failures are protected by soil retaining works or concrete spraying. c. However, there seems to be slight sediment in Casignan River despite devastation status in its watershed.	5 May 2001
Matuno River	a. Sedimentation of the river is conspicuous. Sediment with 3 to 4 m depth on the river bed can be observed around the proposed dam site of hydropower. b. According to hearing to local people carried out by PENRO N. Vizcaya in 1999, it was reported that in 1960 width of water surface of the river was 36 ft and that depth was 16 ft at San Leonaldo. However, in 1999, PENRO N.V. measured the width of 84 ft and the depth of 10 ft at the same location. This indicates severity of aggradation of the riverbed. c. In reconnaissance up to the proposed dam site, an area as principal source of sediment discharge was not identified, although there were small-scale land collapses and shifting cultivation. However, considering the condition of river sedimentation, it is expected that the upper watershed is highly devastated. d. Rills, gullies and slope failures are observed on most of the cut-slopes of roads both existing and under construction in Tiblac, then seem to contribute toward a certain sedimentation of the downstream.	9 May 2001

Table 2.1.2 Rainfall Stations in the Study Area and Calculated R-factor

No.	Station	Elevation (m)	Latitude	Longitude	30min-50year (mm)	Annual Rainfall (mm)	R_Factor
1	Ilagan	47	17-09'	121-53'	98.1	2048.6	554.5
2	Banga-An	1600	17-07'	120-54'	129.8	2196.6	787.0
3	Bontoc	855	17-05'	120-58'	128.9	2141.7	762.0
4	Barlig	1500	17-03'	121-06'	94.9	3197.5	837.9
5	Bauko	1200	16-59'	120-52'	116.0	2128.5	681.7
6	Mt. Polis, Banague	1900	16-58'	121-02'	106.3	4135.0	1213.6
7	Mt. Data, Benguet	1500	16-51'	120-52'	150.2	3276.0	1357.7
8	Lagawe	480	16-48'	121-04'	43.4	3050.5	365.8
9	Nayon, Lamut	320	16-43'	121-10'	76.5	1908.4	403.1
10	Echague	66	16-42'	121-40'	80.6	1645.8	366.2
11	Barat, Bambang	610	16-23'	121-06'	51.3	2008.3	284.4
12	Consuelo, Sta. Fe	506	16-10'	120-57'	210.8	2282.7	1328.1
13	Gabong	N.A.	16-01'	121-21'	156.2	1727.5	744.8
14	Dakgan	N.A.	16-05'	121-30'	290.3	1622.2	1299.8
15	Casiguran	3	16-17'	122-07'	155.4	3434.6	1472.7
16	Hapid, Lamut	280	16-42'	121-15'	62.4	1594.0	274.4
17	Baretbet (Dumayup)	230	16-35'	121-16'	73.3	1784.1	361.0
18	Baligatan	200	16-48'	121-27'	30.5	1742.8	146.9
19	Poblacion Lagawe	400	16-48'	121-07'	204.1	2044.6	1151.7
20	Sto. Domingo	320	16-25'	121-06'	75.7	1464.8	306.0

Source: The Feasibility Study on the Flood Control Project for the Lower Cagayan River (JICA), 2002

Table 2.1.3 Results of Soil Sampling Survey

Soil Name	Sand	Silt	Clay	Textural Grade	Bulk Density	Per_ Silt&sand	Per_ sand	OM	ST	Per	K_Value
San Manuel silt loam	22	54	24	SiL	1.27	54	22	4	4	5	0.43
	18	61	21	SiL	1.32	61	18	4	4	5	0.42
	23	56	21	SiL	1.19	56	23	4	4	5	0.44
San Manuel sandy loam	61	29	10	SL	1.46	29	61	4	4	2	0.22
	66	31	3	SL	1.52	31	66	4	4	2	0.23
	71	21	8	SL	1.98	21	71	4	4	2	0.17
Quingua clay loam	35	25	40	CL	1.29	25	35	4	4	4	0.2
	40	25	35	CL	1.42	25	40	4	4	4	0.2
	45	25	30	CL	1.17	25	45	4	4	4	0.21
	45	25	30	CL	1.31	25	45	4	4	4	0.21
	40	25	35	CL	1.41	25	40	4	4	4	0.2
Sta Rite clay loam	31	37	32	CL	1.35	37	31	4	4	4	0.29
San Juan clay	31	39	30	CL	1.38	39	31	4	4	5	0.28

Source: The Feasibility Study on the Flood Control Project for the Lower Cagayan River (JICA), 2002

Table 2.1.4 Soil Erodibility Index (K) Applied for the Study

Soil-id	Soil Name	Soil Type	K_Factor
407	Alaminos clay loam	clay soil	0.218
98	Annam clay loam	clay soil	0.218
410	Bago clay loam	clay soil	0.218
16	Batang clay loam	clay soil	0.218
108	Bolinao clay loam	clay soil	0.218
397	Cauayan clay loam	clay soil	0.218
280	Guimbalaon clay loam	clay soil	0.218
288	Guimbalaon gravelly clay loam	clay soil	0.218
1051	Lagawe silty clay loam	clay soil	0.218
140	Luisland clay loam	clay soil	0.218
117	Maligaya clay loam	clay soil	0.218
1054	Mayoyao clay loam	clay soil	0.218
1053	Nayon clay loam	clay soil	0.218
1052	Panupdupan clay loam	clay soil	0.218
279	Quimbalaon clay loam eroded phase	clay soil	0.218
109	Quingua clay loam	clay soil	0.218
401	Rugeo clay loam	clay soil	0.218
650	Sevilla clay loam	clay soil	0.218
119	Sta Rite clay loam	clay soil	0.218
580	Sta. Fllomena clay loam	clay soil	0.218
262	Bago sandy clay loam	clay loam	0.315
1050	Longa silty clay loam	clay loam	0.315
285	Quingua silty clay loam	clay loam	0.315
118	Beach sand	sand	0.500
824	Rugao sandy clay loam	sandy clay loam	0.280
548	Bago sandy loam	sandy loam	0.207
396	Cauayan sandy loam	sandy loam	0.207
1055	Lamut sandy loam	sandy loam	0.207
412	Quingua sandy loam	sandy loam	0.207
399	Rugeo sandy loam	sandy loam	0.207
95	San Manuel fine sandy loam	sandy loam	0.260
96	San Manuel sandy loam	sandy loam	0.260
5	Quingua silt loam	silt loam	0.430
82	San Manuel silt loam	silt loam	0.430
607	Brooke's loam	loam	0.310
622	Cauayan loam	loam	0.310
1046	Guinaoang loam	loam	0.310
903	Ilagan loam	loam	0.310
322	Umingan loam	loam	0.310
1049	Balog clay	clay	0.280
192	Bigaa clay	clay	0.280
398	Cauayan clay	clay	0.280
132	Faraon clay	clay	0.280
400	Rugeo clay	clay	0.280
600	San Juan clay	clay	0.280
874	San Juan clay	clay	0.280
14	Sibui clay	clay	0.280
1056	Sta. Maria clay	clay	0.280
402	Bantay-Bauang complex	others	0.311
524	Guimbaiaon-Annam complex	others	0.311
404	Luislang-Annam complex	others	0.311
45	Mountain soils undifferentiated	others	0.200
152	Riverwash	others	0.200
599	Rockland	others	0.000
202	Rough Mountainous	others	0.200
999	Unclasified	others	0.311

Source: Derived from Nomograph (R. P. C. Morgan)

Table 2.1.5 Crop Management Factor (C) Applied for the Study

Level	Land Use and Vegetation	Applied Coefficient	Assumption Basis
1	Old-growth forest	0.0010	Forest or dense shrub
2	Mossy forest	0.0010	Forest (assumed)
3	Residual forest	0.0010	Forest (assumed)
4	Sub-marginal forest	0.0030	Forest (assumed)
5	Pine forest	0.0030	Forest (assumed)
6	Mangrove forest	NA	
7	Reproduction brush	0.0100	Savanna or grass in good condition
8	Coconut plantation	0.2000	Average of palm tree or coffee
9	Other plantation	0.2000	Average of palm tree or coffee
10	Grass land	0.1000	Overgrazed savanna or grass
11	Agricultural land	0.2500	Average of rice and maize*1
12	Bare/rocky land	1.0000	Bare soil
13	Built-up area	0.0000	
14	Water body	0.0000	
15	Cloud	0.0000	
16	Shadow	0.0000	

*1: Maize of high productivity with conventional tillage

Note: Assumption of coefficient is based on R.P.C Morgan (1995) in due consideration of the site condition derived from the field survey.

Table 2.1.6 Estimated Potential Soil Erosion in Each Sub-watersheds (1/2)

ID_1	ID_2	Area(km2)	m3 (σ =2.5g/cm3)	Average of denudation rate (mm)	Class
A		***1147.741***	***930,273***	***0.811***	
A	1-a	71.358	73,737	1.033	2
A	1-b	48.276	15,534	0.322	1
A	1-c	63.698	26,442	0.415	1
A	2-a	58.573	44,359	0.757	1
A	2-b	61.014	13,206	0.216	1
A	2-c	47.832	17,134	0.358	1
A	2-d	61.374	19,394	0.316	1
A	2-e	56.092	22,761	0.406	1
A	2-f	59.089	63,580	1.076	2
A	3-a	42.172	31,264	0.741	1
A	3-b	59.084	115,043	1.947	2
A	3-c	53.710	46,047	0.857	1
A	3-d	67.193	69,194	1.030	2
A	3-e	59.907	74,285	1.240	2
A	3-f	61.104	41,171	0.674	1
A	3-g	41.300	17,933	0.434	1
A	4-a	105.864	89,255	0.843	1
A	4-b	130.101	149,934	1.152	2
C		***3421.627***	***5,253,026***	***1.535***	
C	10-a	93.846	291,507	3.106	4
C	10-b	64.189	160,301	2.497	3
C	10-c	52.813	192,427	3.644	4
C	10-d	53.736	312,099	5.808	6
C	10-e	82.495	76,189	0.924	1
C	10-f	46.558	130,259	2.798	3
C	11-a	142.528	153,107	1.074	2
C	1-a	84.542	55,272	0.654	1
C	1-b	58.777	35,815	0.609	1
C	1-c	77.870	48,210	0.619	1
C	1-d	68.322	51,166	0.749	1
C	1-e	66.194	56,309	0.851	1
C	2-a	59.755	25,310	0.424	1
C	2-b	49.657	22,666	0.456	1
C	2-c	71.177	54,569	0.767	1
C	2-d	52.230	38,859	0.744	1
C	3-a	56.803	52,940	0.932	1
C	3-b	83.324	94,175	1.130	2
C	3-c	54.249	86,871	1.601	2
C	3-d	68.603	59,639	0.869	1
C	3-e	52.209	85,205	1.632	2
C	4-a	28.807	20,319	0.705	1
C	4-b	39.436	65,183	1.653	2
C	4-c	50.241	92,220	1.836	2
C	4-d	49.263	13,202	0.268	1
C	5-a	60.444	121,748	2.014	3
C	5-b	40.236	202,235	5.026	6
C	5-c	87.456	576,743	6.595	6
C	5-d	60.638	62,983	1.039	2
C	5-e	78.337	94,387	1.205	2
C	6-a	89.007	234,227	2.632	3
C	6-b	54.900	198,396	3.614	4
C	6-c	66.526	194,877	2.929	3
C	6-d	45.065	19,448	0.432	1
C	6-e	70.502	34,123	0.484	1
C	7-a	81.532	227,311	2.788	3
C	7-b	55.849	49,321	0.883	1
C	7-c	101.767	46,722	0.459	1
C	8-a	77.046	57,596	0.748	1
C	8-b	70.740	19,304	0.273	1
C	8-c	51.393	44,312	0.862	1
C	8-d	55.066	36,344	0.660	1
C	8-d	76.295	82,738	1.084	2
C	8-e	56.087	17,923	0.320	1
C	8-f	53.490	27,054	0.506	1
C	8-h	82.905	79,441	0.958	1
C	8-i	48.246	25,238	0.523	1
C	9-a	38.045	30,554	0.803	1
C	9-b	56.840	112,897	1.986	2
C	9-c	58.288	11,243	0.193	1
C	9-d	62.369	10,672	0.171	1
C	9-e	36.923	65,116	1.764	2
C	9-f	45.729	187,509	4.100	5
C	9-g	52.282	108,747	2.080	3

Table 2.1.6 Estimated Potential Soil Erosion in Each Sub-watersheds (2/2)

ID_1	ID_2	Area(km2)	m3 (σ =2.5g/cm3)	Average of denudation rate (mm)	Class
M		***4176.630***	***8,673,438***	***2.077***	
M	1-a	66.433	111,814	1.683	2
M	1-b	47.874	105,855	2.211	3
M	1-c	52.429	72,888	1.390	2
M	1-d	122.082	441,231	3.614	4
M	1-e	62.575	160,192	2.560	3
M	1-f	73.161	278,239	3.803	4
M	1-g	67.900	200,833	2.958	3
M	1-h	75.998	583,935	7.684	6
M	1-i	79.004	480,379	6.080	6
M	1-j	74.898	120,003	1.602	2
M	2-a	80.235	72,390	0.902	1
M	2-b	67.874	127,332	1.876	2
M	2-c	56.309	181,740	3.228	4
M	2-d	80.380	420,048	5.226	6
M	2-e	66.980	134,436	2.007	3
M	2-f	43.317	86,615	2.000	2
M	2-g	56.485	109,154	1.932	2
M	2-h	73.056	181,439	2.484	3
M	2-i	76.129	261,884	3.440	4
M	2-j	90.644	64,821	0.715	1
M	2-k	94.866	83,777	0.883	1
M	2-l	78.628	89,286	1.136	2
M	3-a	213.450	94,772	0.444	1
M	3-b	120.260	112,136	0.932	1
M	3-c	45.711	52,090	1.140	2
M	4-a	57.807	200,706	3.472	4
M	4-b	74.541	76,959	1.032	2
M	4-c	55.215	100,859	1.827	2
M	4-d1	68.095	157,678	2.316	3
M	4-d2	74.006	80,453	1.087	2
M	4-e	101.767	134,649	1.323	2
M	4-f	72.217	130,568	1.808	2
M	4-g	107.317	140,371	1.308	2
M	5-a	75.035	282,699	3.768	4
M	5-b	34.214	152,503	4.457	5
M	5-c	66.833	306,689	4.589	5
M	5-d	76.892	507,453	6.600	6
M	5-e	30.886	165,686	5.364	6
M	5-f	40.511	63,881	1.577	2
M	5-g	30.461	100,196	3.289	4
M	6-a	36.041	132,150	3.667	4
M	6-b	46.656	104,509	2.240	3
M	6-c	68.347	154,738	2.264	3
M	6-d	82.955	177,487	2.140	3
M	6-e	46.909	162,576	3.466	4
M	6-f	52.694	36,675	0.696	1
M	6-g	57.585	12,464	0.216	1
M	6-h	36.968	29,722	0.804	1
M	7-a	62.457	36,836	0.590	1
M	7-b	53.664	32,628	0.608	1
M	7-c	61.832	35,340	0.572	1
M	7-d	70.655	42,079	0.596	1
M	7-e	62.546	32,135	0.514	1
M	8-a	60.330	42,767	0.709	1
M	8-b	44.478	59,205	1.331	2
M	8-c	68.993	112,934	1.637	2
M	8-d	48.627	64,944	1.336	2
M	8-e	80.349	88,562	1.102	2
M	8-f	86.546	43,465	0.502	1
M	8-g	78.935	24,066	0.305	1
M	8-h	36.588	19,514	0.533	1

Note:
Class 1: 0~1mm/year Class 2: 1~2mm/year Class 3: 2~3mm/year
Class 4: 3~4mm/year Class 5: 4~5mm/year Class 6: 5mm/year~

Table 2.2.1 Existing Structures for Soil and Water Conservation within the Study Area (Nueva Vizcaya) (1/2)

Structure	Year	Type	Scale	Status	Location	Remarks	
Check dam	1995	Rubble & Loose Rock	56 m^3	Damaged	Left tributary of Casignan River, Oyao, Dupax del Norte	Constructed under Upper Casecnan River Watershed Project, CY '90-'00	1/
Check dam	1999	Rubble Masonry	230 m^3	Serviceable	Left tributary of Casignan River, Macabenga, Dupax del Norte	- ditto -	1/
Check dam	1999	Rubble Masonry	100 m^3	Serviceable	Right tributary of Casignan River, Ganao, Dupax del Sur	- ditto -	1/
Check dam	1990	Rubble & Loose Rock	170 m^3	Damaged	Left tributary of Casignan River, Oyao & Kinabuan, Dupax del Norte	- ditto - 3 units	1/
Check dam	1991	Rubble & Loose Rock	170 m^3	Damaged	Left tributary of Casignan River, Oyao & Kinabuan, Dupax del Norte	- ditto - 4 units	1/
Check dam	1992	Rubble & Loose Rock	325 m^3	Silted	Left tributary of Casignan River, Oyao, Dupax del Norte	- ditto - 2 units	1/
Check dam	1996	Rubble & Loose Rock	126 m^3	Serviceable	Right tributary of Casignan River, Ganao and Sanguiet, Dupax del Sur	- ditto - 2 units	1/
Check dam	1997	Rubble Masonry	50 m^3	Serviceable	Left tributary of Casignan River, Sanguiet, Dupax del Sur	- ditto -	1/
Check dam	1998	Rubble Masonry	175 m^3	Serviceable	Upper Casignan River, Sanguiet, Dupax del Sur	- ditto - 2 units	1/
Check dam	2000	Rubble Masonry	75 m^3	Serviceable	Left tributary of Casignan River, Macabenga, Dupax del Norte	- ditto -	1/
Check dam	1998	Gabion	50 m^3	Serviceable	Right tributary of Kasibu River (upper Addalam), Watwat, Kasibu	Constructed under Kasibu Watershed Project, CY '98-'00	2/
Check dam	1998	Rubble Masonry	100 m^3	Serviceable	Left tributary of Kasibu River (upper Addalam), Cordon, Kasibu	- ditto -	2/
Check dam	1999	Rubble Masonry	128 m^3	Serviceable	Right tributary of Kasibu River (upper Addalam), Kongkong, Kasibu	- ditto -	2/
Check dam	1997	Rubble Masonry	200 m^3	Serviceable	Left tributary of Santa Fe River, Baliling, Santa Fe	3 units	3/
Check dam		Gabion	5 m^3	Damaged	Left tributary of Santa Fe River, Calitlitan, Aritao		3/
Check dam	1998	Rubble Masonry	200 m^3	Serviceable	Left tributary of Santa Fe River, Calitlitan, Aritao	2 units	3/
Check dam	1998	Rubble Masonry	200 m^3	Serviceable	Left tributary of Santa Fe River, Bone South, Aritao	2 units	3/

Table 2.2.1 Existing Structures for Soil and Water Conservation within the Study Area (Nueva Vizcaya) (2/2)

Structure	Year	Type	Scale	Status	Location	Remarks	
Check dam	1996	Rubble Masonry	180 m^3	Damaged	Left tributary of Santa Fe River, Bone South, Aritao		3/
Check dam	2000	Rubble Masonry	75 m^3	Serviceable	Left tributary of Santa Fe River, Bone North, Aritao		3/
Check dam	1996	Rubble Masonry	80 m^3	Damaged	Left tributary of Santa Fe River, Bone North, Aritao		3/
Check dam	2000	Rubble Masonry	75 m^3	Serviceable	Lobo Stream (Left tributary of Santa Fe River), Kirang, Aritao	2 units	3/
Check dam	1998	Rubble Masonry	300 m^3	Serviceable	Lobo Stream (Left tributary of Santa Fe River), Kirang, Aritao	2 units	3/
Check dam	1999	Rubble Masonry	60 m^3	Serviceable	Lobo Stream (Left tributary of Santa Fe River), Kirang, Aritao	2 units	3/
Retaining wall	1999	Rubble Masonry	40 m^3	Serviceable	Lobo Stream (Left tributary of Santa Fe River), Kirang, Aritao	Soil conservation	3/
Check dam	1998	Rubble Masonry	300 m^3	Serviceable	Left Creek of Lobo Stream, Aritao	5 units	3/
Check dam	2000	Rubble Masonry	60 m^3	Serviceable	Barobbob Creek (Left creek of Magat River), Masoc, Bayombong	Cost: PHP111 thou.	4/
Check dam	1999	Rubble Masonry	100 m^3	Serviceable	Dipuday Creek (Left creek of Magat River), Caliat, Quezon	Cost: PHP250 thou.	4/

Source 1/: Map Showing the Location of Constructed Structures and Established Plantations of Upper Casecnan River Watershed Project for CY 1990-2000 (CENRO Dupax, N.V.)
2/: Map Showing the Location of Constructed Structures and Established Plantations of Kasibu River Watershed Project for CY 1999-2000 (CENRO Dupax, N.V.)
3/: CENRO Aritao, N.V.
4/: PENRO Nueva Vizcaya
Remark: Structures installed by DENR only

Table 2.2.2 Existing Structures for Soil and Water Conservation within the Study Area (Quirino)

Structure	Year	Type	Scale	Status	Location	Remarks	
Check dam	2000	Rubble Masonry	65 m^3		Tangliao Creek (left tributary of Cagayan River), Nagtipunan	Cost: PHP166 thou. W=10m, H=1.95m	1/
Retaining wall	1977~79	Masonry	500 m	Damaged completely	Left bank of Cagayan River, Nagtipunan	River bank erosion control	1/
Check dam	1998	Rubble Masonry		Serviceable	Maldanum River (left tributary of Cagayan River), Jose Ancheta, Maddela	Maintained by CENRO Aglipay at present	1/
Check dam	1999	Rubble Masonry		Serviceable	Maldanum River (left tributary of Cagayan River), Balligui, Maddela,	Maintained by CENRO Aglipay at present	1/
Check dam	2000	Rubble Masonry	75 m^3 (?)	Serviceable	Nagtim-og Creek, (right tributary of Maldanum River being left tributary of Cagayan River), Balligui, Maddela		2/
Check dam	2001	Rubble Masonry	63 m^3	Serviceable	Nagtim-og Creek, (right tributary of Maldanum River being left tributary of Cagayan River), Balligui, Maddela	Cost: PHP158 thou.	2/
Impounding dam	1990	Masonry	60 m^3	Damaged	Left tributary of Addalam River, Villa Pagaduan, Aglipay	for irrigation	3/
Riprap	1990	Stone Masonry		Damaged	Left tributary of Addalam River, Villa Pagaduan, Aglipay	with planting	3/

Source 1/: CENRO Nagtipunan, Quirino
2/: CENRO Aglipay, Quirino
3/: PENRO Quirino
Remark: Structures installed by DENR only

Table 2.2.3 Existing Structures for Soil and Water Conservation within the Study Area (Ifugao) (1/2)

Structure	Year	Type	Scale	Status	Location	Remarks	
Retaining wall	1998	Masonry		Serviceable	Upper Alimit River, Buninan, Mayoyao	Canal protection	1/
Retaining wall	1997	Masonry	86 m^3	Serviceable	Left tributary of Alimit River, Mayoyao	Canal protection	1/
Retaining wall	1997	Masonry	47 m^3	Serviceable	Right tributary of Alimit River, Mayoyao	Canal protection	1/
Retaining wall	1997		67 m^3	Serviceable	Right tributary of Alimit River, Mayoyao	Canal protection	1/
Check dam	1994?	Loose Rock	50 m^3 (?)	Silted	Left tributary of Ducligan River being right tributary of Alimit River, Tulaed, Mayoyao	7 units Height of dam: 1.5~2.0 m	1/
Check dam	1991	Loose Rock	150 m^3	Damaged	Right tributary of Lamut River	Soil erosion control (Lamut River protection)	2/
Check dam	1991	Gabion	36 m^3	Damaged	Right tributary of Lamut River	Soil erosion control (Lamut River protection)	2/
Check dam	1994	Gabion, Loose Rock	28 m^3	Damaged	Right tributary of Lamut River	Soil erosion control (Lamut River protection)	2/
Check dam	1994	Gabion	36 m^3	Damaged	Right tributary of Lamut River	Soil erosion control (Lamut River protection)	2/
Check dam	1994	Loose Rock	78 m^3	Damaged	Right tributary of Lamut River	Soil erosion control (Lamut River protection)	2/
Retaining wall	1994	Masonry	29 m^3	Damaged	Left and right tributary of Lamut River	Protection of creek sides (Lumut Watershed Project)	2/
Check dam	1995	Masonry	21 m^3	Existing	Left tributary of Lamut River	Maintenance is needed.	2/
Check dam	1995	Gabion	25 m^3	Existing	Left tributary of Lamut River	Maintenance is needed.	2/
Check dam	1996	Gabion	10 m^3	Existing	Left tributary of Lamut River	Maintenance is needed. Cost: PHP12 thou.	2/
Check dam	1996	Loose Rock	11 m^3	Existing	Left tributary of Lamut River	Maintenance is needed.	2/
Check dam	1996	Masonry	12 m^3	Existing	Left tributary of Lamut River	Maintenance is needed.	2/
Check dam	1997	Stone Masonry	34 m^3	Existing	Right of Bannit, Payawan, Lamut	Cost: PHP58 thou.	2/
Grouted riprap	1997	Stone Masonry	210 m^3	Existing	Right of Bannit, Payawan, Lamut	Cost: PHP254 thou.	2/
Head wall	1997	Stone Masonry	0.7 m^3	Existing	Right of Bannit, Payawan, Lamut	Cost: PHP2 thou.	2/
Check dam	1998	Stone Masonry	106 m^3	Existing	Left tributary of Poblacion, Banaue	Cost: PHP216 thou.	2/

Table 2.2.3 Existing Structures for Soil and Water Conservation within the Study Area (Ifugao) (2/2)

Structure	Year	Type	Scale	Status	Location	Remarks	
Check dam	1999	Stone Masonry	45 m^3	Serviceable	Upper Ducrigan River (right tributary of Alimit River), Bocos, Banaue	Cost: PHP162 thou.	2/
Check dam	1999	Stone Masonry	54 m^3	Serviceable	Left tributary of Ibulao River, Luta, Lagawe	Cost: PHP118 thou.	2/
Check dam	1999	Stone Masonry	81 m^3	Serviceable	Left tributary of Ibulao River, Pullaan, Lagawe	Cost: PHP284 thou.	2/
Check dam	1999	Stone Masonry	43 m^3	Serviceable	Right tributary of Alimit River, Abinuan, Lagawe	Cost: PHP147 thou.	2/
Revetment	2000	Stone Masonry	12 ha	Serviceable	Left tributary of Lamut River	Cost: PHP218 thou. River bank stabilization	2/
Revetment	2000	Stone Masonry	9 ha	Serviceable	Payawan River (left tributary of Lamut River), Payawan, Lamut	Cost: PHP164 thou. River bank stabilization	2/
Revetment	2000	Stone Masonry	4 ha	Serviceable	Lamut River	Cost: PHP73 thou. River bank stabilization	2/
Check dam	2000	Stone Masonry	122 m^3	Serviceable	Upper Bunog River (left tributary of Lamut River)	Cost: PHP250 thou.	2/

Source 1/: CENRO Alfonso Lista, Ifugao
2/: Database Inventory of Watershed Rehabilitation Project (CENRO Lamut, Ifugao)
Remark: Structures installed by DENR only

Table 2.2.4 Existing Structures for Soil and Water Conservation within the Study Area (Isabela)

Structure	Year	Type	Scale	Status	Location	Remarks	
Check dam	1989	Masonry	30 m^3	Silted	Right tributary of Magat River (south of Magat dam site), Tareb, Dallao, Cordon		1/
Impounding dam	1990	Masonry	25 m^3	Serviceable	Right tributary of Magat River (south of Magat dam site), Tareb, Dallao, Cordon		1/

Source 1/: CENRO San Isidro, Isabela
Remark: Structures installed by DENR only

Table 2.3.1 Flood Control Structures in Nueva Vizcaya within the Study Area

Name	River	Component of Structures
Magat River Flood Control	Magat River	a. Dadap Section: Gabion spur dike b. Curifang Section: Gabion spur dike c. Sta Rosa Section: Rubble concrete revetment d. Bayombong Section: Earth dike with concrete facing e. Busilac Magsaysay Section: Gabion spur dike Gabion revetment f. Vista Hill Section: Gabion spur dike Gabion revetment g. Batu Section: Rubble concrete revetment with steel sheet-pile footing h. Abian Section: Rubble concrete revetment with concrete crib frame i. Macate Section: Earth spur dike with concrete facing Gabion spur dike with gabion revetment
Cupas Flood Control	Magat River	Gabion revetment
Indiana Flood Control	Magat River	Earth spur dike with concrete facing Rubble concrete facing Earth dike with concrete facing
Lamut Flood Control	Lamut River	Rubble concrete revetment
Calitlitan Flood Control	Santa Fe River	Rubble concrete revetment
Kayapa Flood Control	Santa Cruz River	Gabion rebetment
Santa Fe Flood Control	Santa Fe River	Gabion revetment Rubble concrete revetment Earth dike with concrete facing
Baliling Flood Control	Santa Fe River	Rubble concrete revetment
Banganan Flood Control	Santa Fe River	Earth dike with concrete facing
Pogumbuaya Flood Control	Santa Fe River	Gabion spur dike Rubble concrete revetment
Benay Flood Control	Benay River	Earth dike with concrete facing

Source: Flood Control Map (DPWH Nueva Vizcaya)

Table 2.3.2 Flood Control Structures in Quirino within the Study Area

Name	River	Component of Structures
Lusod Flood Control	Cagayan River	Revetment (Stone masonry) Bank protection (Stone masonry, Gabion)
Poblacion Norte Flood Control	Cagayan River	Spur dike (Gabion) Bank protection
Ponggo Flood Control	Cagayan River	Spur dike (Gabion) Bank protection (Gabion)
Sangbay Flood Control	Cagayan River	Bank protection (Gabion)
Abbag Flood Control	Cagayan River	Bank protection (Gabion)
Anak Flood Control	Cagayan River	Bank protection (Gabion)
Diduyon Flood Control	Left tributary of Cagayan River	Revetment (Stone masonry, Gabion) Spur dike (Gabion) Bank protection (Stone masonry)
Addalam Flood Control	Addalam River	Revetment (Stone masonry) Spur dike (Gabion)

Source: Flood Control Map (DPWH Quirino)

Table 3.2.1 Estimated Future Potential Soil Erosion in Sub-watersheds (1/2)

ID_1	ID_2	Area(km2)	m3(σ =2.5g/cm3)	Average of denudation rate (mm)	Class
A		***1147.741***	***796,230***	***0.694***	
A	1-a	71.358	73,895	1.036	2
A	1-b	48.276	10,792	0.224	1
A	1-c	63.698	19,166	0.301	1
A	2-a	58.573	40,428	0.690	1
A	2-b	61.014	11,850	0.194	1
A	2-c	47.832	12,798	0.268	1
A	2-d	61.374	14,812	0.241	1
A	2-e	56.092	19,395	0.346	1
A	2-f	59.089	58,222	0.985	1
A	3-a	42.172	23,710	0.562	1
A	3-b	59.084	102,649	1.737	2
A	3-c	53.710	35,854	0.668	1
A	3-d	67.193	47,991	0.714	1
A	3-e	59.907	48,591	0.811	1
A	3-f	61.104	27,510	0.450	1
A	3-g	41.300	11,472	0.278	1
A	4-a	105.864	89,067	0.841	1
A	4-b	130.101	148,026	1.138	2
C		***3421.627***	***4,544,588***	***1.328***	
C	10-a	93.846	284,291	3.029	4
C	10-b	64.189	154,339	2.404	3
C	10-c	52.813	164,683	3.118	4
C	10-d	53.736	247,950	4.614	5
C	10-e	82.495	44,731	0.542	1
C	10-f	46.558	82,894	1.780	2
C	11-a	142.528	107,434	0.754	1
C	1-a	84.542	55,272	0.654	1
C	1-b	58.777	36,102	0.614	1
C	1-c	77.870	47,760	0.613	1
C	1-d	68.322	47,491	0.695	1
C	1-e	66.194	54,838	0.828	1
C	2-a	59.755	25,310	0.424	1
C	2-b	49.657	22,754	0.458	1
C	2-c	71.177	54,664	0.768	1
C	2-d	52.230	39,300	0.752	1
C	3-a	56.803	53,572	0.943	1
C	3-b	83.324	93,619	1.124	2
C	3-c	54.249	84,990	1.567	2
C	3-d	68.603	57,169	0.833	1
C	3-e	52.209	83,929	1.608	2
C	4-a	28.807	20,498	0.712	1
C	4-b	39.436	64,622	1.639	2
C	4-c	50.241	89,072	1.773	2
C	4-d	49.263	12,414	0.252	1
C	5-a	60.444	120,324	1.991	2
C	5-b	40.236	193,920	4.820	5
C	5-c	87.456	558,863	6.390	6
C	5-d	60.638	52,849	0.872	1
C	5-e	78.337	90,070	1.150	2
C	6-a	89.007	221,370	2.487	3
C	6-b	54.900	185,294	3.375	4
C	6-c	66.526	165,517	2.488	3
C	6-d	45.065	13,299	0.295	1
C	6-e	70.502	30,520	0.433	1
C	7-a	81.532	148,461	1.821	2
C	7-b	55.849	34,974	0.626	1
C	7-c	101.767	29,038	0.285	1
C	8-a	77.046	39,721	0.516	1
C	8-b	70.740	9,023	0.128	1
C	8-c	51.393	26,039	0.507	1
C	8-d	55.066	32,379	0.588	1
C	8-d	76.295	76,261	1.000	1
C	8-e	56.087	11,591	0.207	1
C	8-f	53.490	29,289	0.548	1
C	8-h	82.905	70,046	0.845	1
C	8-i	48.246	23,673	0.491	1
C	9-a	38.045	15,303	0.402	1
C	9-b	56.840	80,763	1.421	2
C	9-c	58.288	7,020	0.120	1
C	9-d	62.369	9,397	0.151	1
C	9-e	36.923	42,453	1.150	2
C	9-f	45.729	126,679	2.770	3
C	9-g	52.282	70,755	1.353	2

Table 3.2.1 Estimated Future Potential Soil Erosion in Sub-watersheds (2/2)

ID_1	ID_2	Area(km2)	m3 (σ =2.5g/cm3)	Average of denudation rate (mm)	Class
M		***4176.630***	***4,498,331***	***1.077***	
M	1-a	66.433	83,853	1.262	2
M	1-b	47.874	61,896	1.293	2
M	1-c	52.429	34,580	0.660	1
M	1-d	122.082	231,359	1.895	2
M	1-e	62.575	116,250	1.858	2
M	1-f	73.161	113,871	1.556	2
M	1-g	67.900	65,456	0.964	1
M	1-h	75.998	253,732	3.339	4
M	1-i	79.004	230,797	2.921	3
M	1-j	74.898	74,232	0.991	1
M	2-a	80.235	60,194	0.750	1
M	2-b	67.874	79,247	1.168	2
M	2-c	56.309	80,409	1.428	2
M	2-d	80.380	174,228	2.168	3
M	2-e	66.980	53,078	0.792	1
M	2-f	43.317	24,026	0.555	1
M	2-g	56.485	33,063	0.585	1
M	2-h	73.056	57,243	0.784	1
M	2-i	76.129	86,178	1.132	2
M	2-j	90.644	26,669	0.294	1
M	2-k	94.866	53,673	0.566	1
M	2-l	78.628	41,271	0.525	1
M	3-a	213.450	90,408	0.424	1
M	3-b	120.260	100,751	0.838	1
M	3-c	45.711	34,679	0.759	1
M	4-a	57.807	92,466	1.600	2
M	4-b	74.541	35,581	0.477	1
M	4-c	55.215	21,399	0.388	1
M	4-d1	68.095	61,528	0.904	1
M	4-d2	74.006	42,693	0.577	1
M	4-e	101.767	61,060	0.600	1
M	4-f	72.217	66,151	0.916	1
M	4-g	107.317	91,386	0.852	1
M	5-a	75.035	163,476	2.179	3
M	5-b	34.214	96,940	2.833	3
M	5-c	66.833	189,241	2.832	3
M	5-d	76.892	206,310	2.683	3
M	5-e	30.886	51,545	1.669	2
M	5-f	40.511	38,783	0.957	1
M	5-g	30.461	48,535	1.593	2
M	6-a	36.041	62,087	1.723	2
M	6-b	46.656	60,736	1.302	2
M	6-c	68.347	93,134	1.363	2
M	6-d	82.955	122,589	1.478	2
M	6-e	46.909	99,989	2.132	3
M	6-f	52.694	22,342	0.424	1
M	6-g	57.585	6,603	0.115	1
M	6-h	36.968	20,324	0.550	1
M	7-a	62.457	30,285	0.485	1
M	7-b	53.664	21,346	0.398	1
M	7-c	61.832	23,991	0.388	1
M	7-d	70.655	20,568	0.291	1
M	7-e	62.546	12,231	0.196	1
M	8-a	60.330	41,534	0.688	1
M	8-b	44.478	50,448	1.134	2
M	8-c	68.993	93,156	1.350	2
M	8-d	48.627	57,142	1.175	2
M	8-e	80.349	72,778	0.906	1
M	8-f	86.546	33,734	0.390	1
M	8-g	78.935	13,612	0.172	1
M	8-h	36.588	11,464	0.313	1

Note:
Class 1: 0~1mm/year Class 2: 1~2mm/year Class 3: 2~3mm/year
Class 4: 3~4mm/year Class 5: 4~5mm/year Class 6: 5mm/year~

Figures

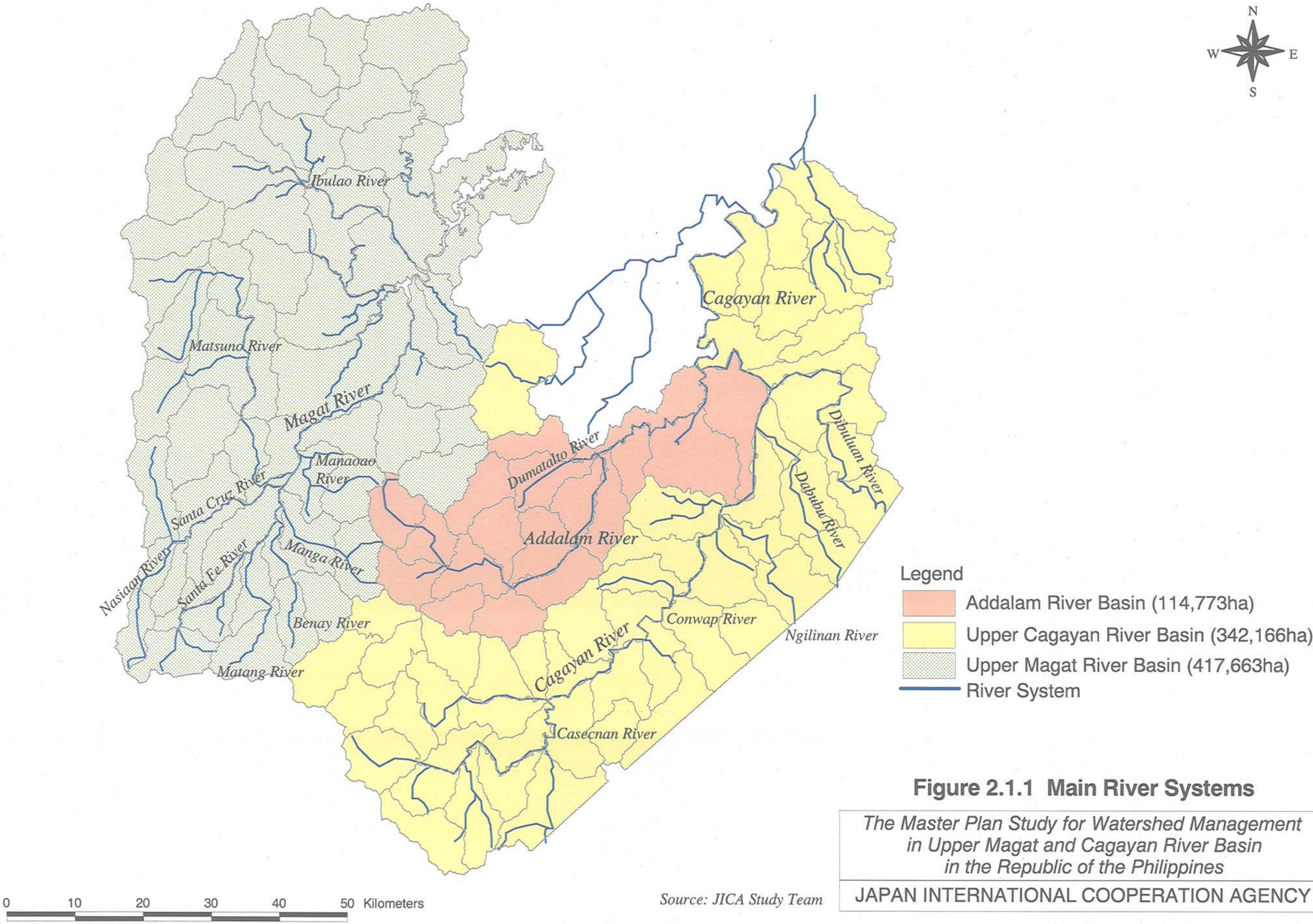
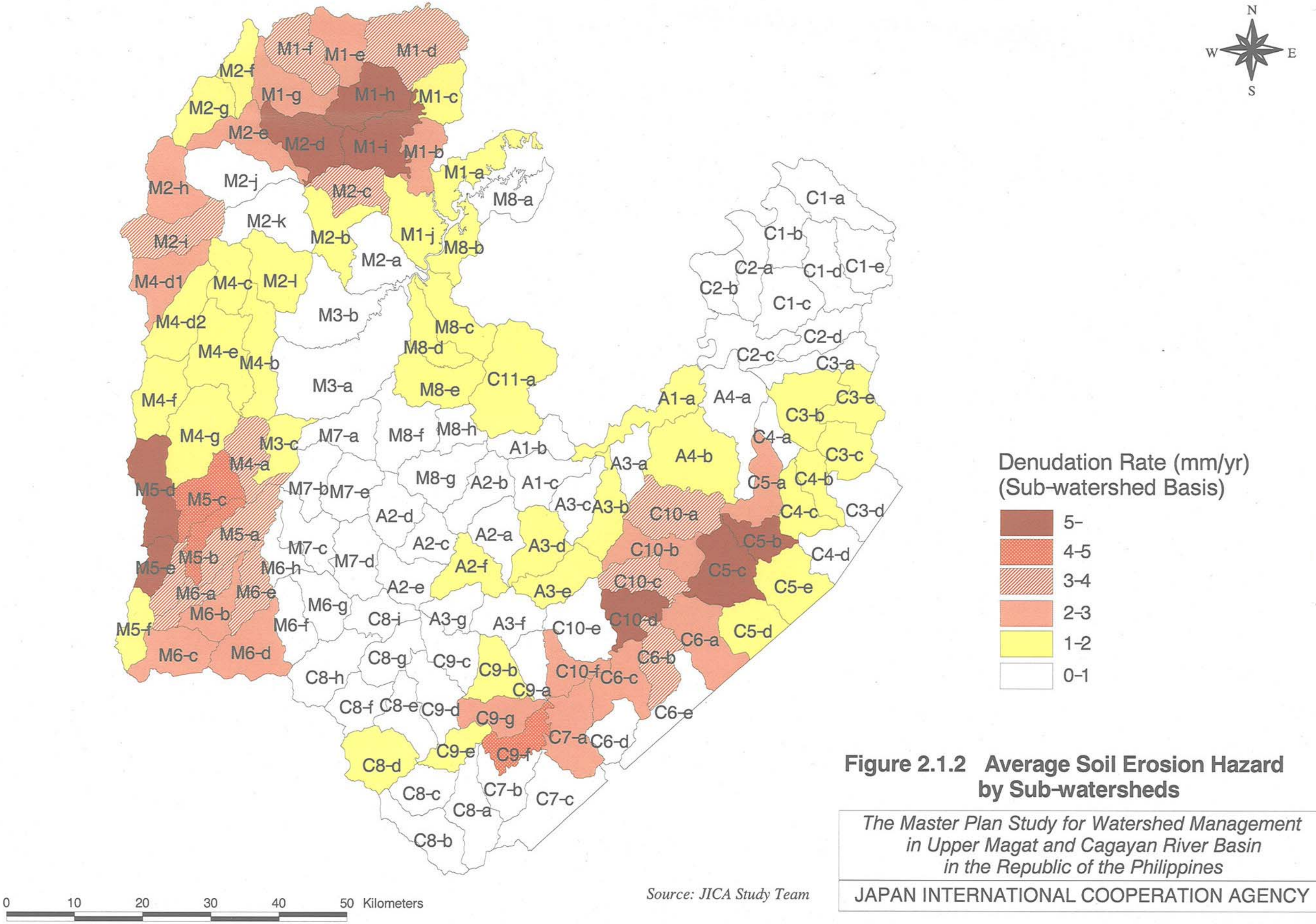


Figure 2.1.1 Main River Systems

The Master Plan Study for Watershed Management in Upper Magat and Cagayan River Basin in the Republic of the Philippines

JAPAN INTERNATIONAL COOPERATION AGENCY

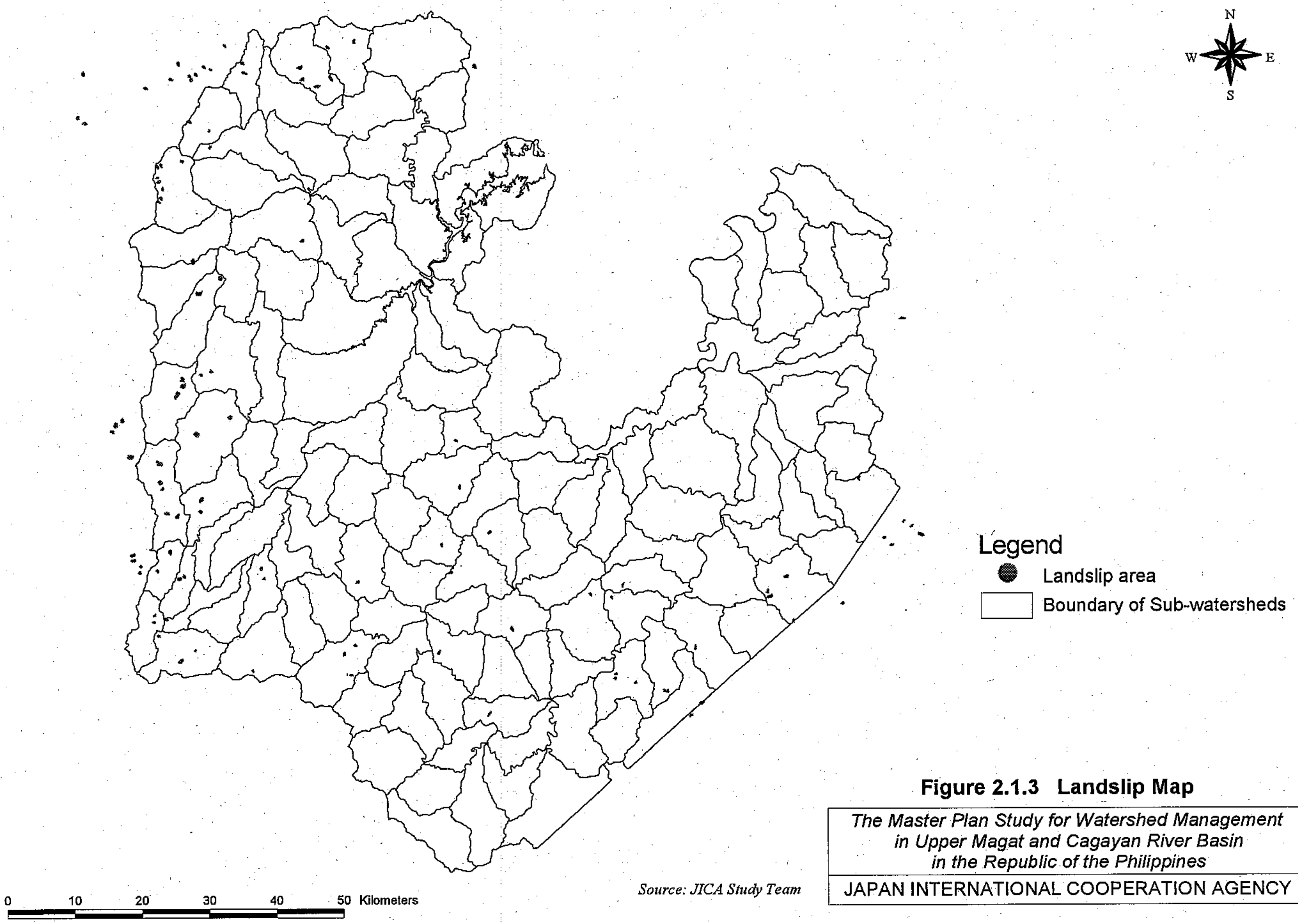


Source: JICA Study Team

Figure 2.1.2 Average Soil Erosion Hazard by Sub-watersheds

The Master Plan Study for Watershed Management in Upper Magat and Cagayan River Basin in the Republic of the Philippines

JAPAN INTERNATIONAL COOPERATION AGENCY



Source: JICA Study Team

Figure 2.1.3 Landslip Map

The Master Plan Study for Watershed Management in Upper Magat and Cagayan River Basin in the Republic of the Philippines

JAPAN INTERNATIONAL COOPERATION AGENCY

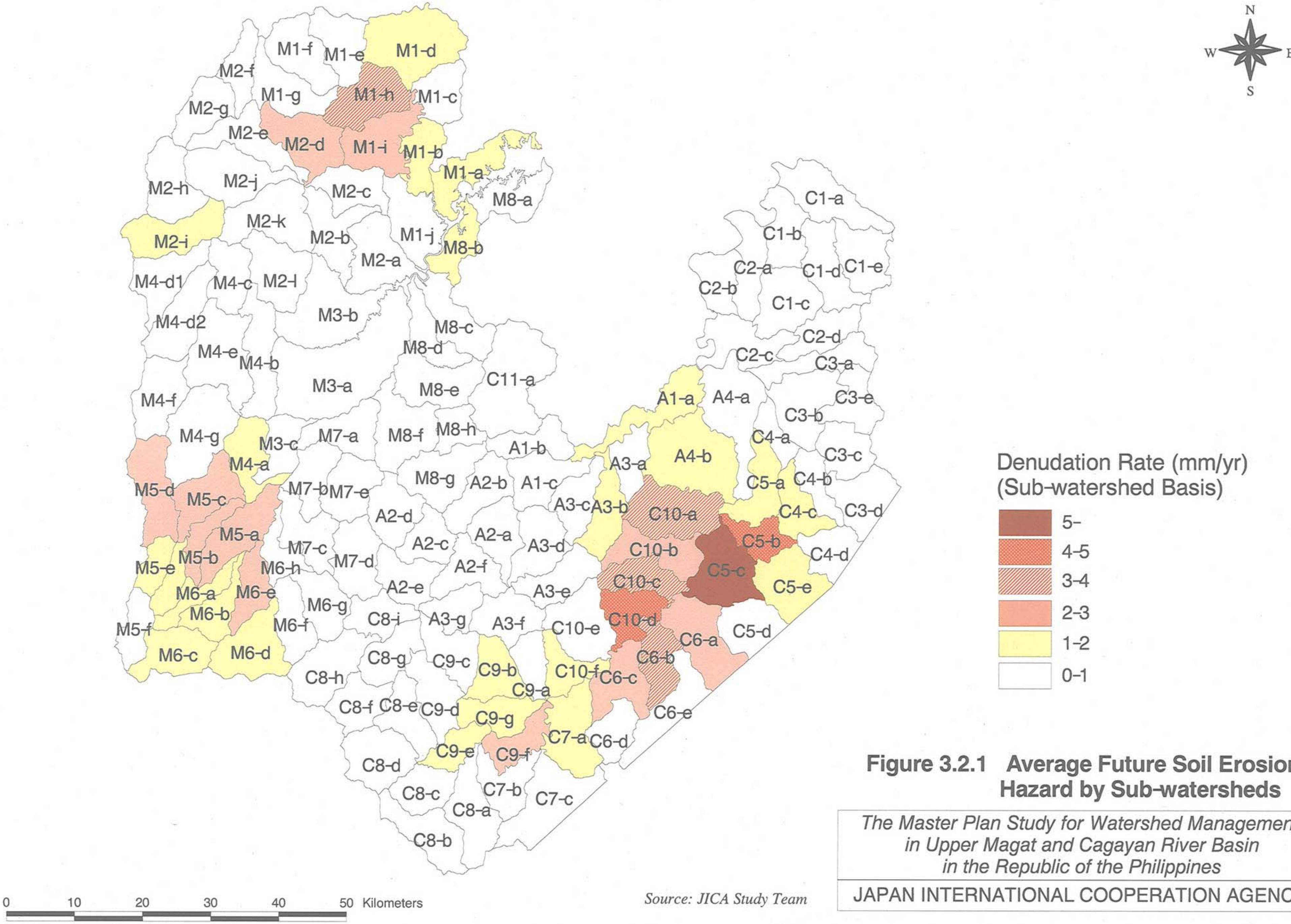


Figure 3.2.1 Average Future Soil Erosion Hazard by Sub-watersheds

Source: JICA Study Team

The Master Plan Study for Watershed Management in Upper Magat and Cagayan River Basin in the Republic of the Philippines

JAPAN INTERNATIONAL COOPERATION AGENCY