MANAGEMENT PLAN

for Irrigation Water Resources (MPIWR) of Cantilan Irrigation System (CANTIS)

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CANTILAN IRRIGATION SYSTEM (CANTIS) CONTRACT NO. WATERSHED-2022-CANTILAN IS-01-SDS-RO-R

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ABBREVIATIONS

A&D	Alienable and Disposable
BAMS	Biodiversity Assessment and Monitoring System
BSWM	Bureau of Soils and Water Management
CADC	Certificate of Ancestral Domain Claim
CADT	Certificate of Ancestral Title
CALT	Certificate of Ancestral Land Title
CANTIS	Cantilan Irrigation System
CBMFA	Community-based Forest Management Agreement
CDP	Comprehensive Development Plan
CENRO	Community Environment and Natural Resources
CLUP	Comprehensive Land Use Plan
DAO	DENR Administrative Order
DENR	Department of Environment and Natural Resources
DO	Dissolved Oxygen
DOST	Department of Science and Technology
FLUP	Forest Land Use Plan
FMB	Forest Management Bureau
GIS	Geographic Information System
IEM	Integrated Ecosystem Management
IMO	Irrigation Management Office
IS	Irrigation System
IWRMP	Irrigation Water Resources Management Plan
IWS	Irrigation Water Sources
LCM	Land Classification Map
LIDAR	Light Detection and Ranging
LGU	Local Government Unit
LTP	Local Tourism Plan
MGB	Mines and Geosciences Bureau
MOA	Memorandum of Agreement
NAMRIA	National Mapping and Resources Information Authority
NCIP	National Commission on Indigenous People
NGP	National Greening Program
NIA	National Irrigation Administration
NIMP	National Irrigation Master Plan
PENRO	Provincial Environment and Natural Resources
PHIVOLCS	Philippine Institute of Volcanology and Seismology
PSA	Philippine Statistic Authority
SPISP	Southern Philippines Irrigation Sector Project
TDS	Total Dissolved Solids

TSS	Total Suspended Solids
TOR	Terms of Reference

Executive Summary: Integrated Watershed Management Plan for Cantilan Irrigation System

ES. 1. Background and Rationale

The Cantilan Irrigation System (CANTIS) in Surigao del Sur, Philippines, is planned for rehabilitation as part of the Southern Philippines Irrigation Sector Project (SPISP). A 2019 memorandum of agreement between the Department of Environment and Natural Resources (DENR) and National Irrigation Administration (NIA) underscores the need to protect and manage crucial Irrigation Water Resources (IWR).

This initiative aligns with the National Irrigation Master Plan (NIMP) 2020-2030, which emphasizes the importance of safeguarding water resources in the face of climate change, particularly in critical watersheds and river basins that feed irrigation networks.

The existing Cantilan Irrigation System (CANTIS) covers 23,763.69 ha with a 2,290-ha service area, the latter of which has suffered damage and obliteration over the past three decades. Neglected maintenance led to damaged irrigation canals and auxiliary structures, causing reliance on rain-fed irrigation for rice production over the past five years (SPISP-LARP Cantilan River Irrigation Project, 2007).

The proposed NIA management area encompasses 7,907.83 ha where the proposed programs and interventions will be implemented. Once fully rehabilitated, it is projected to support 10,906 households predominantly dependent on agriculture, fishery, and forestry.

The formulation of the detailed management plan has undergone holistic and systematic approach through situational analysis—Ecological Profiling and Vulnerability Assessment (EPVA), series of workshops identifying key problems, issues and concerns, and the utilization of GIS mapping tool—which overall outlines the strategy for CANTIS' rehabilitation, protection, and management.

This detailed management plan delineates specific programs, interventions, practices, and strategies along with corresponding work targets and costs. The coordinated efforts behind this proactive and systematic initiative aim to secure the sustainable functionality of CANTIS' water sources, ensuring the continued prosperity of the local communities it serves.

ES. 2. Detailed Management Plan Objectives

An effective watershed management requires implementation of integrated strategies to achieve its objectives based on the Terms of Reference (TOR) for Cantilan Irrigation System Watershed (Annex III). The Management plan provides action to:

1. **Abate sedimentation** of river channel leading to the irrigation system reservoir, intake, and drainage facilities; particularly those leading to the irrigation system's reservoir, intake points, and drainage facilities. This ensures the unobstructed flow of water and maintains the efficiency of the irrigation system.

2. **Promote sustainable land use** in sloping areas especially along channels to minimize the rate of erosion; a critical concern in water resource management is minimizing erosion. These efforts will help maintain soil integrity, prevent sediment runoff, and preserve the overall health of water sources.

3. **Identify climate-resilient structures** to mitigate erosion and sedimentation in irrigation water sources; To ensure the long-term viability of irrigation water sources, structures should effectively prevent soil erosion and sediment buildup despite changing environmental conditions.

4. **Restore degraded land** within the delineated NIA area of management; This restoration work contributes to enhancing the overall health of the ecosystem, preventing further soil erosion, and safeguarding the quality of water resources.

5. **Ensure quantity and quality of irrigation waters**; Efficiently managing water availability and ensuring its cleanliness are essential for sustaining agriculture and other water-dependent activities within the region.

6. **Provide other livelihood programs** to minimize high dependency on natural resources extraction within irrigation water sources promoting balanced and sustainable approach to utilizing available resources.

ES. 3. Ecological Profiling and Vulnerability Assessment

ES. 3.1 Project Profile

ES. 3.1 Table 1-1: Project Profile

Project Proponent	**: Surigao del Sur Irrigation Management Office (SDS-IMO)**
Name of RIS	: Cantilan Irrigation System
Geographic Coordinates (WGS84)	: N 9^{0}28'52" latitude; E 125^{0}93'75" longitude
Municipalities Covered	: Cantilan, Carrascal, and Madrid
Source of Water	: Carac-an River
Drainage Area	: 23,763.69 hectares
Service Area	: 2,209.00 hectares

ES. 3.2 Vulnerability Assessment Results

ES. 3.2.1 Flooding

Approximately **75.05%** (17,834.92 hectares) of CANTIS is characterized by **minimal susceptibility to flooding**. This suggests that during rainfall events, a significant portion of the watershed can accommodate and channel precipitation, resulting in relatively lower-magnitude floods.

In contrast, **14.73%** of the watershed is categorized as having a **moderate vulnerability to flooding**. This implies that these areas could experience a moderate level of inundation when subjected to rainfall-induced runoff.

Around **10.22%** (2,427.93 hectares) of the watershed is identified as **highly susceptible to flooding**. This indicates that these areas are at a heightened risk of experiencing substantial flooding impacts during periods of intense rainfall and runoff.

ES. 3.2.2 Landslide

The **majority of CANTIS** falls under the **"Moderate" landslide susceptibility** category, covering **45.30%** of the total area. This suggests that a significant portion of the land has a moderate likelihood of experiencing landslides, indicating the need for precautionary measures and proper land use planning in these regions.

The "**High**" landslide susceptibility category covers 34.97% of the total area, indicating that a substantial part of CANTIS is at a high risk of landslides. These areas may require significant attention and priority in terms of landslide risk management and mitigation efforts.

The "**Low**" landslide susceptibility category covers 19.73% of the total area, representing regions with relatively lower risk of landslides. However, it is essential to consider that even in low susceptibility areas, landslides can still occur under certain conditions, and preventive measures should not be overlooked.

ES. 3.2.3 Sediment Transport

The sediment transport in the CANTIS watershed varies widely. The **majority** of the area **(95.52%)** transports a **relatively small amount of sediment**, ranging from 0 to 12.36 tons per year. This indicates that most of the watershed experiences low sediment movement.

ES. 3.2.4 Forest Fire

Data shows that the **majority** of the CANTIS area (around **64.23%**) falls under the **moderate susceptibility category**, making it a significant concern for forest fire management. Although the highly susceptible areas cover a smaller percentage, they should not be underestimated due to their high-risk nature.

ES. 3.2.5 Water Quality

In relation to water quality and pollution, the results of the water quality test conducted in Cantilan Irrigation System suggests that the ***measured parameters generally fall within acceptable ranges***, indicating relatively good water quality. However, it's important to note that a comprehensive assessment of water quality and pollution requires a deeper analysis that considers these parameters in conjunction with specific water quality standards and the potential sources of pollution within the study area.

ES. 3.2.6 Encroachment

The visual assessment of the forested watershed area in CANTIS reveals the ***presence of human settlements along riverbanks***, engaged primarily in agricultural practices such as "*kaingin*."

These settlements consist mostly of wooden dwellings, with limited concrete structures. Despite their presence, these settlements account for a small portion (0.06%) of the watershed, indicating minimal human impact. The forest cover remains largely undisturbed, suggesting responsible stewardship and coexistence by forest communities.

However, ***mining activities are also evident***, characterized by intensive land clearing that significantly alters the landscape. Visual indicators include excavated areas, exposed earth, and potential disruption of waterways. The scale and intensity of mining suggests a potentially high environmental impact with long-term consequences on the ecosystem.

ES. 4. Analysis of Environmental Issues, Problems, and Opportunities

A multi-stakeholder consultation and workshop were held for the Cantilan Irrigation System. This event encouraged active participation from stakeholders and facilitated collaborative problem-solving and decision-making, empowering the community and incorporating local knowledge.

During the workshop, ***several interconnected issues were identified, including flooding, forest degradation, river degradation, and a lack of livelihood and opportunities for the CANTIS*** community. Additionally, the conversion of public lands for other purposes, issues with informal settlers, illegal logging activities, water supply shortages, and extreme climatic events were also recognized as prevalent problems in the area. Alongside these challenges, stakeholders also identified potential opportunities to address these issues.

ES. 5. Delineation of NIA Area of Management

The **proposed NIA Area of Management (3,692.40 hectares)** is based on the overlayed layers of vulnerability maps and culling out in the equation are the areas like densely vegetated area, protected area, key biodiversity area, and areas with existing land tenurial instrument.

1. INTRODUCTION

1.1 Rationale

A **watershed** is an area of land where all the water, including rainfall and runoff, drains into a common outlet such as a river, lake, or ocean. Watersheds are essential as they serve as the primary source of freshwater for communities, support diverse ecosystems, and play a critical role in regulating water quality and quantity.

However, watersheds are also susceptible to various disturbances and stresses. These include loss of biodiversity, soil erosion, water pollution, and disruption of ecosystem services. As a result, numerous watersheds are now in a critical state due to overexploitation and mismanagement. Critical watershed is a drainage area of a river system which supplies the major water requirements of several irrigation systems, hydroelectric dams and domestic, as well as industrial water systems or existing water facilities needing immediate protection and rehabilitation.

To address this, Integrated Water Resources Management (IWRM) is increasingly adopted as a process and a management strategy to achieve sustainable use of the resources by all stakeholders at catchment, regional, and national levels, while maintaining the characteristics and integrity of water resources at the catchment scale within agreed limits.

In the Philippines, IWRM adopts a **holistic planning** approach encompassing a range of location-specific strategies and actions designed to enhance long-term sustainability and resilience of watersheds. It also highlights the importance of a **participatory approach** to planning procedures, involving users, planners, and policymakers at all levels in decision-making processes.

1.2 Objectives

The Cantilan Irrigation System Management Plan encompasses a set of strategic objectives designed to optimize the system's functionality while maintaining ecological integrity and addressing the multifaceted needs of the surrounding communities. These objectives collectively contribute to the holistic management of the irrigation system and its associated watershed.

Each objective reflects a commitment to balanced resource management and the sustainable utilization of water resources for the benefit of all stakeholders involved.

This is discussed in ES. 2. Detailed Management Plan Objectives from which each objective are as follows:

- Abate sedimentation
- Promote sustainable land use.
- Identify climate-resilient structures.
- Restore degraded land within the delineated NIA area of management.
- Ensure quantity and quality of irrigation waters.
- Provide other livelihood programs.

1.3 Study Approach and Methodology

The guiding principles of watershed management prioritizes a **demand-driven** and **science-based** approach. This includes actively involving stakeholders in decision-making and tailoring management strategies to address their specific needs. It highlights the importance of a **participatory approach** to planning procedures, involving users, planners, and policymakers at all levels (ridge-to-reef) in decision-making processes. This integrated approach leads to sustainable management, effective resource allocation, improved ecosystem health, and enhanced social and economic well-being within the watershed.

1.4 Integrated Water Resources Management Planning Process

The Integrated Water Resources Management Planning Process represents a strategic approach to the sustainable management of water resources within the Cantilan Irrigation System. **Figure 1-1** shows the Planning process in formulating the Irrigation Water Resources Management Plan.

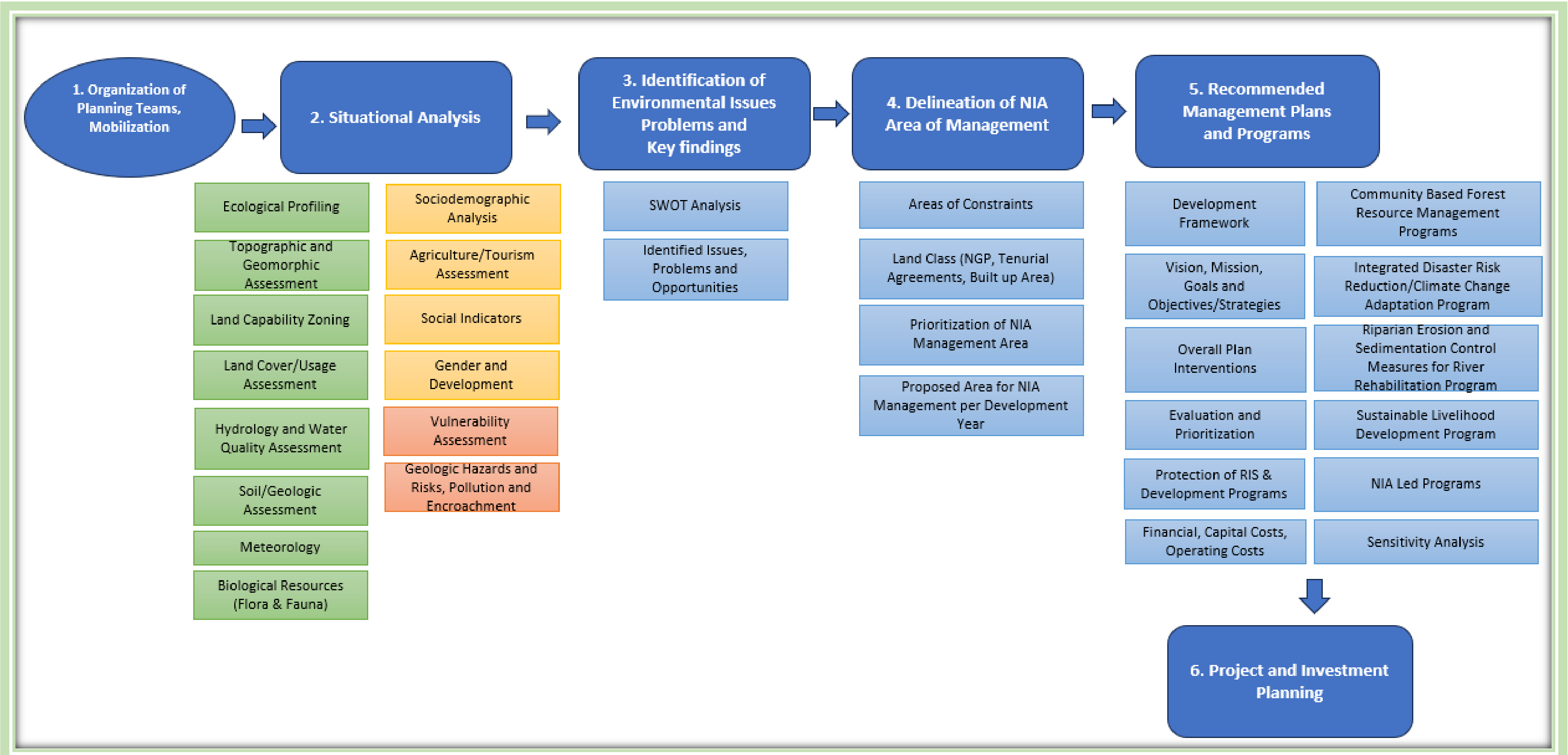


Figure 1-1: Process in formulating the Irrigation Water Resources Management Plan

2. ECOLOGICAL PROFILING OF IRRIGATION WATER RESOURCES

The DENR defines **ecological profile** as a ***comprehensive and structured set of data describing the geo-physical, biological, and socioeconomic environment and its relationships in a geographical planning unit***. The ecological profile is comprehensive in the sense that it includes all pertinent information about the various aspects of the environment as well as information about the features outside the planning area that have impacts on the environment.

Another definition of an ecological profile is a description of an organism's or group of organisms' living environment, including physical, chemical, and biological factors that influence their survival and reproduction. It can also refer to an examination of the effects of human activities on the environment, as well as the consequences for biodiversity and ecosystem services.

> In the context of irrigation water systems, the DENR defines ecological profiling as the process of assessing the environmental conditions and ecological "**health**" of irrigation systems, including the water sources, distribution channels, and surrounding ecosystems. Its objective is to identify potential risks and threats to the environment and ecosystem services in order to develop appropriate mitigation strategies and ensure the sustainability of the irrigation system.

This profiling is a multidisciplinary strategy integrating scientific data, stakeholder participation, and local knowledge is required to harness ecological profiling in developing a management plan in Cantilan Irrigation System. This integrated approach allows for the deployment of targeted interventions. Consequently, the integration of ecological profiling into irrigation water management ensures the optimization of resource utilization while minimizing adverse ecological impacts.

2.1 Physical Environment

2.2 Project Settings

The **Carac-an River** is one of the 11 major river systems that traverses the province of Surigao del Sur and is **tapped for irrigation water by the NIA**. The Cantilan Irrigation System has a total service area of 2,209.00 hectares and a drainage area of 23,763.69 hectares.

In the context of the Cantilan Irrigation System (CANTIS), the significance of Cantilan River's contribution to Carac-an River's water supply becomes evident. Cantilan River feeds into Carac-an River, ultimately sustaining the water flow necessary for the irrigation needs of CANTIS. This interconnection highlights the importance of preserving the health and quality of Cantilan River, as its condition directly impacts Carac-an River's water quality and, subsequently, the efficiency of the entire irrigation system. Hence, addressing the challenges and ensuring sustainable management of the Cantilan River Irrigation System watershed, particularly Carac-an River, is crucial to safeguarding its long-term functionality and reliability for agricultural productivity.

Tabulated below (**Table 2.1**) is the brief profile of CANTIS.

Table 2-1 Brief Profile of CANTIS

Project Proponent	: Surigao del Sur Irrigation Management Office
Name of RIS	: Cantilan Irrigation System
Geographic Coordinates (WGS84)	: N 9^{0}28’52” latitude; E 125^{0}93’75” longitude
Municipalities Covered	: Cantilan, Carrascal, and Madrid
Source of Water	: Carac-an River
Drainage Area	: 23,763.69 hectares
Service Area	: 2,209.00 hectares

2.3 Administrative Location

The project area is located in the northern portion of CARAGA Region, covering three (3) municipalities namely Cantilan, Carrascal, and Madrid, Surigao del Sur. It is geographically centered at 9^{0}15’31.47” N, 125^{0}56’13.12” E.

The Carac-an river which encompasses the project area was observed to play a significant role as a crucial water source for the Cantilan River Irrigation System. The Carac-an River's waters are harnessed for irrigation purposes within the study area, contributing to the functionality and sustainability of the Cantilan River Irrigation System.

The project area can be reached using cars and motor vehicles from downstream to midstream portions using service and mining roads present in the area. While upstream portions are reachable through *habal-habal* or trekking.

Table 2-2 shows the distribution of CANTIS drainage area.

The location of the Project Area is indicated in Figure 2.1 overlayed in NAMRIA topographic map, showing also therein is the road access in Figure 2.2.

Table 2-2 Watershed Area Distribution

Municipality	Barangay	Area (ha.)	Percent of Drainage Area to Total
Cantilan	Lobo	13,434.89	56.54%
	Cabangahan	468.2	1.97%
Madrid	Bayogo	366.20	1.54%
Carrascal	Pantukan	9,494.40	39.95%
Total		**23,763.69**	**100.00%**

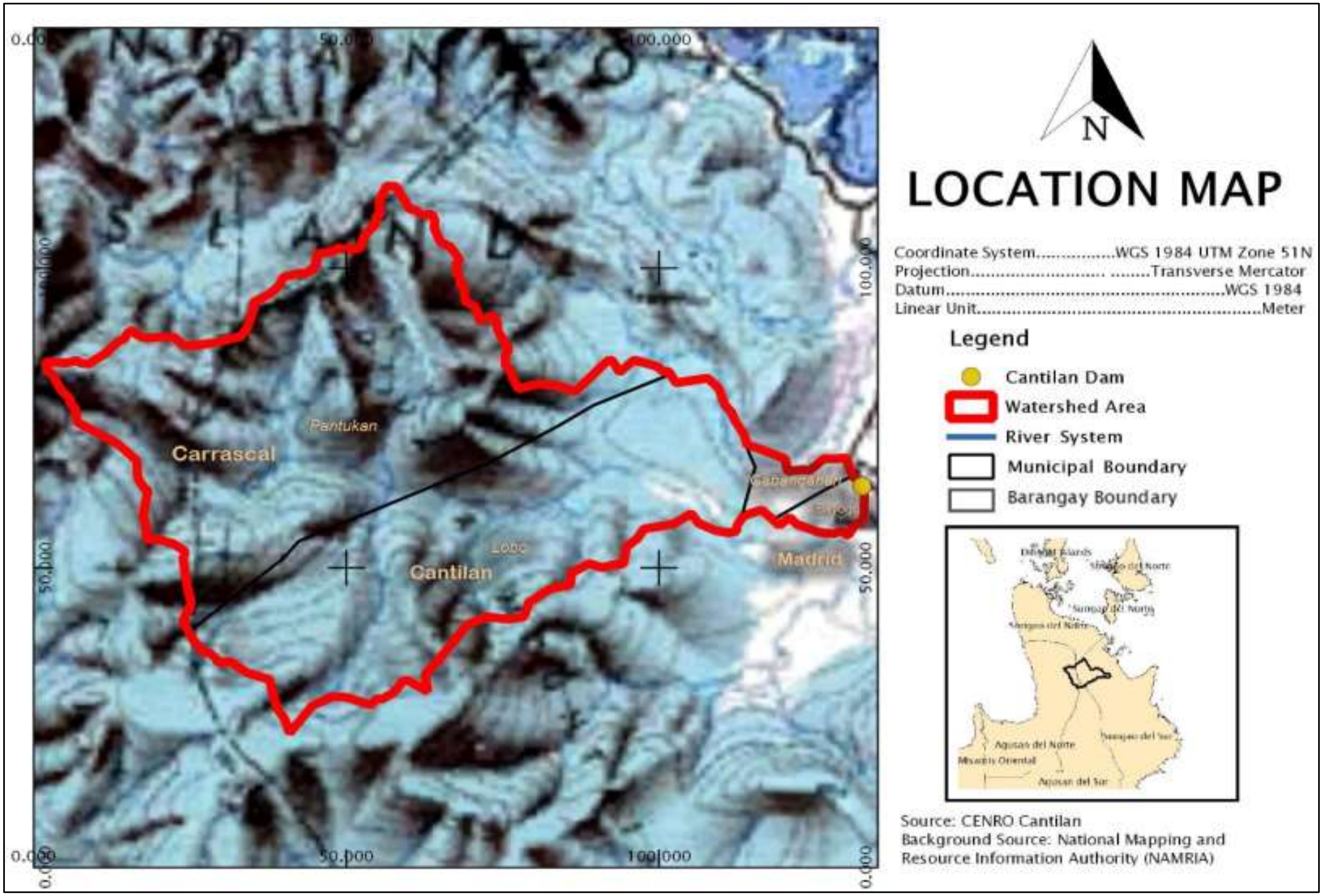


Figure 2-1 Administrative Map

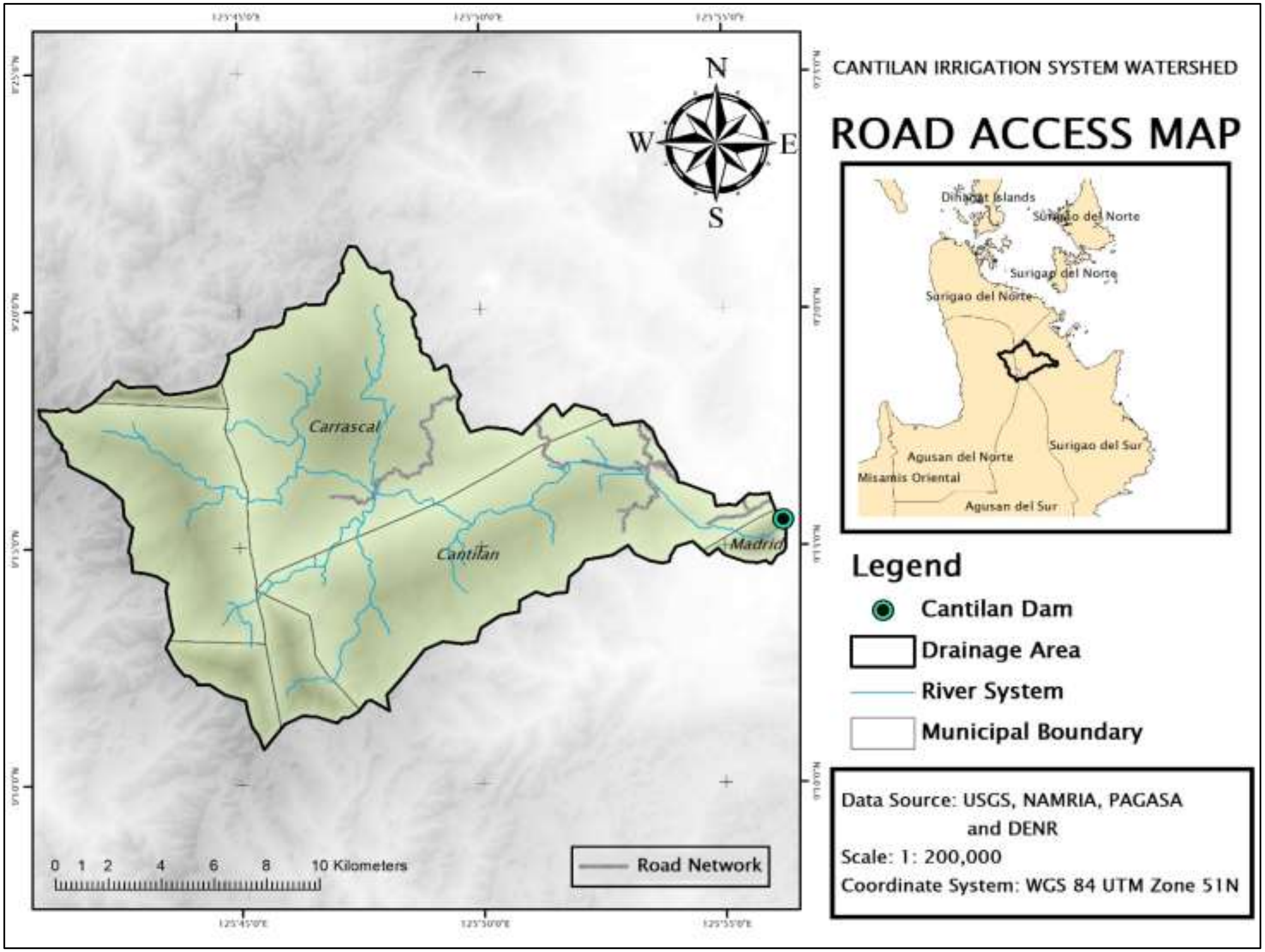


Figure 2-2 Road Access Map

2.4 Topography and Geomorphological Features

Topography is an important factor in the physical environment of an irrigation system, as it affects the flow of water and the design of irrigation infrastructure. Sloping terrain can affect the rate of water movement and require the use of terraces or other erosion control measures. Flat terrain may require the use of pumps or other means of water distribution to ensure that water reaches all areas of the field.

2.4.1 Slope

Slope refers to an elevated geological formation that defines the steepness or gradient of a land. Slope is critical in determining the management interventions to be applied in a particular area. Soil and water conservation practices differ from one area to another. The productivity of the land is inversely proportional to the decreasing degree of steepness of the land. Growing crops in generally rolling terrain is more productive as compared to sloping areas. The map is typically created using digital elevation data from LiDAR and other elevation survey methods.

Elevation data is analyzed to calculate the change in elevation over a given distance, which is then expressed as a percentage or degree of slope on a slope map.

The slope values correspond to a slope classification and are colored or shaded to create a visual representation of the terrain's steepness. Steep slopes may have significant impacts on the landscape and ecosystem. They can affect water runoff, soil erosion, and vegetation patterns, and can create hazards such as landslides and rockfalls. The slope map can be used for a variety of purposes, including land use planning, conservation, and disaster risk management.

Table 2.3 shows the slope values and its corresponding slope classification while a map shown in Figure 2-3 illustrates the steep slopes formations that are evident in most of the landforms in CANTIS.

Table 2-3 Slope Classifications in Cantilan Irrigation System Watershed

Slope Classification	Classification	Area (ha)	Percent Share	Remarks
Level to nearly flat	3% to 8%	1,181.07	4.97%	Fall into the gentle slope category, which has a very low angle of inclination.
Undulating to rolling	8% to 18%	4,687.79	19.72%	Undulating and rolling slopes are common in many different types of terrain, such as hilly areas, coastal regions, and agricultural landscapes. They can provide a pleasing visual effect and may be easier to navigate than steeper slopes.
Rolling to Moderately Steep	18% to 30%	8,557.94	36.01%	Characterized by gradual to moderate changes in elevation and slope angle. Here are some common features of rolling to moderately steep slopes.
Steep	30% to 50%	701.51	2.95%	Characterized by a relatively high angle of inclination and a rapid change in elevation over a short distance. Here are some common features of steep slopes.
Very Steep	>50%	8,635.38	36.34%	Characterized by an extremely high angle of inclination and a rapid change in elevation over a short distance.
Total			**100%**	

The Cantilan Irrigation System watershed area slope classification falls under the category of level to nearly flat, undulating to rolling, rolling to moderately steep, steep, and very steep. These slope classifications are described as follows:

- **Level to nearly flat:** the municipalities of Madrid and Cantilan have this slope classification and share 4.97% of the total land area of Cantilan Irrigation System.

- **Undulating to rolling:** this slope classification is found within the municipalities of Madrid and Cantilan, and shares about 19.72% of the total land area of the drainage area.

- **Rolling to moderately steep to very steep:** the three municipalities (Madrid, Cantilan, and Carrascal) have this slope classification, scattered rugged terrain and forest area can be found within this slope class.

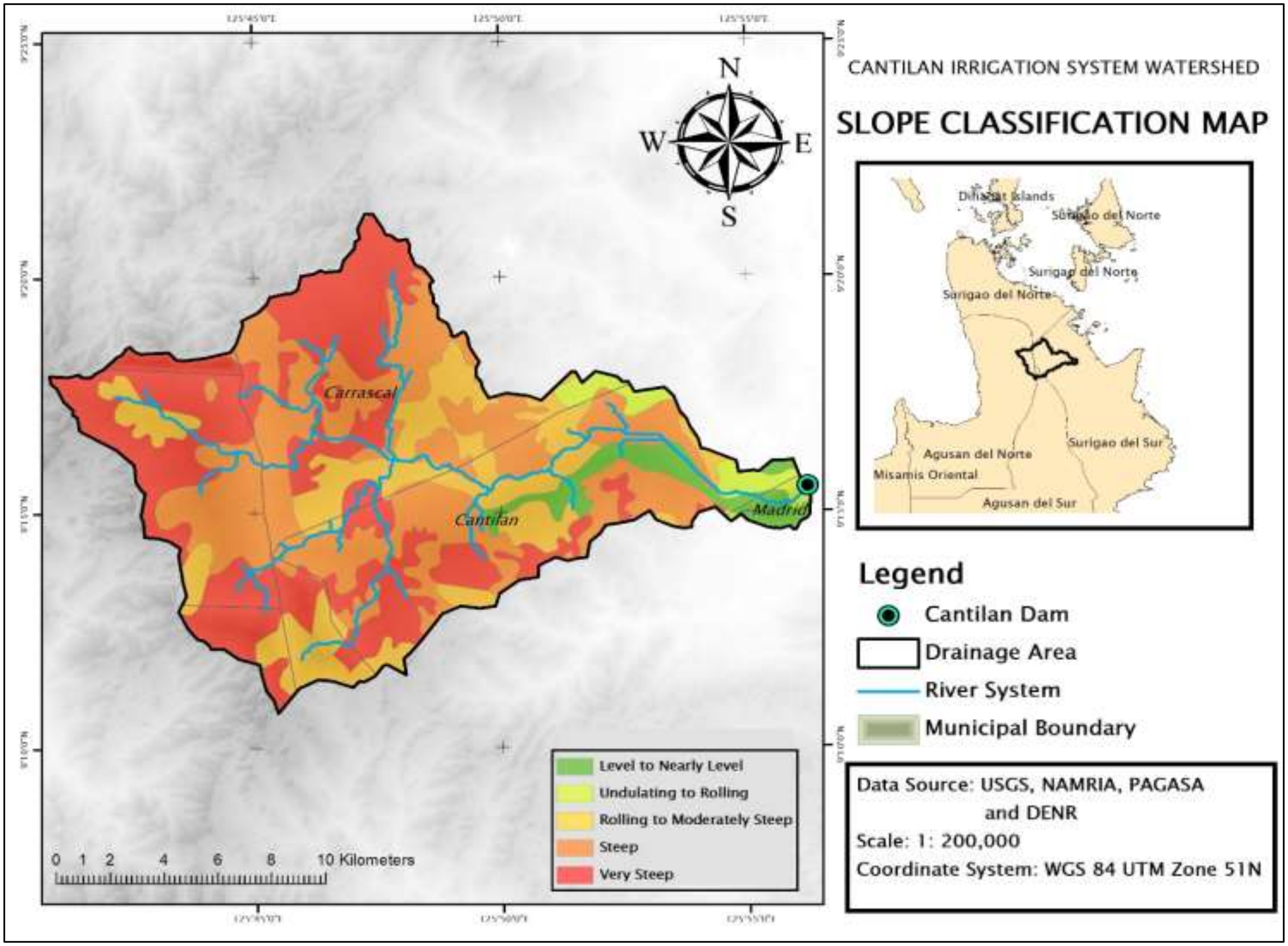


Figure 2-3 Slope Classification Map

2.4.2 Topography

Topography represents the description of the forms and features of the Earth's surface such as the steepness of the terrain. It affects the stability of the soil and flow of water. Areas with steeper gradient and longer slopes tend to have unstable soil materials and faster flowing of water, and thus, higher erosivity.

The topographic features of CANTIS can be best described based on:

Shape parameters

- Area
- Gravelius form factor
- Bifurcation ratio
- Elongation ratio
- Circulatory ratio
- Basin length

Relief characteristics

- Relief ratio
- Relative relief
- Elevation
- Slope
- Aspect ratio using Digital Elevation Model (DEM)
- Channel morphology

Drainage Texture

- Drainage density
- Stream density
- Length of overland flow

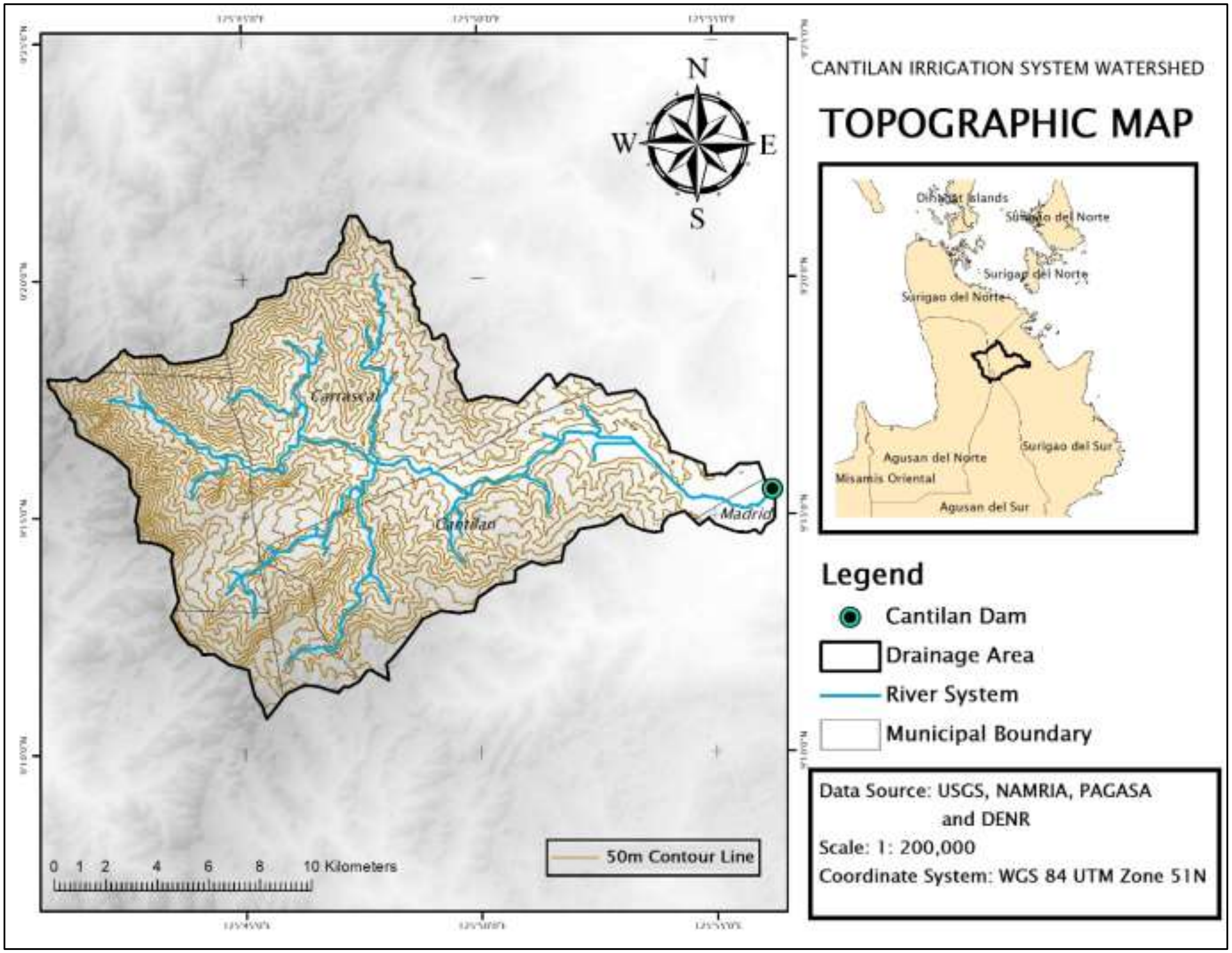


Figure 2-4 Topographic Map

The topographical features of CANTIS watershed vary and include islands, seacoast, coastal plain, swampland, agricultural land, foothills, and mountains. Its estimated slope is approximately 50 degrees, the highest point of which can be found at 1,134 meters; however, this peak is far in the interior near the Agusan border. Most of the mountainous area within CANTIS watershed has lower elevation (300- 500 meters in Cabangahan).

Figure 2-4 shows the watershed's inhabited area which is 10- 15 meters above sea level.

In terms of its natural features, the Cantilan and Bacahan river empty into the sea within the Cantilan Boundaries, and the Carac-an river flows through Cabangahan. The Malinawa Spring in Parang is a unique physical feature of Cantilan along with the Malitangtang Cave (CDP 2020-2025).

2.4.3 Elevation

Elevation is commonly defined as the average mean sea level of the area which is directly proportional to slope. Elevation increases with the steepness of the land. The susceptibility of the area to landslides and rockslides also increases as the elevation increases. The creation of elevation map shows the vertical elevation of the terrain in a specific area. Elevation data (**Table 2-4**) is analyzed and processed to create a grid or mesh of elevation values in order to create an elevation map (**Figure 2-5**). These values are usually represented as a shaded relief map, with different elevations represented by different colors or shades. This generates a 3D-like representation of the elevation of the terrain, allowing users to better understand its shape and structure.

Table 2-4 Elevation Classes in CANTIS

Elevation (masl)	Area (ha.)	Percent of Drainage Area to Total
16 - 300	5,021.50	21.13%
300 - 600	7,728.76	32.52%
600 - 900	5,921.67	24.92%
900 -1200	3,284.28	13.82%
1200 - 1772	1,807.49	7.61%
Total	**23,763.69**	**100.00%**

Dominantly, the Cantilan drainage area has an elevation of 16 to 1,772 masl. Areas with elevation range of 600 to 1,772 and above are highly susceptible to landslides and rockslides during continuous and heavy rain occurrences, there are parts of Cantilan and Carrascal covering the > 600 masl these ranges making them prone to geological hazards.

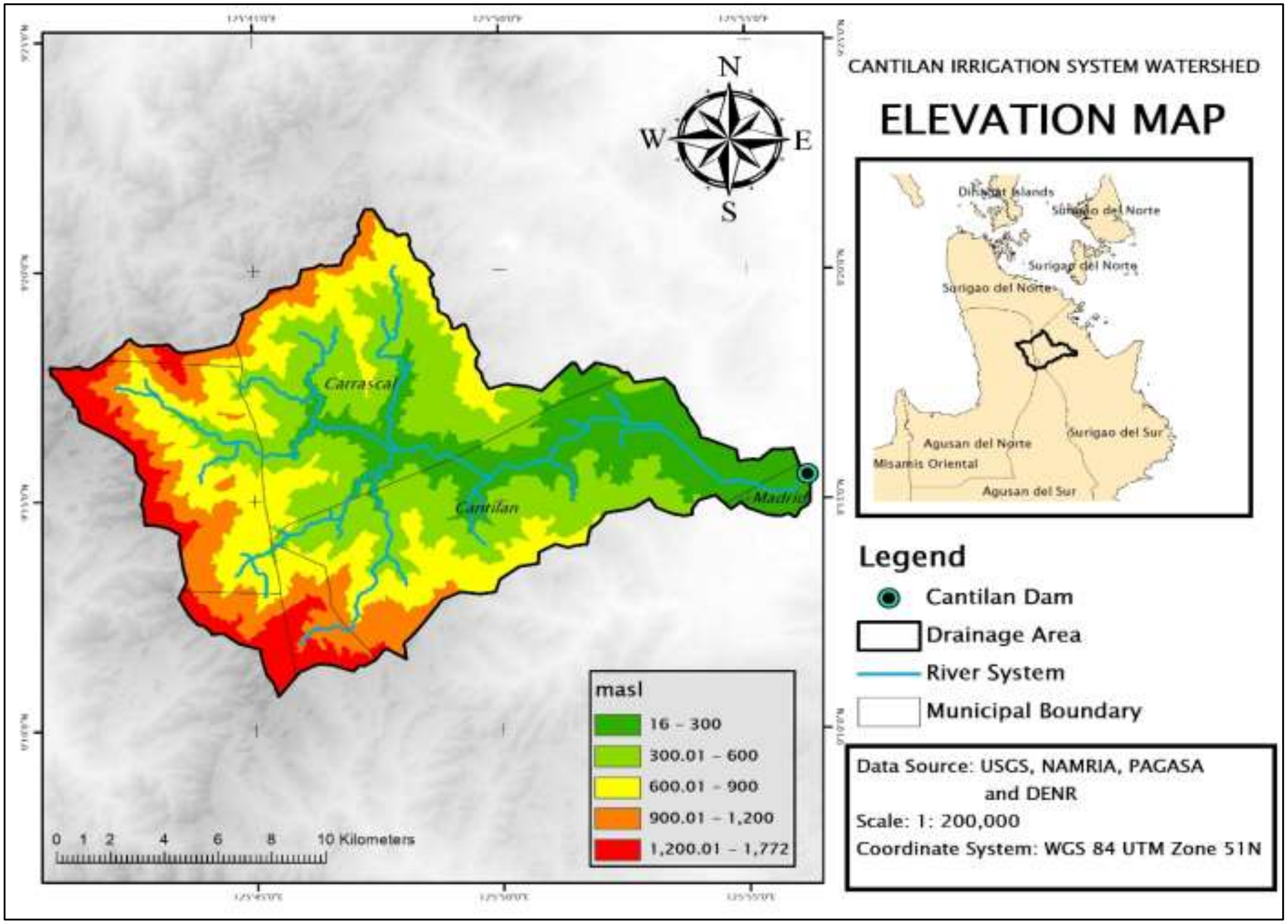


Figure 2-5 Elevation Map

2.4.4 Soil

The soil profile in Cantilan (**Table 2-5 and Figure 2-6**) consists mainly of several types of loam; and most of the soil found in the flat areas of Cantilan are suitable for rice cultivation, especially if the land is irrigated. The generation of soil map includes data from field observations, laboratory testing, and remote sensing. Based on factors such as texture, structure, color, and organic matter content, this data is then used to classify and map the various types of soils in the area.

Table 2-5 Soil Types within CANTIS

Soil Type	Area (ha.)	Percent of Drainage Area to Total
Kabatohan loam	5,583.10	23.49%
Mountain soil (undifferentiated)	17,660.41	74.32%
San Manuel silt, San Manuel silt loam, San Miguel silt loam	520.18	2.19%
Total	**23,763.69**	**100.00%**

2.4.4.1 San Manuel Soil

A non-calcareous soil formed in recently deposited sediments, primarily in flood plains. As a result, these soils are subject to frequent flooding and thus stratified saturated with water for repeated periods of time aquic and contain an appreciable amount of organic carbon. It is in the early stages of development toward a mature soil epts. Inceptisol is a fine loamy textured soil with a moderate amount of clay 18-35%. According to Philippine Rice Research Institute (**Table 2.6-2.8**), it has a mean annual soil temperature higher than 22 degrees Celsius.

Table 2-6 San Manuel Soil Series Description

Depth (cm)	Description
0-6	Brown to dark brown 10YR 43 moist silt loam fine to medium granular structure loose many fine to medium roots many fine inped pores abrupt smooth boundary
6-36	Dark yellowish brown 10YR 44 moist sandy clay loam moderate medium subangular blocky structure firm many fine roots few medium and many fine open tubular pores clear smooth boundary
36-69	Very dark grayish brown 10YR 32 moist clay loam moderate fine to medium subangular blocky structure friable few fine roots few fine tubulars and many fine inped pores gradual smooth boundary
69-90	Brown to dark brown 10YR 43 moist silt loam moderate fine to medium subangular blocky structure friable very few fine roots

Depth (cm)	Description
	few fine tubulars and many fine inped pores gradual smooth boundary
90 and below	Dark yellowish brown 10YR 44 moist clay loam fine to medium subangular blocky structure friable very few fine roots few fine tubulars and many fine inped pores

Source: *Philippine Rice Research Institute*

Table 2-7 Fertility Status of San Manuel Soil Series

Soil fertility	Content
Soil pH	Moderate
Phosphorus	Moderate
Potassium	Moderate
Nutrient Retention	High
Base Saturation	High
Salinity Hazard	Low
Organic Matter	Slightly Acidic-Neutral (6.5-7.5)

Source: *Philippine Rice Research Institute*

Table 2-8 Physical Soil Quality of San Manuel Soil Series

Physical soil quality	
Relief	Level to slightly undulating
Water Retention	High
Drainage	Good
Permeability	Moderate to Rapid
Workability/Tilth	Easy
Stoniness	None
Rooting Depth	Deep (>1m)
Flooding	Seasonal
Erosion	-

Source: *Philippine Rice Research Institute*

2.4.4.2 Kabatohan Loam

This type of soil is under the Bantog Soil Series (**Table 2.9-2.11**), this is a very fine textured soil with high clay content 60% composed of mixed minerals This soil is formed from recent alluvial deposits washed down from nearby hills and uplands It is saturated with water repeatedly but is well aerated because either groundwater is deep or the period of saturation is shorter. This soil has high calcium saturation in its subsoil horizon. It has a mean annual soil temperature higher than 22-degree Celsius isohyperthermic.

Table 2-9 Kabatohan Loam Soil Description

Depth (cm)	Description
0-13	Dark brown 75YR 33 wet clay fine granular and medium subangular blocky structure firm sticky and plastic common fine roots many fine and in ped pores clear smooth boundary
13-24	Dark brown 75YR 32 wet clay moderate fine to medium subangular blocky structure common Fe red concretions many very fine roots many fine in ped and common tubular pores abrupt smooth boundary
24-42	Dark grayish brown to 10YR 42 wet clay fine granular and medium subangular structure Fe mottles present many very fine to fine roots many in ped pores abrupt smooth boundary
42-60	Brown 75YR 52 wet sandy clay loam loose few fine roots many fine in ped pores many Fe and Mn concretions Minuri clear smooth boundary
69-110	Grayish brown 10YR 52 wet massive clay very sticky and very plastic Fe mottles

Source: *Philippine Rice Research Institute*

Table 2-10 Fertility Status of Kabatohan Loam

Soil Fertility	Content
Soil pH	Neutral - moderately alkaline (6.5 - 8.5)
Phosphorus	Adequate
Potassium	Low to Medium
Nutrient Retention	High
Base Saturation	High
Salinity Hazard	Low
Organic Matter	Adequate

Source: *Philippine Rice Research Institute*

Table 2-11 Physical Soil Quality of Kabatohan Loam

Physical Soil Quality	
Relief	Level to slightly undulating
Water Retention	High
Drainage	Poor
Permeability	Slow
Workability/Tilth	Hard
Stoniness	None
Rooting Depth	Deep (>1m)
Flooding	None to Seasonal
Erosion	-

Source: Philippine Rice Research Institute

2.4.4.3 Mountain Soil

Mountain soils are an important component of the terrestrial ecosystem, occupying elevated areas and contributing significantly to hydrological processes and biodiversity conservation. Because of the interaction of topography, climate, parent material, and vegetation, these soils have distinct characteristics. They are primarily classified as Andisols because of their high organic matter content, volcanic ash deposition, and porous structure, which promotes excellent water retention and nutrient retention. Inceptisols and Ultisols are also common, with moderate to low organic matter content, weathered mineral composition, and distinct soil horizons. These mountain soils aid in water infiltration, recharge groundwater, and regulate streamflow, all of which contribute to the sustainability of water resources. Their unique properties and ecological functions underline their significance in land management practices, emphasizing the necessity of preserving and managing these soils to ensure sustainable watershed management strategies.

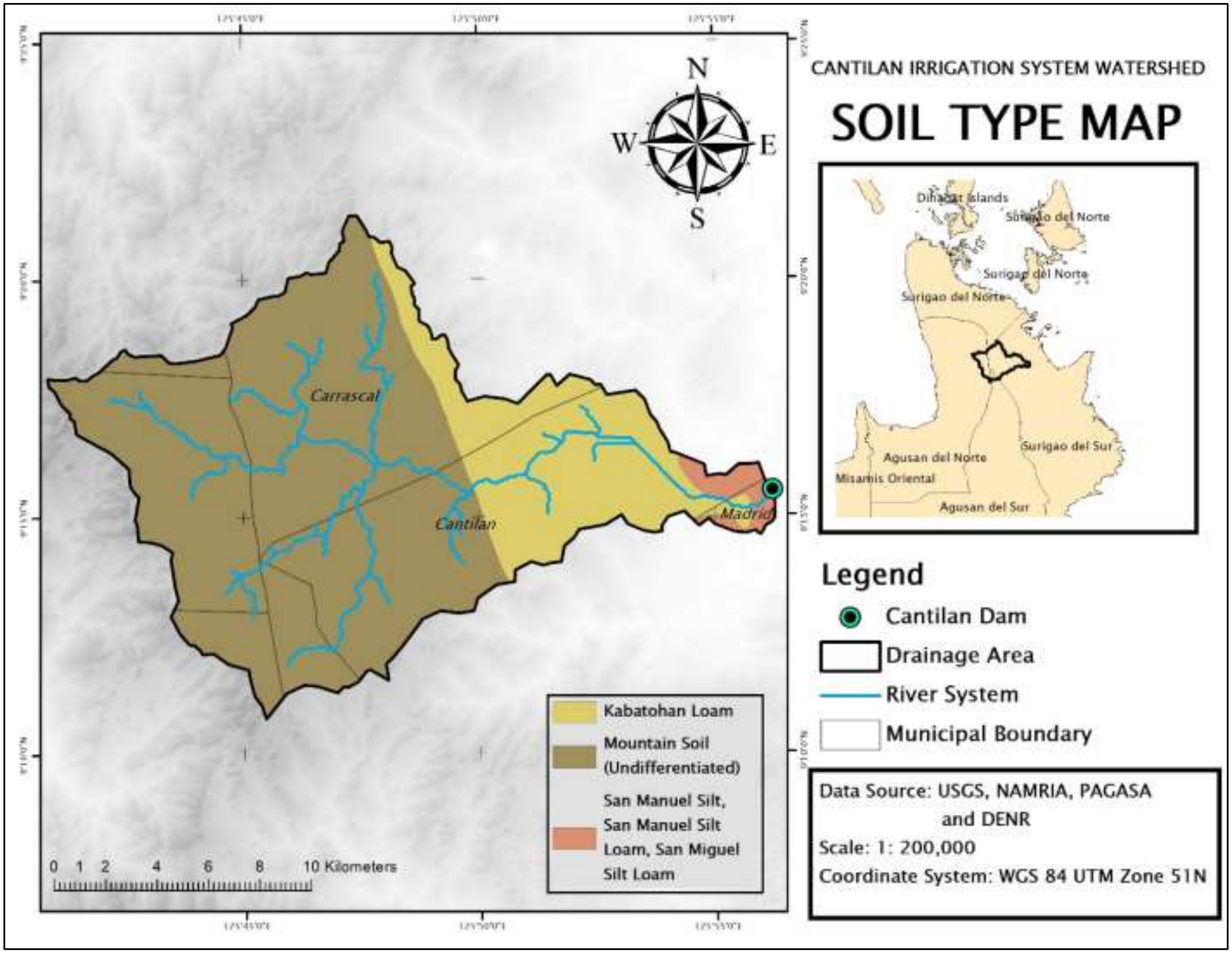


Figure 2-6 Soil Type

2.4.4.4 Soil Analysis

An actual field survey was conducted as part of the project's approach to collect primary data (**Figure 2.7 & Table 2.12**). Random sampling is the arbitrary collection of samples within a defined area. The plow depth was 15 cm to 20 cm, and a 1-kilogram soil sample was collected and thoroughly mixed into a bucket from each sampling station (**Figure 2.8 & Figure 2.9**). As a result, the soil samples were air-dried, and the soil parameters were determined using the Office of the Vice Chancellor for Research and Extension – University of the Philippines Los Baños (OVCRE-UPLB) Soil Test Kit.

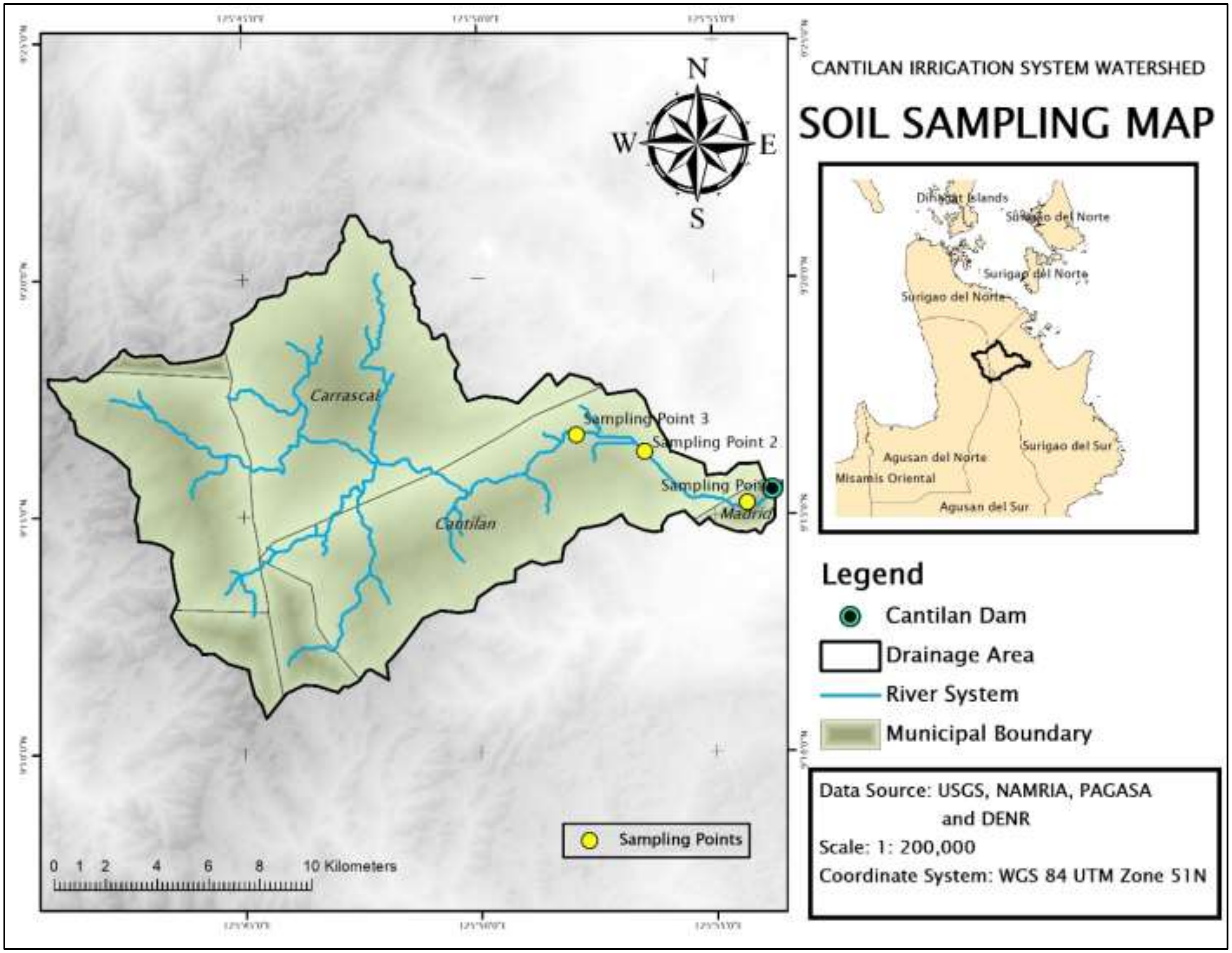


Figure 2-7 Soil Sampling Area Map

Table 2-12 Soil Sampling Points

Station ID	Location	Location	
		Latitude	Longitude
1	Cantilan, Caraga, Surigao Del Sur (Downstream)	9°15'34"	125°56'16"
2	Cabangahan, Surigao Del Sur (Midstream)	9°18'17"	125°54'10"
3	Carrascal, Caraga, Surigao Del Sur (Upstream)	9°16'45"	125°53'24"

Figure 2-8 Soil Sampling Site (Midstream)

Figure 2-9 Soil Sampling Site (Upstream)

Soil pH

Soil pH is a measure of soil acidity and alkalinity. The pH scale ranges from 0 to 14. A soil with a pH less than 7 is acidic, while one with a pH greater than 7 is alkaline. Soil samples in Sampling Point 3 were found to be slightly alkaline on the other hand Sampling Point 1 and Sampling Point 2 were found to be slightly acidic. The pH values (**Table 2.13**) across three (3) sampling points can still support the growth of trees and other agricultural crops within Cantilan Irrigation System.

Table 2-13 Soil pH Results

Sampling point	Soil pH
Point 1	6.8
Point 2	6.8
Point 3	7.2

Salinity levels in soil

The salinity levels are associated with electrical conductivity of soluble salts in soil. Salinity may vary in different forms. Excessive number of salts in soil may have a limiting effect on the availability of water for vegetation. All soil samples tested do not have dissolved salts in their soil solution (**Table 2**.**14**).

Table 2-14 Salinity Level Results

Sampling Point	Salinity Level
Point 1	Null
Point 2	Null
Point 3	Null

Nitrogen

Nitrogen is found in all soils and is one of the requirements of all living things. In plants, a large amount of nitrogen is required. It is one of the key elements in critical organic molecules such as amino acids, nucleic acids, and proteins. All soil samples tested shows low nitrogen level (**Table 2.15**). In agricultural crop management, nitrogen through supplementing 60-0-0 fertilizer will boost the crop yield within the CANTIS.

Table 2-15 Nitrogen Level Results

Sampling Point	Nitrogen
Point 1	Low
Point 2	Low
Point 3	Low

Phosphorus

Phosphorus is an essential nutrient for plant growth and development. It plays a critical role in photosynthesis, energy transfer, and the formation of DNA and cell membranes. Without enough phosphorus, plants cannot develop properly, and their growth and yield are significantly reduced. Plant growth is slowed in the absence of phosphorus. Plants are stunted and spindly, with stunted roots. Symptoms of deficiency include dull greyish-green leaves, red pigment in leaf bases, and dying leaves. Phosphorus deficiency is difficult to detect, and by the time it is discovered, it may be too late. Plants that are deprived of phosphorus as seedlings may not recover when phosphorus is added later.

Phosphorus is also necessary for the development of strong roots, which is essential for water and nutrient uptake. A lack of phosphorus can lead to poor root development, making plants more vulnerable to drought stress and waterlogging.

Based on the results (**Table 2.16**), Soil sampling point 2 and soil sampling point 3 have a low presence of Phosphorus while sampling point 1 has a medium level of phosphorus. Plant growth is slowed in the absence of phosphorus. Plants are stunted and spindly, with stunted roots. Symptoms of deficiency include dull greyish-green leaves, red pigment in leaf bases, and dying leaves.

Table 2-16 Phosphorus Level Results

Sampling Point	Phosphorus
Point 1	Medium
Point 2	Low
Point 3	Low

Potassium

Potassium (K) is an essential element for plant growth and development; however, its scarcity or excess causes distortions in a variety of plant functions. It helps to control a variety of critical functions in plant development. Potassium (K) is an important nutrient for plant growth. It's classified as a macronutrient because plants take up large quantities of it during their life cycle. Sampling point 1 and sampling point 3 have a deficient amount of Potassium while sampling point 2 tested sufficient (**Table 2.17**).

According to the importance index, Potassium comes in second place after nitrogen for overall plant growth. More than 60 enzymes in the plant system rely on it for activation, and it serves an important regulatory role. Potassium helps plants resist abiotic stress in the environment. In light of this, the physiological functions of K in plants, such as stomatal regulation, photosynthesis, and water uptake (Johnson and Vishwakarna, 2022).

Table 2-17 Potassium Level Results

Sampling Point	Potassium
Point 1	Deficient
Point 2	Sufficient
Point 3	Deficient

2.4.5 Geology

The geology of CANTIS (**Table 2.18**) is made up sedimentary and metamorphic parent materials of the Oligocene-Miocene and Cretaceous origin. The geological composition of the area will determine the geological hazard and soil classification that will develop over-time period in the area. It will also determine the floristic and faunal composition that will thrive over succession period. Mineral and land resources also depend and vary based on geological composition. Geologic survey data, which includes information on the composition, age, and origin of rocks and other geological formations, is typically used to create the geological map of Cantilan Irrigation System. Field observations, laboratory testing, and remote sensing are common methods for collecting and analyzing geologic survey data. Based on factors such as composition, texture, and structure, this data is then used to classify and map the various types of rocks and geological features in the area.

Sedimentary rocks are formed on the surface of the Earth. They often appear as layered deposits forming a strata or bed structures (Philippine National Museum). They are classified based on their origin, the clastic sedimentary rocks, biological sedimentary rocks, and other sedimentary rocks.

Table 2-18 Geologic Composition of CANTIS

Geologic Type	Area (ha.)	Percent of Drainage Area to Total
Cretaceous-Paleogene	4229.36	17.80%
Oligocene-Miocene	92.32	0.39%
Oligocene-Miocene	982.58	4.13%
Paleocene-Eocene (Igneous Rocks)	1.34	0.01%
Paleocene-Eocene (Sedimentary and Metamorphic Rocks)	10.18	0.04%
Recent	343.07	1.44%
Undifferentiated (Igneous Rocks)	6207.06	26.12%
Undifferentiated (Sedimentary and Metamorphic Rocks)	11897.79	50.07%
Total	**23763.69**	**100.00%**

In the CANTIS watershed, (**Figure 2.10**), ***Undifferentiated (Sedimentary and Metamorphic Rocks) make up around 50.07% of the surface***. These undifferentiated rocks, which covered 11,897.79 hectares and half of the watershed were created during a definite geological age but were unable to be identified by their specific type. While their specific characteristics, such as their stability, porosity, and erodibility, largely depend on their specific type, which is hard to identify, this type of geologic profile could indicate diverse soil and water conditions due to the shared characteristics of sedimentary and metamorphic rocks. However, in general, metamorphic rocks may be more erosion-resistant, while sedimentary rocks may have a more compact, less erodible structure.

The **second** most prevalent geologic formation in the watershed is the ***Undifferentiated (Igneous Rocks) geologic formation covering an area of 6207.06 or 26.12% of the total area***. The permeability, porosity, and resistance to erosion of these rocks are also complex to determine since it needs more specific information due to undifferentiation.

Cretaceous-Paleogene rocks were formed in a geological period that occurred approximately 66 million years ago. This formation covers a total of 4,229.36 hectares, or about 17.80% of the total area of the watershed. The soil formed on this geologic formation could be highly erodible and prone to landslides due to the presence of soft, easily weathered sedimentary rocks. The presence of these complex, impermeable rocks can also influence water flow, which can obstruct runoff and groundwater movement.

Recent rocks that were formed lately (<0.01 mega annum) cover 343.07 hectares and share 1.44% of the total drainage area.

The remaining areas are covered with the Paleocene-Eocene (Sedimentary & Metamorphic Rocks), Paleocene-Eocene (Igneous Rocks), Oligocene-Miocene (Sedimentary and Metamorphic Rocks), and Oligocene-Miocene (Igneous Rocks). Due to their longer geological age of origin, Oligocene-Miocene (Igneous Rocks) are sturdier and more stable, and as a result, these geologic formations are less prone to landslides and soil erosion.

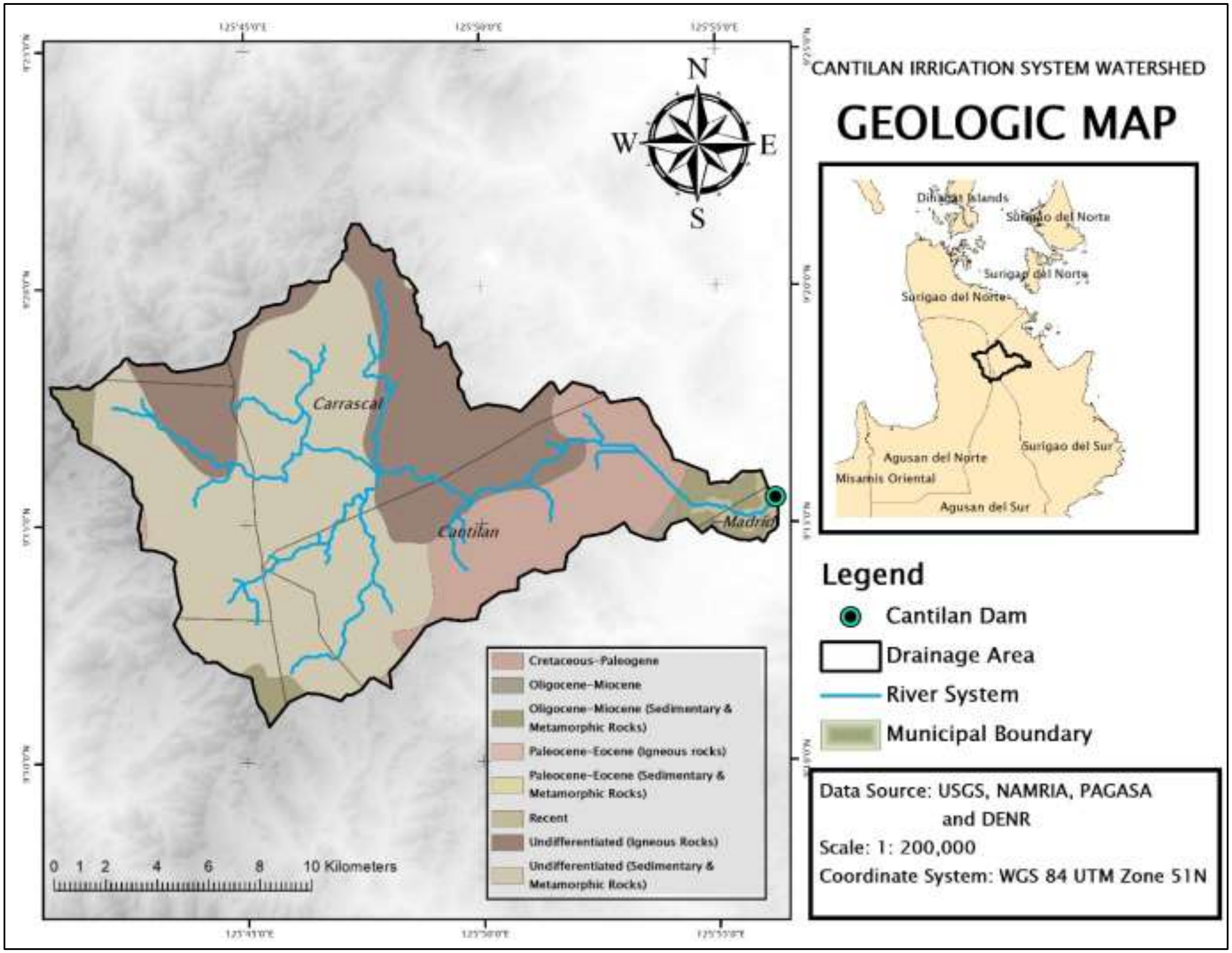


Figure 2-10 Geologic Map

2.4.6 Geomorphology

2.4.6.1 Form Factor (*Ff*)

Form factor (*Ff*) is defined as the ratio of basin area to square of the basin length. The results (**Table 2.19**) of which provide information as to the proportion of the entire watershed. The form factor is computed using the following formula:

$$Ff = \frac{A}{Lb^2}$$

where:

Lb is the maximum Basin Length
A is the Area of watershed

Table 2-19 Form Factor Results

Name of RIS	Basin Area (A)	Basin Length (Lb^2)	Form Factor
CANTIS	237.63 km^2	1108.22 km^2	0.21

The value 0.21 implies that the watershed is more elongated in shape. A watershed that has a more elongated shape has a form factor value of less than 0.5, whereas values less than 0.5 indicate a circular shaped watershed. Other factors, such as the size and land use of the watershed, as well as local hydrological and geomorphic conditions, may influence the interpretation of a form factor value.

The form factor is used to assess the degree of elongation or complexity of a watershed. A low form factor represents a more elongated or complex watershed shape, whereas a high form factor represents a more circular or simple shape. The implications of form factor in watershed management are that it can affect the watershed's hydrologic response, such as runoff volume and timing. Because of their more circular shape and shorter flow paths, watersheds with high form factors have a more concentrated and rapid runoff response, whereas watersheds with low form factors have a more dispersed and delayed runoff response due to their elongated and complex shape and longer flow paths. Understanding the form factor of a watershed can aid in the development of effective water resource management strategies such as flood control, water supply, and erosion control.

2.4.6.2 Length of Overland Flow (*Lg*)

Length of Overland Flow (*Lg*) is a length of water over the ground before it gets concentrated into certain stream channels where Drainage Density (*Dd*) is in km/km^2. Low value of Lg indicates high relief, short flow paths, more runoff, and less infiltration which leads to more vulnerable to flash flooding. Meanwhile, a high value of Lg means gentle slopes and long flow paths, more infiltration, and reduced runoff. The formula used to find *Lg* is shown below:

$$(Lg) = \frac{1}{Dd\ (2)}$$

where:

Dd is the Drainage Density of the watershed

Table 2-20 Length of Overland Flow Results

Name of RIS	Drainage density (km)	Length of overland flow (km)
CANTIS	0.4	1.25

A watershed with an overland flow length of 1.25 km indicates that water travels a total distance of 1.25 kilometers before entering a stream channel or other drainage feature. This value may indicate that the watershed has a moderate steep terrain, allowing water to spread out and travel further before being concentrated into a channel. Alternatively, it could indicate that the watershed has a relatively large area and/or receives a lot of rain, resulting in longer overland flow distances (**Table 2.20**).

2.4.6.3 Bifurcation Ratio (*Rb*)

The bifurcation ratio expresses the relationship between the number of streams in the watershed and the number of streams in the next lower order. In terms of determining flooding susceptibility, the bifurcation ratio can be used as a tool. The lower the value of the bifurcation ratio, the greater the likelihood that portions of the watershed will flood. Long, narrow basins with a high bifurcation ratio will have low flood discharge periods, whereas round basins with a low bifurcation ratio will have sharply peaked flood discharges. Stream orders are used to identify stream networks. There are no tributaries.

in first-order streams. Bifurcation ratio indicates the relationship of the number of streams in the watershed vis-à-vis stream order to the number of streams in the next lower order.

In terms of determining susceptibility to flooding, bifurcation ratio can be used as a tool for determining such. The lower the value of the bifurcation ratio, the higher the chance that portions of the watershed are susceptible to flooding. Long narrow basins with high bifurcation are expected to have low flood discharge periods, whereas round basins of low bifurcation ratio are expected to have sharply peaked flood discharges. Stream networks are designated by using stream orders.

First-order streams have no tributaries. A second-order stream begins at the intersection of two first-order streams. A third-order stream is formed by the confluence of two second-order streams, and so on. As a result, a lower Bifurcation Ratio indicates a higher risk of flooding. Natural drainage system formed in a homogeneous rock. A second- order stream starts at the confluence of two first-order streams. The confluence of two second-order streams is a third-order stream and so on. Therefore, the lower Bifurcation Ratio means higher risk of flooding. According to the Watershed Characterization and Vulnerability Assessment using GIS and Remote Sensing by FMB-DENR, values ranging from 3 to 5 indicate that natural drainage system that formed in a homogeneous rock.

The parameter can be calculated using this particular formula:

$$Rb = \frac{Nu}{Nu + 1}$$

where:

Nu	is the total number of stream segments order of u
$Nu + 1$	is the number of stream segments of the next higher order

CANTIS has four (4) stream orders. The average bifurcation ratio of CANTIS is 1.10.

Table 2-21 Bifurcation Ratio Results

	Stream Order	Count	Bifurcation Ratio	Average Bifurcation Ratio
CANTIS	1	29	1.61	1.10
	2	18		
	3	5	0.28	
	4	7	1.40	
		59		

A bifurcation ratio of 1.10 indicates that the watershed's stream network has multiple branches, with numerous smaller tributaries feeding into larger streams. This value indicates that there are two streams of the next higher order for every four streams of a given order (**Table 2.21**).

2.4.6.4 Stream Order

Stream order measures the relative size in a given watershed with dimensionless units. Stream order is a method of categorizing streams based on their position in a watershed hierarchy. The smallest streams are first order streams, which are typically fed by springs or seepage. As streams merge, their stream order increases, with each new order stream formed by the confluence of two or more smaller streams of the next lower order. The stream order has important implications for watershed management because it can affect the watershed's hydrological response. Higher-order streams have higher discharge and longer flow paths than lower-order streams, and thus play a larger role in the watershed's overall water balance. Higher-order streams also have more stable channels and more complex habitats, which support a wider range of aquatic organisms.

Understanding the stream order can help with watershed management by assessing water quality, estimating flow rates and water availability, and identifying potential risks of flooding or erosion. Stream order can also be used to prioritize conservation efforts, such as protecting headwater streams important for maintaining downstream water quality and aquatic habitats.

Strahler (1952) gave a modified definition and considered each fingertip channel as of first order. The second stream commences from the point where the two first order channels meet and continues down to the intersection of two second order streams for which point a third order stream commences and so on.

There are two (2) stream orders identified in CANTIS (**Table 2.22**). The 1st stream order has 29 stream counts. The 2nd stream order has 18 stream counts. The 3rd stream order has 5 stream counts, and the 4th stream order has 7 stream counts.

Table 2-22 Stream Order Results

Stream Order	Count
1	29
2	18
3	5
4	7
Total	**59**

If a watershed is dominated by 1st order streams, it means the drainage network is relatively dense and complex, with many small, intermittent channels feeding into larger streams. Because first-order streams are typically small and only flow during periods of heavy rainfall or snowmelt, the presence of a large number of them indicates that the watershed has a relatively high runoff potential and receives frequent precipitation.

2.4.6.5 Stream Length (Lμ)

Stream length is the total length of all streams within a watershed, from the headwaters to the main stem channel and finally to the watershed's outlet or discharge point. This measurement can be used to characterize a watershed's hydrology and geomorphology, as well as the ecological functions and services it provides.

Stream length represents the length of a major stream in kilometers per Stream Order (u) viz a viz number of Stream Segments. The number of streams of various orders in the basin and watersheds are counted and their lengths from mouth to drainage divide are measured with the help of GIS software.

2.4.6.6 Total (*TLμ*) and Mean Stream Length (*Lsm*)

The Total Stream Length (*TLμ*) represents the sum of all stream length from Stream Orders 1 to 4 (**Table 2.23**). On the other hand, the Mean Stream Length (*Lsm*) represents the quotients between total stream length of order '*u*' over total number of stream segments of order '*u*' represented by the formula:

$$Lsm = Lu/Nu$$

where:

Lu is the total stream length order of u
Nu is the total number of stream segments order of u

Table 2-23 Stream Length Results

Stream Order	Stream Length (km)	Mean Stream Length (km)
1	40.60	0.43
2	30.10	0.31
3	4.10	0.05
4	19.50	0.20
Total	**94.30**	**0.99**

2.4.6.7 Perimeter (*P*)

Basin perimeter is the total length of the drainage basin boundary. It is the total length along the water divide of the basin. The perimeter (*P*) is a linear measure of the size of the basin, and it is largely dependent on the texture of the topography. The drainage area perimeter (87.19 km), or the boundary that separates one watershed from another, has several implications for water management and environmental protection. An 87.19 km perimeter of a watershed could indicate a relatively large area that needs to be managed and monitored to ensure the sustainability of water resources and the surrounding ecosystem.

It is important to note that the perimeter of a watershed can affect its hydrologic and geomorphic properties. A watershed with a long and irregular perimeter, for example, may have more varied topography and more opportunities for infiltration and groundwater recharge, whereas a watershed with a shorter and more regular perimeter may be more vulnerable to surface runoff and erosion. The following are the environmental factors affected by the Perimeter:

1. **Water Quality**: The perimeter of a watershed can have an impact on the quality of the water within it. Pollutants, sediment, and nutrients, for example, that enter a watershed from outside its boundaries can have an impact on the quality of water within the watershed. As a result, understanding and protecting a watershed's perimeter is critical for maintaining water quality within it.

2. **Flood Control**: A watershed's perimeter determines the area that drains to a specific point in a stream or river. As a result, changes in the watershed's perimeter, such as land use changes or construction, can affect the amount and timing of water flow downstream. This has implications for flood control because changing the perimeter of a watershed increases the risk of flooding.

3. **Ecosystem Health**: The perimeter of a watershed can have an impact on the health of the ecosystem within it. Changing the perimeter of a watershed can have an impact on the area's hydrology, soil, vegetation, and wildlife, which can have a domino effect on the ecosystem's health.

2.4.6.8 Elongation Ratio (*Re*)

The Elongation Ratio (*Re*) is a parameter used to evaluate a watershed's physical characteristics. This parameter is used by the DENR as part of their Watershed Characterization and Assessment Framework (WCAF) to assess the potential impacts of land use changes and other activities on watershed hydrology and ecology. The elongation ratio is defined as the ratio of the maximum distance between two points on the watershed boundary to their perpendicular distance. This ratio indicates the extent of elongation or stretching of the watershed shape (**Table 2.24**).

Table 2-24 Elongation Ratio Index Classification

Sequence	Standard	Classification
1	< 0.5	More Elongated
2	0.5 – 0.7	Elongated
3	0.7 – 0.8	Less Elongated
4	0.8 – 0.9	Oval
5	0.9 – 1.0	Circular

A value of 1 indicates that the watershed is circular, whereas higher values indicate more elongated or stretched shapes. The implications of the elongation ratio for watershed management are determined by the watershed's specific characteristics. Because of their elongated shape, watersheds with higher elongation ratios may have higher runoff volumes and faster surface runoff, which can increase the risk of flooding and erosion. They may also have more complex flow patterns, which can affect sediment and nutrient distribution in the watershed. Understanding the elongation ratio can aid in the development of effective management strategies, such as identifying areas for conservation or restoration and managing land use activities to minimize impacts on the watershed's hydrology and ecology. The elongation ratio was determined following the formula below:

$$Elongation\ Ratio\ (Re)\ = \left(\frac{2}{Lb}\right)\left[\left(\frac{A}{\pi}\right)^{0.5}\right]$$

where:

Lb is the maximum basin length
A is the Area of watershed

$$Elongation\ Ratio\ (Re)\ = 0.52$$

The elongation ratio value of CANTIS ranges from 0.5 to 0.7 indicating that the watershed is classified as elongated shaped, characterized by high relief with steep slopes. The Elongation ratio of CANTIS was computed at 0.52 which is classified as elongated following the elongation ratio standard.

2.4.6.9 Circularity Ratio (*Rc*)

The circulatory ratio, which is defined as the ratio of the length of the main channel of the river to the length of the watershed's perimeter, is a measure of the shape of a watershed. Watersheds with a low circulatory ratio (less than 0.5) tend to be elongated and have a larger area relative to their perimeter. Watersheds with a high circulatory ratio (greater than 0.6) on the other hand, are more circular or compact.

A watershed with a low circulatory ratio may be more prone to erosion and sedimentation because water moves more slowly through the watershed, and it may be more likely to flood. A watershed with a high circulatory ratio, on the other hand, may have a more even flow of water and be less prone to erosion and sedimentation. Furthermore, a watershed with a low circulatory ratio may have a larger area relative to its perimeter, making management and protection more difficult. A watershed with a high circulatory ratio, on the other hand, may be easier to manage because it is smaller. and easier to monitor. Circulatory ratio (*Rc*) is defined as the ratio of watershed area to the area of a circle having equal perimeter of the drainage basin. Lower values of Rc will indicate more run-off for watersheds of the same size. Circulatory Ratio was computed using the following formula:

$$Circulatory\ Ratio\ (Rc) = \frac{4\pi A}{P}$$

where:

P is the Perimeter of watershed
A is the Area of watershed

$$\text{Circulatory Ratio (Rc)} = \frac{4\pi(237.636918)}{87196.010825}$$

$$\text{Circulatory Ratio (Rc)} \approx 0.03$$

The result provides information as to the shape form of the CANTIS in terms of circularity, the smaller the value with 0.5, means the IS is more elongated. The result for CANTIS was only 0.03 and therefore, this reveals that CANTIS is elongated rather than circular in shape and in form. The elongated shape will allow enough space for the flow of rivers to slow down especially during rainy season (**Table 2.25**).

Table 2-25 Circulatory Ratio Results

Name of RIS	Area (km)	Perimeter (km)	Circulatory Ratio
CANTIS	237.63	87.19	0.03

2.4.6.10 Relief Ratio (*Rr*)

The relief ratio, which is defined as the ratio of the difference in elevation between the highest and lowest points in the watershed to the length of the main channel of the river, is a measure of the steepness of a watershed. High relief ratio watersheds have a steep gradient and are often characterized by rapid water flow and high erosion rates, whereas low relief ratio watersheds have a gentle gradient and may have slower water flow and lower erosion rates.

A watershed with a high relief ratio may be more prone to erosion and sedimentation, which can lead to water quality degradation and damage to aquatic habitats.

Furthermore, steep slopes increase the likelihood of landslides and flooding, both of which can have serious consequences for the surrounding environment and human communities.

A watershed with a low relief ratio, on the other hand, may be less susceptible to erosion and sedimentation, but it may also have less capacity to hold and filter water, resulting in increased runoff and flooding during heavy rain events. Furthermore, because of the limited range of physical conditions, low relief watersheds may have less diverse aquatic habitats. As a result, when assessing the health of watersheds and developing strategies to protect them, it must consider planting vegetation or installing erosion control structures in watersheds with high relief ratios to reduce erosion and sedimentation. In watersheds with low relief ratios, it needs to implement measures such as creating wetlands or restoring streams to increase water retention and improve habitat diversity. The equation provided here can be used to compute the Relief Ratio:

$$\text{Relief Ratio} = \frac{Highest\ Point - Lowest\ Point}{Maximum\ Basin\ Length}$$

$$\text{Relief Ratio} = \frac{1772-16}{33.29}$$

where:

Bh is the vertical distance between the lowest and highest points
Lb is the maximum basin length

Relief Ratio = 0.05

The watershed relief ratio of CANTIS is 0.05 with its basin length at 33.29 kilometers and the highest and lowest elevation at 1,772 and 16 masl, respectively as shown, indicating faster and higher peak flows (**Table 2.26**).

Table 2-26 Relief Ratio Results

Name of RIS	Highest Point	Lowest Point	Maximum Basin Length	Relief Ratio
CANTIS	1,772	16	33.29	0.05

2.4.6.11 Drainage Density

Drainage density is defined as the total length of all streams and channels in the watershed divided by the total area of the watershed, is a measure of the amount of surface runoff within a watershed. Watersheds with a high drainage density have many streams and channels, as well as rapid water flow and high erosion rates, whereas watersheds with a low drainage density have fewer streams and channels, as well as slower water flow and lower erosion rates. A watershed with a high drainage density may be more vulnerable to erosion and sedimentation, which can lead to water quality degradation and damage to aquatic habitats. Furthermore, high drainage densities may increase the risk of flooding and cause more damage to human communities and infrastructure during heavy rain events.

A watershed with a low drainage density, on the other hand, may have limited water availability and be more susceptible to droughts. Furthermore, due to the limited range of physical conditions, low drainage density watersheds may have less diverse aquatic habitats. It is recommended to implement measures to reduce runoff in watersheds with high drainage density, such as installing green infrastructure or increasing vegetation cover. In low drainage density watersheds, there is a need to implement measures to improve the watershed's capacity to move water, such as constructing artificial drainage channels or improving natural watercourses. Furthermore, drainage density can be used to identify areas at risk of erosion and sedimentation and to prioritize conservation efforts in those areas. This equation is used for computing the Drainage Density:

$$Drainage\ Density\ (Dd)\ = \frac{Total\ Length\ of\ Stream\ (L)}{Area\ of\ Watershed\ (A)}$$

where:

TLu is the Total Stream Length
A is the Area of watershed

$$\text{Drainage Density} = \frac{94.3}{237.63}$$
$$\text{Drainage Density } (Dd) \approx 0.4$$

CANTIS has drainage density of 0.4 km/km^2 indicating a relatively high value of drainage density indicating that it is more likely that the watershed collects more water in a given time (**Table 2.27**).

Table 2-27 Relief Ratio Results

Name of RIS	Length Of Stream (km)	Area (km^2)	Drainage Density (Length of Streams/ km)
Cantilan Irrigation System	95.17	237.63	0.4

2.4.6.12 Area

Morphometric analysis of watershed is the best method to identify the relationship of various aspects in the area. The watershed can be classified as either river basin, large, medium, small, or micro based land area as described in the table below. Cantilan Irrigation System has a total area of 23,763.69 and is considered to a medium-sized watershed (**Table 2.28**).

Table 2-28 Watershed Classification based on Area

Classification	Area (in km^2)	Area (in ha)
Drainage/ River Basin	>1,000	>100,000
Large	500 to 1,000	50,000 to 100,000
Medium	100 to 500	10,000 to 50,000
Small	10 to 100	1,000 to 10,000
Micro	<10	<1,000

The table below summarizes the values of the Geomorphological Parameters in CANTIS (**Table 2.29**).

Table 2-29 Summary of Geomorphological Parameters

Parameter	Value
Area (km^2)	237.63
Perimeter (m)	87.19
Stream Network Length (km)	94.3
Drain Density (km/km^2)	0.4
Mean Height (masl)	354.4
Bifurcation Ratio	1.10
Stream Order	59
Circularity Ratio	0.03
Elongation Ratio	0.52
Relief Ratio	0.05
Length of Overland Flow (km)	1.25

2.5 Legal Land Classification

2.5.1 Land Capability, and Current Land Use

The CANTIS has a total land area of 23,763.69 hectares. There are two (2) types of land classification inside the municipality of Cantilan; Alienable and Disposable (A&D) land and forestland (**Figure 2.11**). About 16,856.10 hectares or 63.38% of the total land area comprise the forestland and 6,907.59 hectares or 29.06% are under A&D land (**Table 2.30**).

Table 2-30. Legal Land Classification of CANTIS

Land Classification	Area (ha)	Percent to Total
Alienable/Disposable	6,907.59	29.07%
Forest Land	16,856.10	70.93%
Total	**23,763.69**	**100.00%**

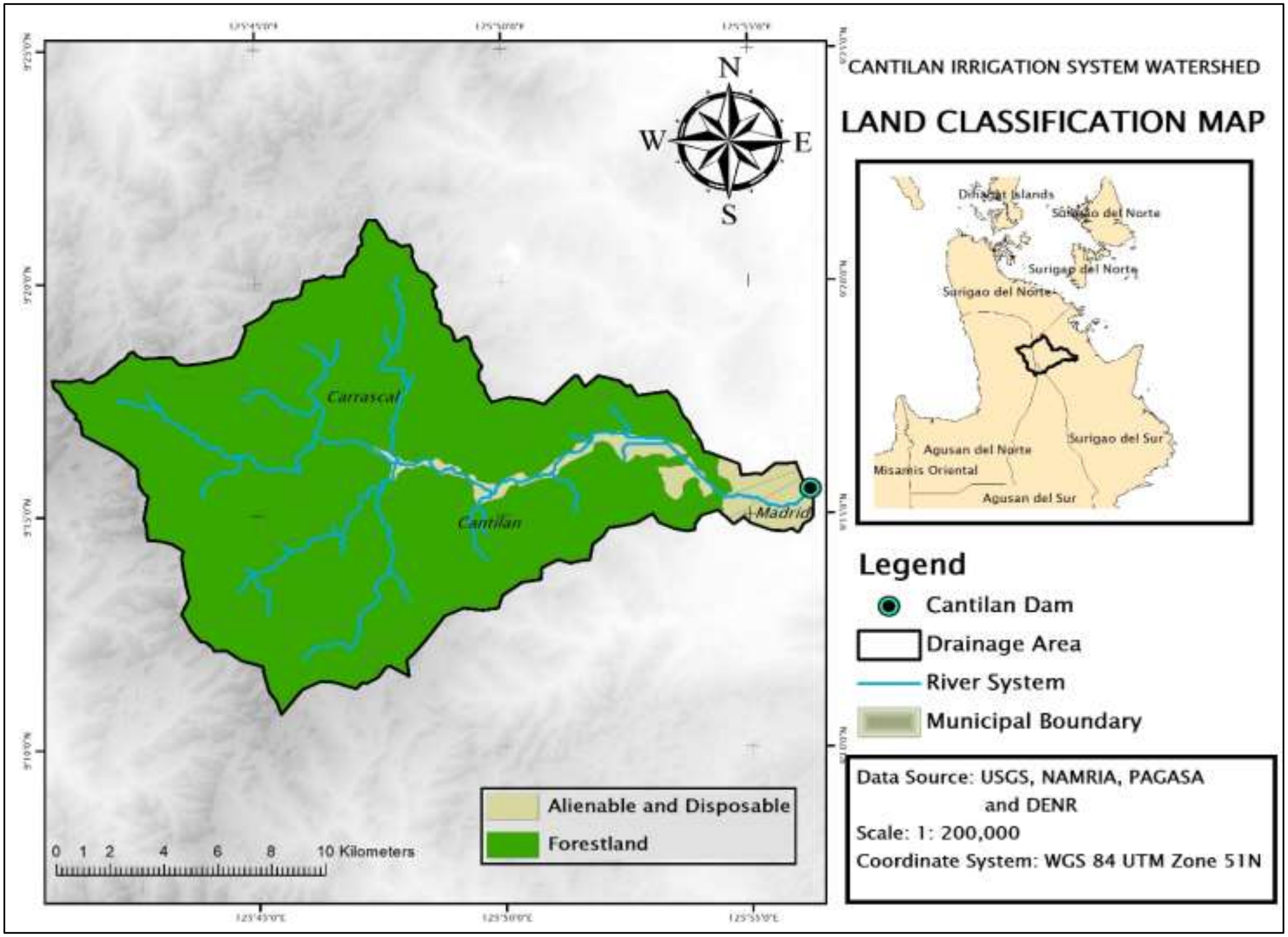


Figure 2-11 Land Classification Map

There are five (5) land use classes of CANTIS (agricultural area, built-up area, vegetated, municipal waters). CANTIS is predominantly vegetated, however, mining activities converts forested area into mining sites, making the land barren and contaminated (**Table 2.31 & Figure 2.12**).

Table 2-31 Land Use Classification of CANTIS

Land Use	Area (ha.)	Percent Share
Agricultural Area	11.62	0.01%
Built-up Area	12.15	0.01%
Others	1,577.64	0.07%
Forest	21,976.01	92.00%
Rivers and Creeks	186.28	7.00%
Total	**23,763.69**	**100%**

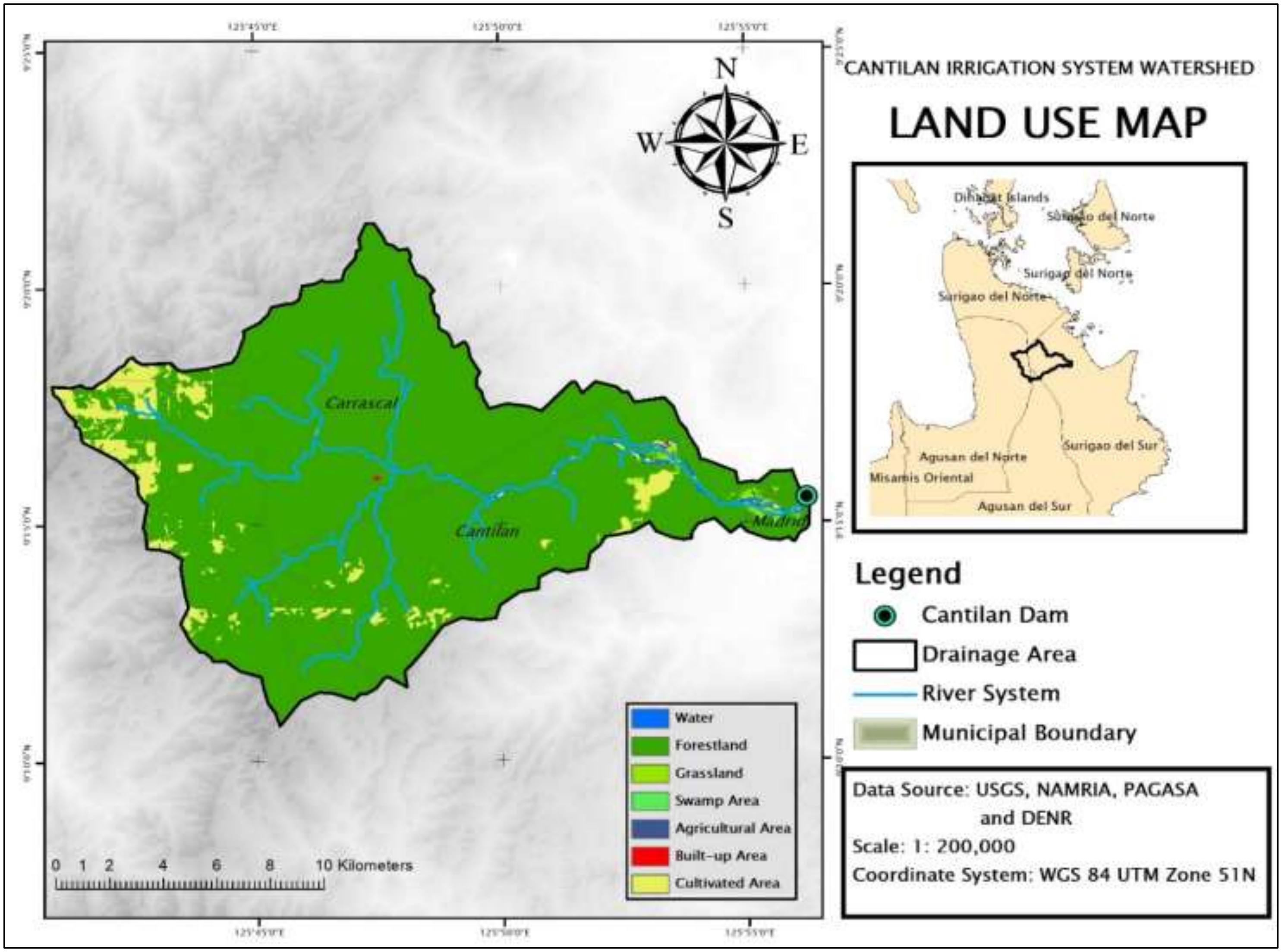


Figure 2-12 Land Use Map

There are different types of land cover or vegetation types found in CANTIS (**Table 2.32**):

- **Arable land** with mainly cereal and sugar crops: This refers to land that is used for agriculture, specifically for growing crops such as wheat, corn, or sugarcane.
- **Closed canopy**, mature trees covering > 50 percent: This describes a forested area where the canopy of trees is so dense that it covers more than half of the ground below, allowing very little light to penetrate through to the forest floor.
- **Cultivated area mixed with brushland/grassland**: This refers to land that is used for agriculture but has a mixture of different vegetation types, such as areas of grassland or shrubland mixed in with cultivated fields.
- **Mossy forest:** This is a type of forest that is characterized by a thick layer of moss growing on the forest floor and on the trunks and branches of trees, creating a unique and diverse ecosystem.
- **Open canopy**, mature trees covering < 50 percent: This describes a forested area where the canopy of trees is less dense, covering less than half of the ground below, allowing more light to penetrate through to the forest floor.
- **Riverbeds:** This refers to the area of land covered by a river or stream, including the banks and the bed of the river itself. It is typically characterized by bare or sparsely vegetated soil due to the regular disturbance caused by water flow.

Table 2-32 Land Cover Classification of CANTIS

Land Cover	Area (ha)	Percent Share
Arable land, crops mainly cereals and sugar	720.84	3.03%
Closed canopy, mature trees covering > 50 percent	4,390.33	18.47%
Cultivated Area mixed with brushland/grassland	1,152.21	4.85%
Mossy forest	690.34	2.91%
Open canopy, mature trees covering < 50 percent	16,804.02	70.71%
Riverbeds	5.96	0.03%
Grand Total	**23,763.69**	**100%**

Typically, land use and land cover map are created using land use planning data, which includes zoning regulations, land use policies, and development plans from Comprehensive Land Use Plan (CLUP) of the Municipality of Cantilan. They provide a visual representation of the land use activities in the area and aid in identifying areas of potential conflict or development opportunities. Aerial photography, satellite imagery, and on-the-ground surveys are commonly used to collect and analyze land use planning data.

This information is then used to categorize and map the various land use activities in the area, including residential, commercial, agricultural, and industrial land use. While land cover map shows the physical characteristics of the Earth's surface in a specific area, such as vegetation cover, water bodies, and built-up areas, are depicted. It is created using remote sensing data, such as satellite imagery or aerial photography. The data is then used to categorize and map the various types of land cover in the area, such as forests, grasslands, wetlands, bodies of water, and built-up areas (**Figure 2.13**).

Agricultural area which is also termed as alienable and disposable lands has a total of 1,491.81 hectares including land disputed from other municipalities. Settlements are mostly concentrated in the agricultural lands. Most of the settlement areas are surrounded by rice lands making the settlements ancillary to agricultural activities. Infrastructure lands are those within agricultural or forest lands utilized for infrastructure and utilities such as roads and bridges, irrigation canal, dams and other socio-economic. The physical and biological cover of the earth's surface, including vegetation, soil, water bodies, and built structures, is referred to as land cover. A change in land use and land cover can have various implications for watersheds. Here are some of the effects of changing land cover and land use on watersheds:

- **Water quality:** Changes in land cover and land use can have an impact on water quality in watersheds. Deforestation and agricultural activities can cause erosion and sedimentation in bodies of water, increasing the concentration of pollutants in the water.
- **Water quantity:** Changes in land cover and land use can have an impact on the amount of water that flows into a watershed. Urbanization can increase the number of impervious surfaces, such as roads and buildings, which can speed up and increase the volume of stormwater runoff.
- **Flood risk:** Land cover and land use changes can also increase the risk of flooding in watersheds. The removal of vegetation and soil compaction can reduce the ability of the land to absorb and store water, which can increase the likelihood of flash floods.
- **Climate change:** Land cover and land use changes can also have implications for climate change in watersheds. Deforestation can lead to increased carbon emissions, while afforestation can help sequester carbon from the atmosphere.

Changes in land cover and land use can result in habitat loss for aquatic and terrestrial species in watersheds. Conversion of wetlands to agricultural land, for example, can result in the loss of critical habitat for migratory birds and other wildlife.

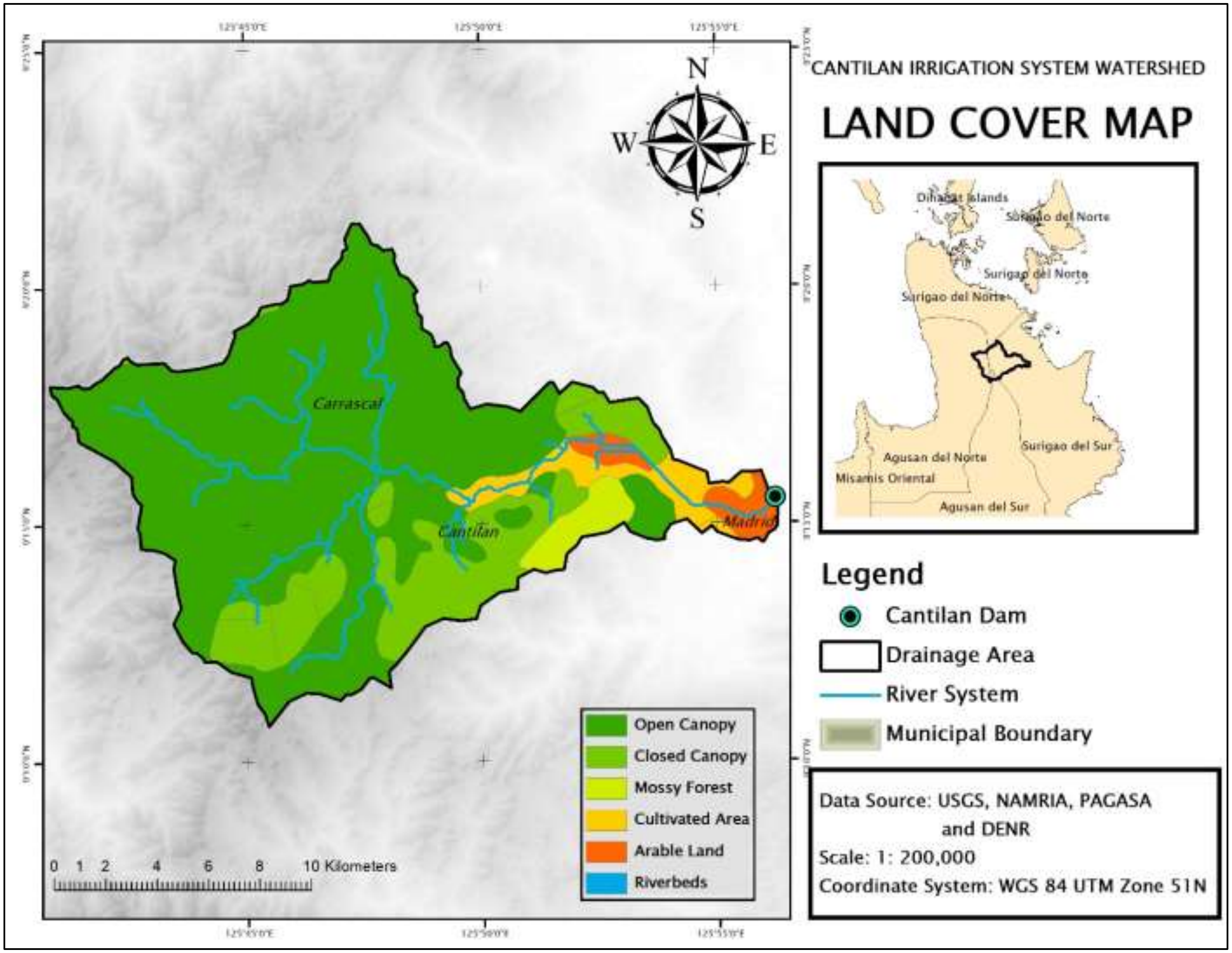


Figure 2-13 Land Cover Map

The CANTIS has different land capability, he Land Capability Classification (LCC) is a method established to assess the appropriateness of land for various purposes such as agriculture, forestry, and residential construction (**Table 2.33**).

The LCC is based on soil properties, slope, and other physical parameters that influence land production and resilience to erosion and other types of degradation.

Table 2-33 Land Capability Shares in CANTIS

Land Capability	Area (ha.)	Percent Share
Unlimited Production Zone	5,946.70	25.00%
Agroforestry Production Zone	12,635.46	53.00%
Limited Production Zone	3,201.27	13.00%
Strict Protection Zone	1,800.81	8.00%
Protection Buffer Zone	179.46	1.00%
Grand Total	**23,763.69**	**100%**

Unlimited Production Zone: has a total area of 5,946.70 ha and shares about 25% of the total land area of CANTIS. This is used for extraction, harvesting, cultivation, or production of natural resources, agricultural products, or industrial commodities. Mining, forestry, fishing, agriculture, and industry can all be classified as production zones. Production zones are essential issues for government agencies, including the Department of Environment and Natural Resources (DENR), since they may have a considerable influence on the environment, local people, and the economy. Production zones must be developed and maintained in a sustainable manner to guarantee that resources are used efficiently and that any negative environmental consequences are avoided.

Agroforestry Production Zone: has a total area of 12,635.46 ha and shares about 53% of the total land area of CANTIS. Agroforestry production zone is a plot of land maintained according to agroforestry principles, which include the integration of trees, crops, and livestock in a unified farming system. Farmers cultivate crops, rear animals, and grow trees all at the same time in an agroforestry production zone, employing strategies that optimize the advantages of these many aspects.

Trees in agricultural settings provide several advantages, including better soil health, biodiversity, climatic resilience, and greater production.

Agroforestry production zones may aid in the conservation of natural resources, the enhancement of ecosystem services, and the creation of economic possibilities for farmers and local communities.

Limited Production Zone: has a total area of 3,201.27 ha and shares about 13% of the total land area of CANTIS. Production or resource usage is limited or restricted in places owing to environmental concerns or other considerations.

Strict Protection Zone: has a total area of 1,800.81 ha and shares about 8% of the total land area of CANTIS. A Strict Protection Zone is a defined region of land or water for the

conservation and protection of biodiversity and natural ecosystems. These zones are often places of great ecological significance that need rigorous management and preservation in order to preserve their natural form and to avoid human activities that might cause harm or deterioration. National parks, animal sanctuaries, and other protected places may be included in these zones if they are maintained to retain their natural features and safeguard vulnerable or endangered species.

Human activities including hunting, logging, and commercial development are often restricted or tightly regulated in Strict Protection Zones to limit their influence on the natural environment. A Strict Protection Zone's major purpose is to protect the area's natural integrity and biodiversity while also offering possibilities for scientific study, education, and ecotourism.

Protection Buffer Zone: has a total area of 179.46 ha and shares about 1% of the total land area of CANTIS. A Protected Buffer Zone is an area of land that is maintained to create a buffer or transitional zone between a protected area and human activities or land uses. The goal of a Protection Buffer Zone is to reduce the pressure and disruptions from neighboring land uses in order to reduce the negative consequences of human activities on the protected area. Buffer zones might include buffer zones around national parks, wildlife refuges, and other protected places that need extra protection and management to retain their biological integrity.

Some activities, including sustainable agriculture, ecotourism, and scientific research, may be permitted within a Protected Buffer Zone under particular circumstances.

Activities that may affect the protected area, such as logging, mining, and commercial development, are usually forbidden or tightly controlled (**Figure 2.14**).

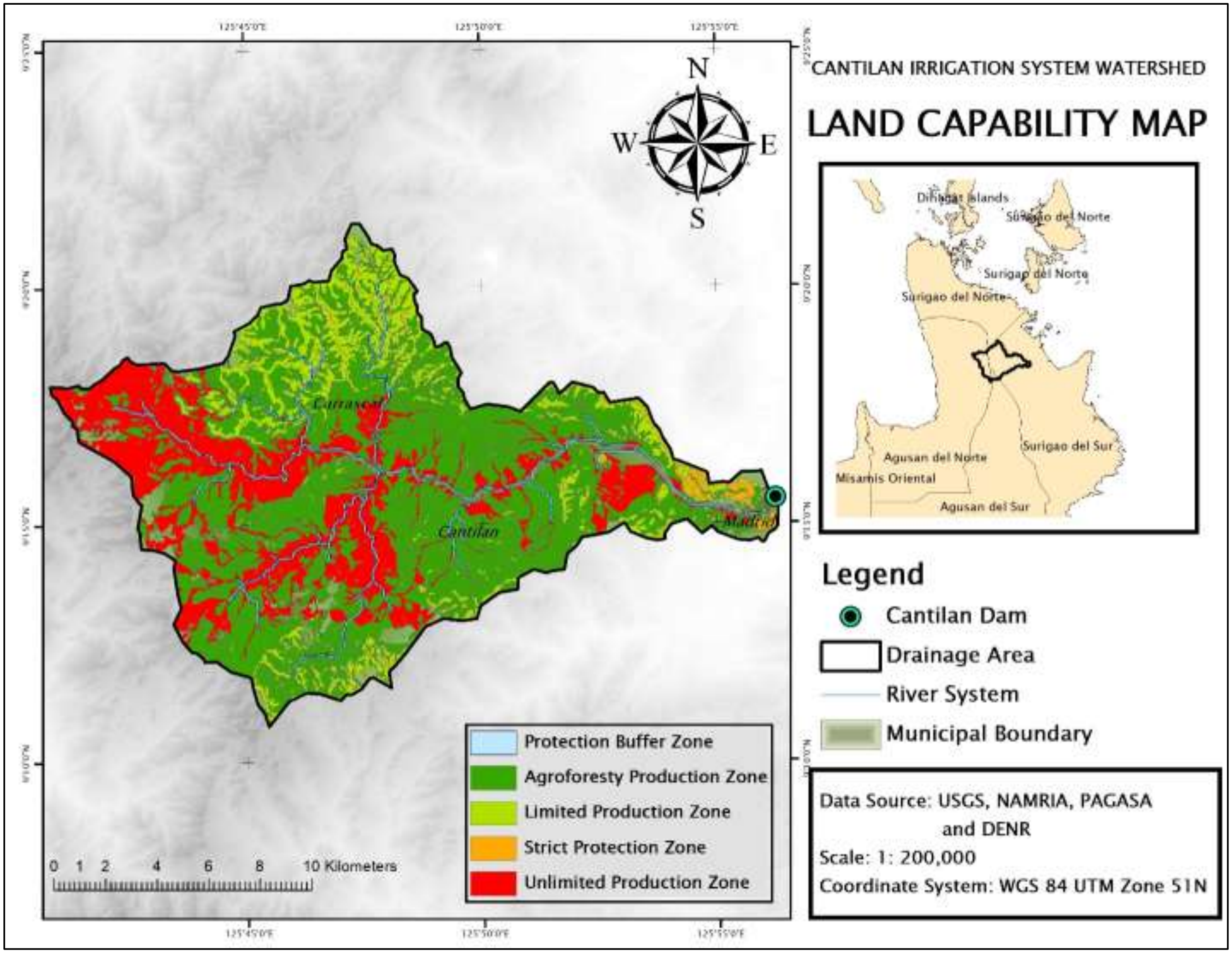


Figure 2-14 Land Capability Map

2.6 Network of Protected Areas for Agriculture and Agro-industrial Development

The Network of Protected Areas for Agricultural and Agro-industrial Development (NPAAAD) refers to agricultural areas identified by the Department of Agriculture (DA) through the Bureau of Soils and Water Management (BSWM) in coordination with the National Mapping and Resources Information Authority (NAMRIA). The NPAAAD ensures the efficient utilization of land for agriculture and Agro-industrial development and promotion of sustainable growth (**Table 2.34 & Figure 2.15**).

The NPAAAD covers the following:

- **Ecologically Fragile Lands:** These are areas that are highly vulnerable to environmental degradation and have limited capacity to support sustainable agriculture.
- **Erodible Lands:** These are lands that are highly susceptible to soil erosion and have low soil fertility. They are not suitable for intensive agriculture.
- **Expansion Areas:** These are lands that have potential for agricultural expansion and development.
- **Irrigable and Efficient Diversified Agri Lands:** These are lands that are suitable for irrigation and can support diverse agricultural crops.
- **Alluvial Irrigated Lands:** These are lands that are located near rivers or streams and can be irrigated using water from these sources.
- **Non-Agricultural Uses:** These are lands that are not suitable for agriculture but can be used for other purposes such as residential, commercial, or industrial development.
- **Present Agro-Industrial Lands:** These are lands that are currently being used for agriculture and are capable of supporting the production of crops for industrial use, such as sugarcane, coconut, and oil palm.

Table 2-34 NPAAAD Description

NPAAAD Description	Area (ha.)	Percent Share
Ecologically Fragile lands: Erodible lands	638.07	2.68%
Expansion Areas	58.76	0.25%
Irrigable and Efficient Diversified Agri Lands: Alluvial	180.75	0.76%
Irrigated Alluvial lands	6.26	0.03%
Non-Agricultural Uses	21,946.16	92.35%
Present Agro-Industrial lands	933.69	3.93%
Total	**23,763.69**	**100%**

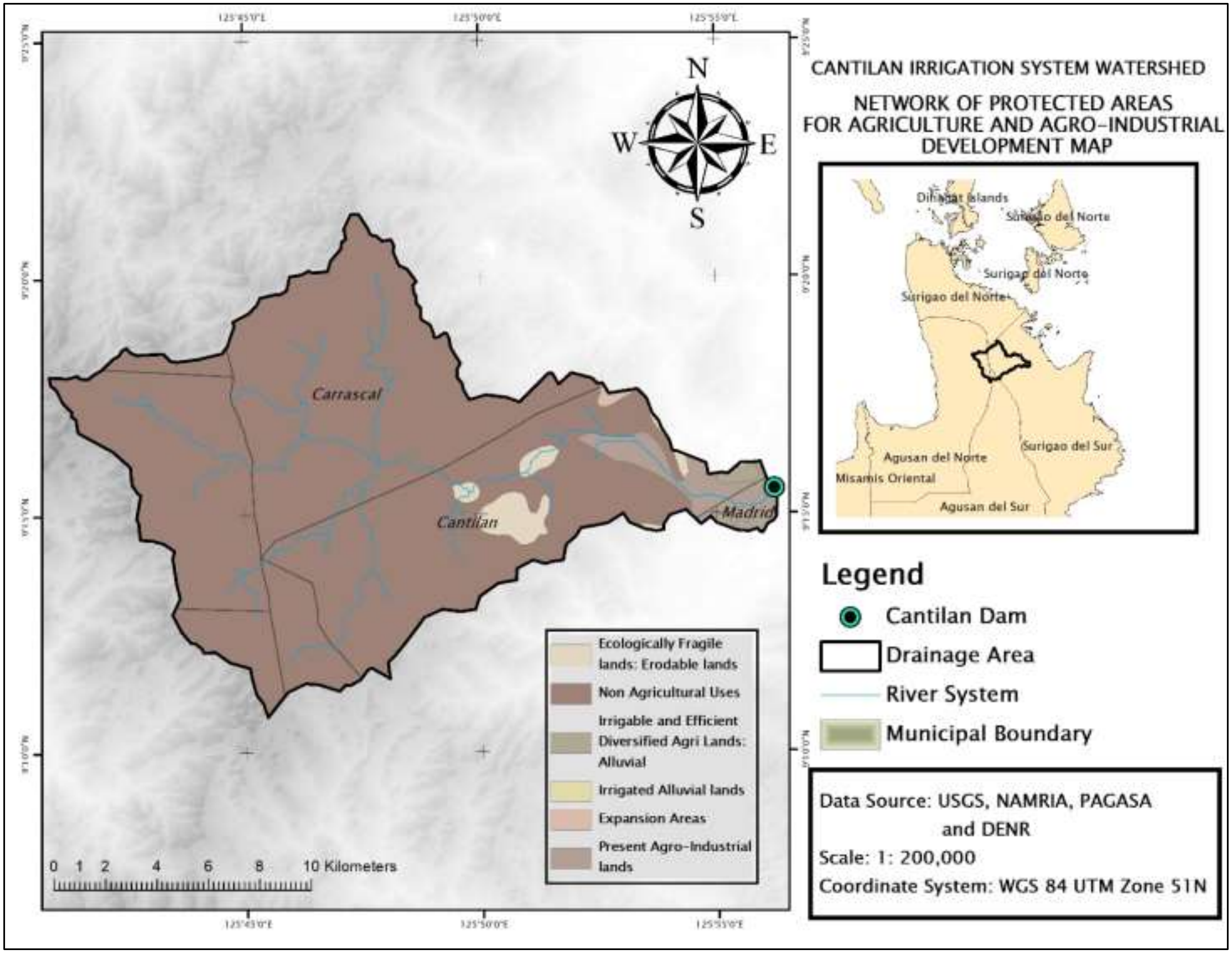


Figure 2-15 NPAAAD Map

2.7 Tenurial Agreements/ Permits

Lands classified as public forest may be granted tenure for:

1. National Greening Program (NGP)
2. Industrial Forest Management Agreements (IFMA)
3. Community Based Forest Management Agreement (CBFMA) - 25-Year Term
4. Rattan Cutting Contract
5. Certificate of Stewardship Contract (CSC) - 25-year term
6. Certificate of Ancestral Domain Claim-Community Based Forest Management Agreement (CADC-CBFMA) and
7. Certificate of Ancestral Land Claim-Community Based Forest Management Agreement (CALC-CBFMA)
8. Mining Tenements

In the context of CANTIS, a significant portion of the entire area, about 69% to be precise, is covered by existing tenurial agreements and permits issued by the Department of Environment and Natural Resources (DENR). This encompasses a total of 16,418.33 hectares, as depicted in **Figure 2.16** and elaborated upon in **Table 2.35**.

Table 2-35 Land Tenurial Percentage

Land Tenure	Area (ha.)	Percent Share
Ancestral Domain / CADT Area	5,379.02	23%
CBFM Area	1,073.86	5%
IFMA Area	69.06	0%
Rattan Cutting Contract R13-ICC-089	9,896.39	42%
Grand Total	**16,418.33**	**69%**

Regions with a Certificate of Ancestral Domain Title (CADT) are delineated zones, often covering large, forested areas, where a significant portion of the land. In CANTIS, 5,379.02 hectares of land is identified as an ancestral domain. These zones may currently include habitations, which are primarily inhabited by indigenous groups and individuals involved in forest product cultivation.

Furthermore, it's important to highlight the presence of mineral extraction agreements within the CANTIS area. This involves a substantial land area of 9,208.23 hectares.

Notably, three distinct development corporations are actively engaged in extracting mineral resources from this region, as illustrated in **Figure 2.17** and detailed in **Table 2.36**. These corporations are Marcventures Mining and Development Corporation, with an expansive area of 2,585.34 hectares, followed by Bright Green Development Corporation, operating across 4,500.41 hectares, and First Highlander Indigenous Resources Development Corporation, which has a presence over 2,122.48 hectares, as visualized in Figure 2.18. This underscores the diverse range of entities involved in mineral resource extraction within CANTIS.

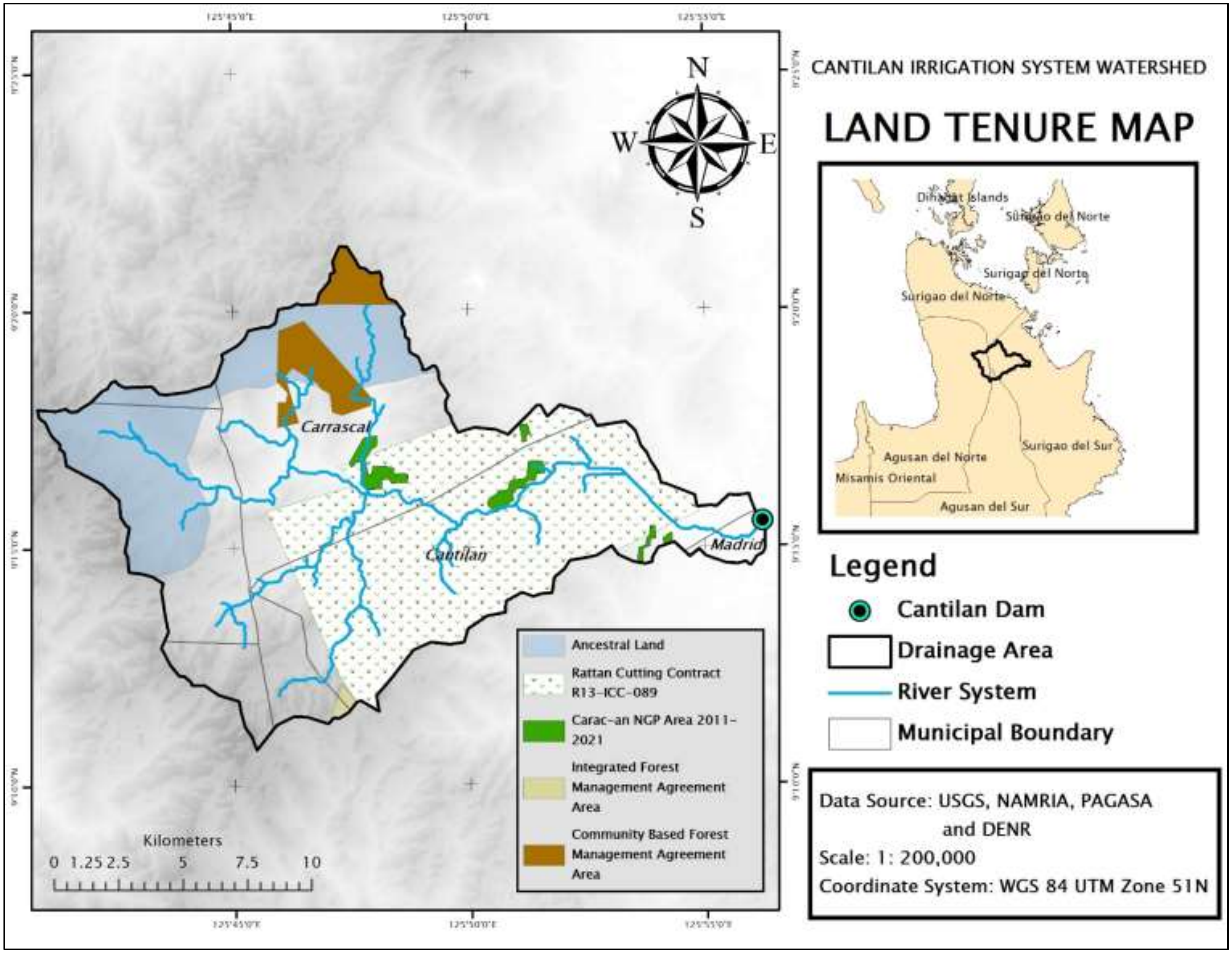


Figure 2-16 Land Tenure Map

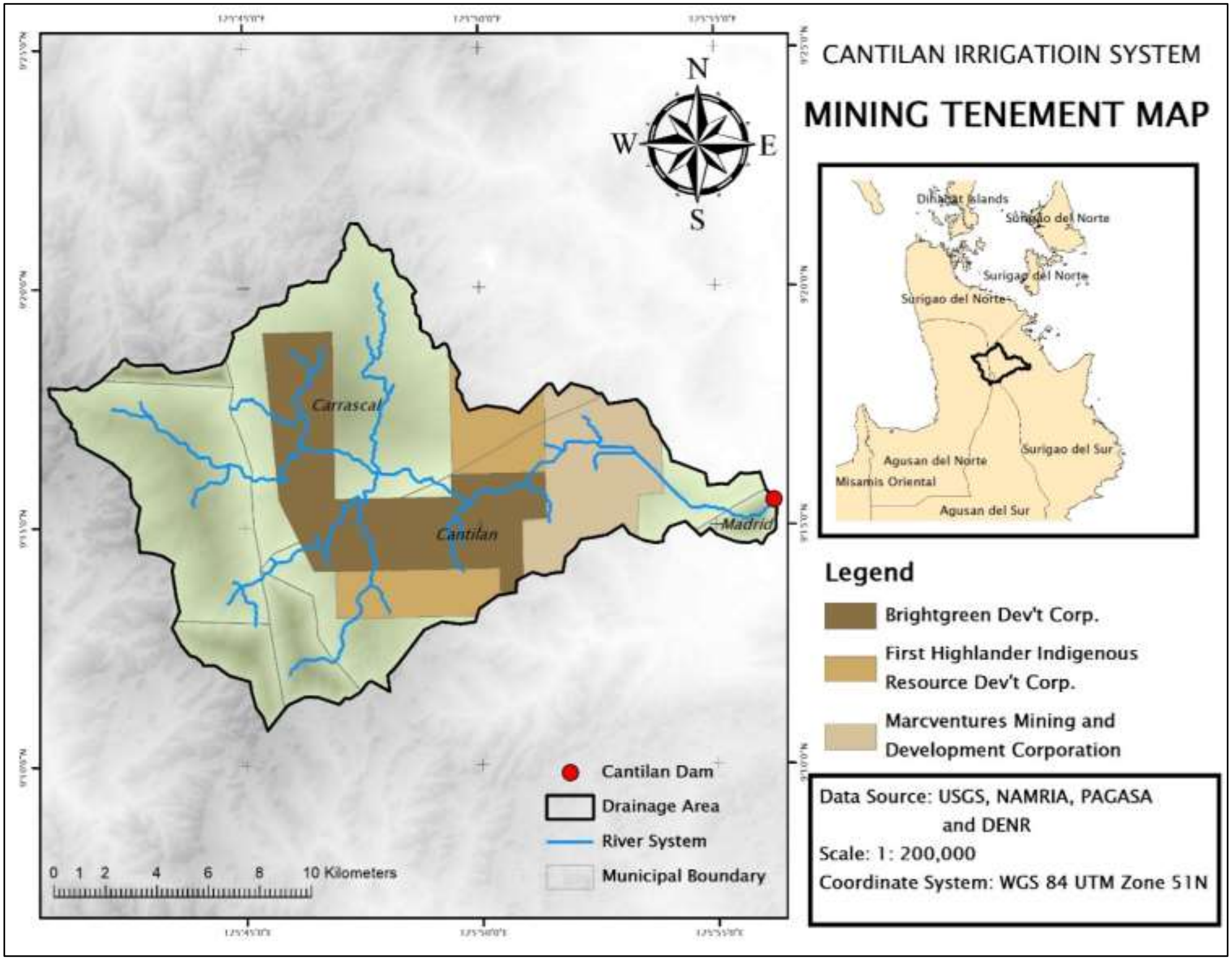


Figure 2-17 Mining Tenement Map

Table 2-36 Mining Tenements in CANTIS

Mining Firm	Area (ha.)	Percent of Drainage Area to Total
Marcventures Mining and Development Corporation	2,585.34	10.88%
Bright Green Development Corporation	4,500.41	18.94%
First Highlander Indigenous Resources Development Corporation	2,122.48	8.93%
Total	**9,208.23**	**38.75%**

Figure 2-18 Mining Area

2.8 Protected Area

The National Integrated Protected Areas System was created and is maintained under the Republic Act 7586, often known as the NIPAS Act. This law was amended by the Republic Act 11038 (Expanded National Integrated Protected Areas System Act of 2018) which established there are 94 additional protected areas classified as National Park based on the requirements of the Philippine Constitution and RA 7586.

Protected Areas (PAs) are designated areas of land and water that have been set aside due to their special physical and biological significance. They are managed to increase biological diversity and are safeguarded from destructive human exploitation. The following classifications result in an area being designated as a protected area:

1. **Strict nature reserve** - an area possessing some outstanding ecosystems, features, and species of flora and fauna of national scientific importance, established to protect nature and natural processes and maintain ecologically representative examples of the natural environment for scientific study, environmental monitoring, and education.

2. **Natural park** - a relatively large area not materially altered by human activity, where extractive resource uses are not allowed and which is maintained to protect outstanding natural and scenic areas of national or international significance for scientific, educational and recreational use.

3. **Natural monument** - a relatively small area focused on the protection of nationally significant natural features on account of their special interest or unique characteristics.

4. **Wildlife sanctuary** - an area that assures the natural conditions necessary to protect nationally significant species, groups of species, biotic communities or physical features of the environment, where these may require specific human manipulation for perpetuation.

5. **Protected landscapes and seascapes** - areas of national significance that provide opportunities for public enjoyment through recreation and tourism within the normal lifestyle and economic activity of the resident community.

6. **Resource reserve** - an extensive and relatively isolated and uninhabited area normally with difficult access designated as such to protect the natural resources for future use and prevent or control development that could affect the resource

   pending the establishment of objectives based upon appropriate knowledge and planning.

7. **Natural biotic areas** - areas set aside to allow the way of life of societies living in harmony with the environment to adapt to modern technology at their pace. These societies include the; Indigenous cultural community, a group of people sharing common bonds of language, customs, traditions, and other distinctive cultural traits, and who have, since time immemorial, occupied, possessed and utilized a territory. - Tenured migrant communities, those that have actually and continuously occupied a protected area for five years and who are solely dependent therein for subsistence.

Other categories established by law, conventions, or international agreements of which the Philippine Government is a signatory.

According to the NIPAS Act, a protected area is defined as:

> *"An identified portion of land and/or water set aside by reason of its unique physical and biological significance, managed to enhance biological diversity and protected against destructive human exploitation. It is governed by legal or other effective means and managed through a system of interrelated planning, managerial, and enforcement provisions."*

In the case of CANTIS (**Table 2.37 & Figure 2.19**), there was a protected area declared that covers the drainage area. The Alamio, Buayan, Carac-an, Panikian River and Sipangpang Falls Watershed Forest Reserve with Proclamation 1747 s. 2009 and total area of 23,283.64 ha or (97.98% of the total drainage area).

Table 2-37 Protected Area within CANTIS

Protected Area	Area (ha.)	Percent of Drainage Area to Total
Alamio, Buayan, Carac-an, Panikian River and Sipangpang Falls Watershed Forest Reserve	23,283.64	97.98%
Total	**23,283.64**	**97.98%**

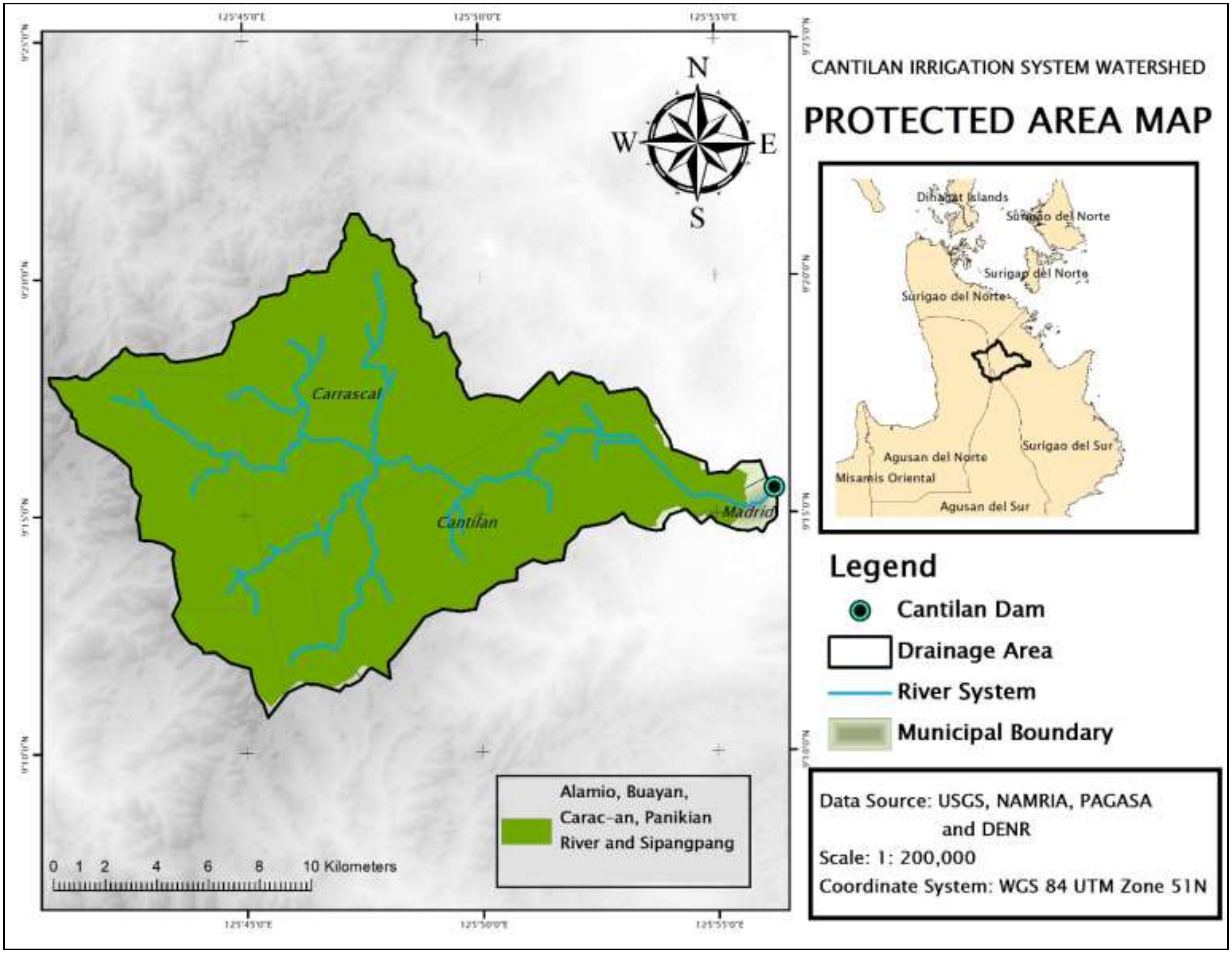


Figure 2-19 Protected Area Map

2.9 Key Biodiversity Area

The Philippines, one of the 17 mega-diverse nations, is faced with the issue of putting plans in place to stop habitat degradation and species extinction. The Philippines is home to a number of endemic wildlife species. The country's biodiversity and endemism are seriously threatened. The amount of original forest in the Philippines has dramatically decreased over the past few years, and the IUCN Red List has seen an increase in the number of internationally threatened species. An effective framework for determining fine-scale conservation priorities in the Philippines is provided by the "Key Biodiversity Area" (KBA) approach. The foundation for planning landscape-level conservation and upholding efficient ecological networks to stop biodiversity loss is provided by these internationally important and conservation priority sites (**Table 2.38**).

Identification, documentation, and protection of a network of sites for the conservation of globally significant biodiversity are the objectives of the KBA strategy (those assessed as critically endangered according to IUCN Red List). Using the two conservation planning principles of irreplaceability and vulnerability, Important Biodiversity Areas are defined:

Criteria: 1. Vulnerability is measured by the confirmed presence of one or more globally threatened species categorized as:

- **Endemic species** – species unique to a defined geographic location, such as an island, nation, country or other defined zone, or habitat type.
- **Congregatory species** – species that gathers in large numbers at specific sites at some stage in their life cycle for feeding, breeding or resting during migration (e.g., boobies, spoon bill, heron, great egret, Philippine duck)

Criteria: 2. Irreplaceability is determined through the presence of geographically concentrated species: the extent to which the loss of an area will compromise conservation targets.

Table 2-38 Key Biodiversity Area

Terrestrial Key Biodiversity Area	Area (ha.)	Percent Share
Mt. Hilong-hilong	21,717.30	91.39%

The Haribon Foundation and Birdlife International's list of 117 Important Bird Areas (IBAs) for the Philippines and the Philippine Biodiversity Conservation Priority-setting Program's list of 206 Conservation Priority Areas (CPAs) serve as the foundation for identifying KBAs across the country (CPHM, 2017).

In the Philippines, Mt. Hilong-Hilong has been designated as a Key Biodiversity Area (KBA). KBAs are globally recognized sites with high biodiversity concentrations that are critical for the conservation of threatened species and ecosystems. Mt. Hilong-Hilong is located in Mindanao Island's CARAGA region and is recognized as one of the most important conservation sites in the Philippines. It is home to a wide variety of flora and fauna, including several endangered and endemic species like the Philippine eagle, Mindanao flying squirrel, and Philippine tarsier (**Figure 2.20**).

Mt. Hilong-Hilong's status emphasizes the importance of conserving and protecting the site's unique biodiversity. Threats to the site include deforestation, illegal logging, mining, and hunting, which can disrupt its ecological balance and endanger the survival of its species.

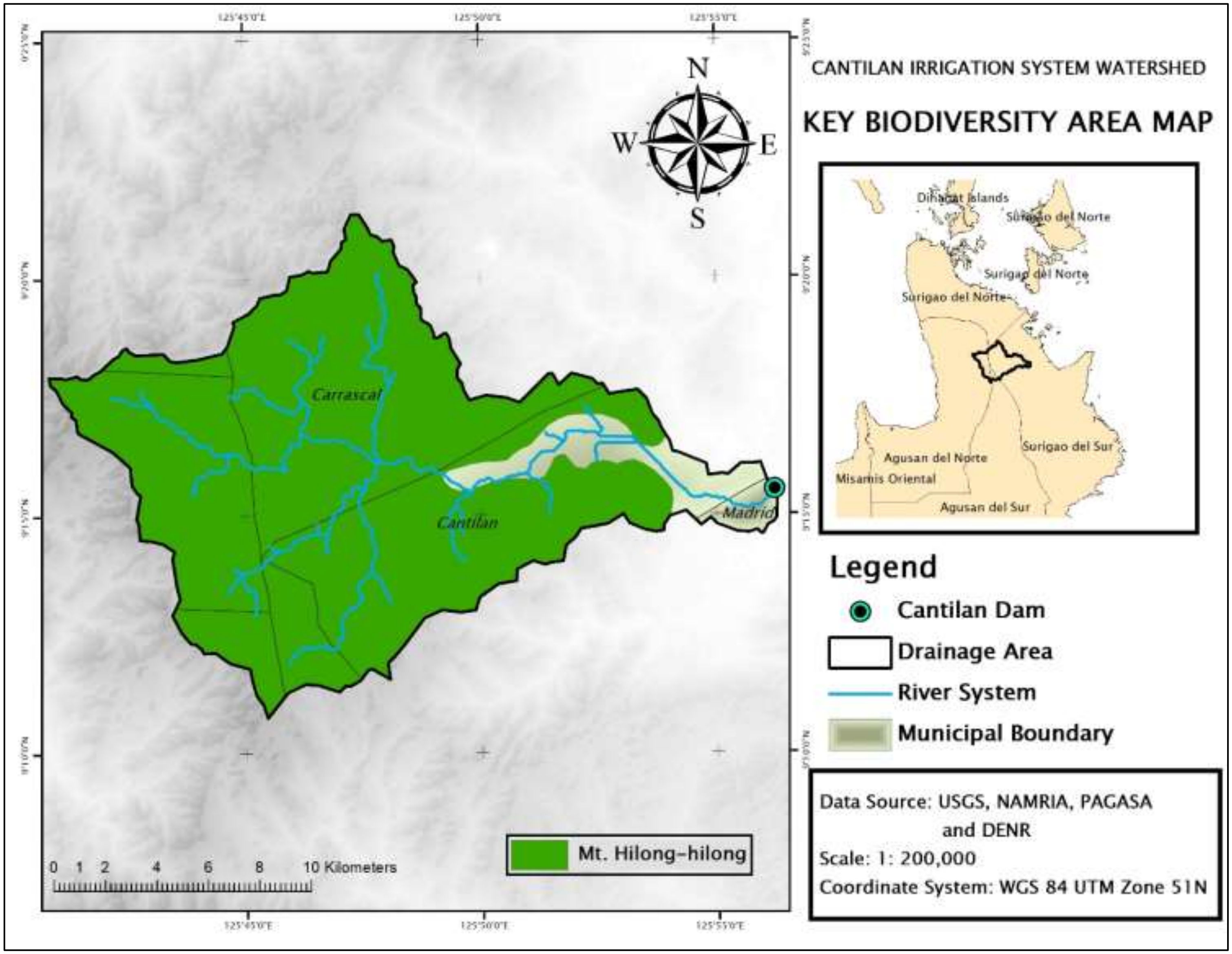


Figure 2-20 Key Biodiversity Areas Map

2.10 Hydrology and Water Quality

Hydrology and water quality are critical components of a watershed because they are inextricably linked and play critical roles in maintaining ecosystem health and the sustainability of human activities that rely on them. Some of the reasons why hydrology and water quality are important in a watershed are as follows:

- A watershed is an important source of water for human consumption, agriculture, and other uses. Understanding a watershed's hydrology can help ensure a consistent and reliable supply of water for various purposes.
- **Flood control**: A watershed's hydrological characteristics influence the flow of water and its potential for flooding. Understanding a watershed's hydrology allows for measures to be taken to reduce the risk of flooding and its consequences.
- **Erosion control**: In a watershed, proper land use and management practices can help prevent soil erosion, which can degrade water quality and endanger aquatic ecosystems.
- **Water quality**: The quality of water in a watershed is critical for aquatic life and human activities like recreation and fishing. Water quality monitoring and management in a watershed can help prevent pollution and ensure the health of ecosystems and the communities that rely on them.
- **Protecting habitat**: A watershed's diverse habitats, such as wetlands, riparian zones, and other aquatic and terrestrial ecosystems, rely on healthy water quality and hydrology. It is critical to protect these habitats in order to preserve biodiversity and promote sustainable development.

2.10.1 Water Quality Testing Result

Water quality sampling stations were established in strategic locations within the CANTIS to examine its current state. Physical and chemical parameters were measured to identify which of the following classifications these parameters fall through. The field observation was done on November 20, 2022. The sampling stations are composed of upstream, midstream, and downstream sampling stations. The data gathered from these sampling stations are subjected to water quality analysis (**Figure 2.21-2.24 & Table 2.39**).

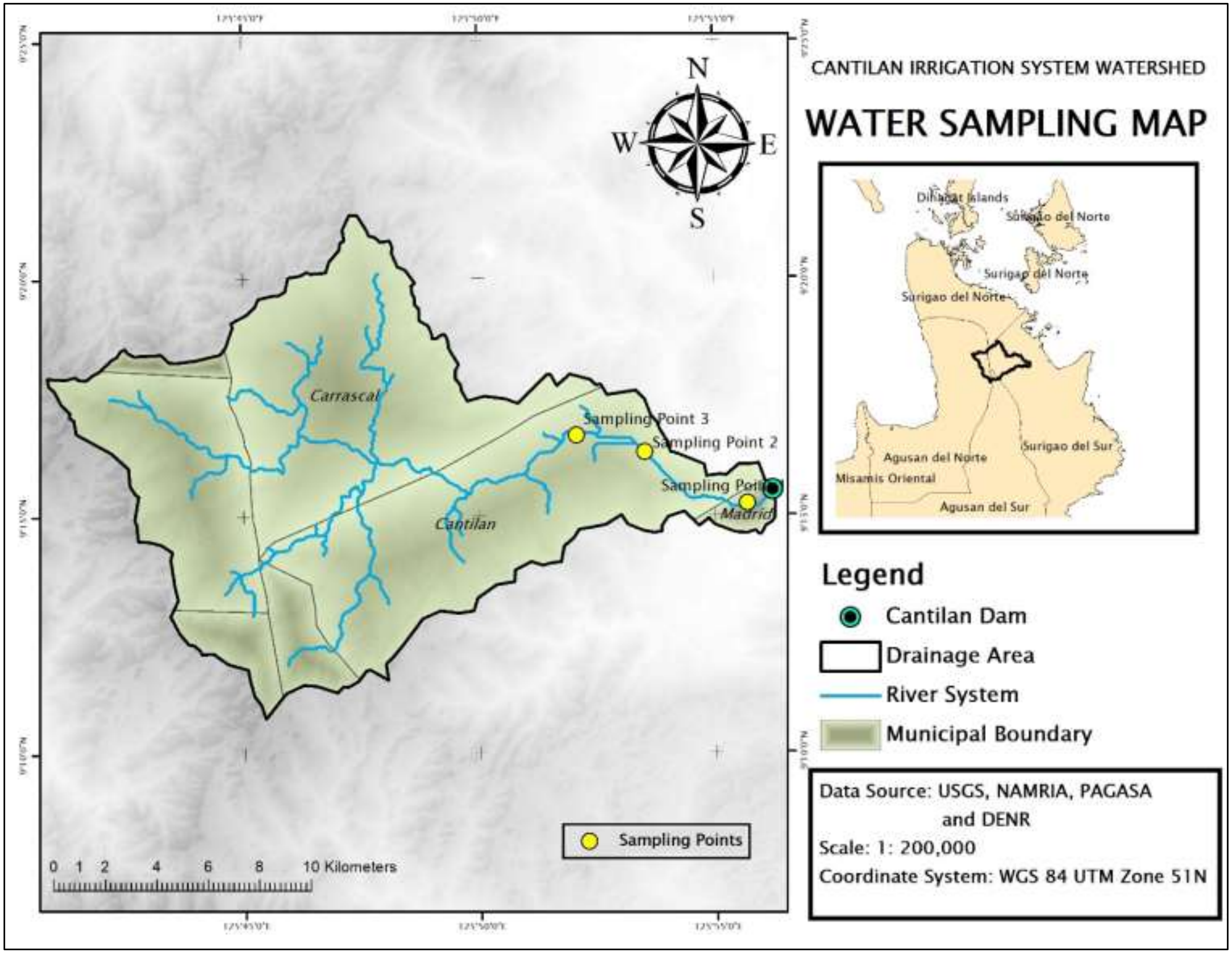


Figure 2-21 Water Sampling Locations

The parameters tested were Dissolved Oxygen (DO), Total Suspended Solids (TSS), and Temperature (℃), Conductivity (C-μS/cm), Turbidity (NTU), and Chlorophyll (μg/L). The stations were probed using the YSI Multiparameter Water Quality Meter.

Table 2-39 Water Quality Sampling Points

Station ID	Location	Location		Classification
		Latitude	Longitude	
1	Cantilan, Caraga, Surigao Del Sur (Downstream)	9°15'34"	125°56'16"	C
2	Cabangahan, Surigao Del Sur (Midstream)	9°17'33"	125°57'42"	C
3	Carrascal, Caraga, Surigao Del Sur (Upstream)	9°16'45"	125°53'25"	C

Figure 2-22 Water sampling (Downstream)

Figure 2-23 Water sampling (Midstream)

Figure 2-24 Water sampling (Upstream)

According to the guidelines set by the DENR in DAO 2016-08 (**Table 2.40**), the surface water bodies are classified according to the most suitable use, as shown in the table below. The guidelines follow the idea of maintaining water quality to its intended beneficial usage. The standard set for each parameter is used as a benchmark for maintaining water quality in accordance with such classification.

Table 2-40 DENR Water Quality Guidelines

Classification	Intended beneficial use
Class AA	**Public Water Supply Class I -** Intended primarily for waters having watersheds, which are uninhabited and/or otherwise declared as protected areas, and which require only approved disinfection to meet the latest PNSDW
Class A	**Public Water Supply Class II -** Intended as sources of water supply requiring conventional treatment (coagulation, sedimentation, filtration, and disinfection) to meet the latest PNSDW
Class B	**Recreational Water Class I -** Intended for primary contact recreation (bathing, swimming, etc)
Class C	**Fishery Water** - for propagation and growth of fish and other aquatic resources **Recreational Water Class II** - For boating, fishing, or similar activities **For Agriculture -** irrigation and livestock watering
Class D	**Navigable Waters**

The following table summarizes the results of water quality sampling at three (3) sampling stations located in different barangays near the CANTIS. The obtained values were compared to the DENR AO No. 2016-08 standard limit for Class C Water (**Table 2.41**).

Table 2-41 Water Quality Results

Cantilan Irrigation System			Station 1	Station 2	Station 3
Parameters	**Units**	**Limit**			
Dissolved Oxygen	mg/L	5	8.66	8.17	8.32
Temperature	°C	25-31	23.8	24.4	24.1
Conductivity	(C-μS/cm)	0 - 1,500	165.56	178.83	183.83
Total Dissolved Solids	(mg/L)	50 - 1,000	110.06	117.63	121.41
Turbidity	(NTU)	≤ 5	-	0.79	0.44
Chlorophyll	(μg/L)	< 25	-	-	-

2.10.1.1 Dissolved Oxygen

Dissolved oxygen levels are important for aquatic life in any water body. It is crucial for the survival of fishes and other organisms (EPA USA, 2022). In terms of irrigation, water with higher concentrations of dissolved oxygen will increase the performance of crops, specifically greenhouse crops. While 5 mg/L is considered acceptable for plant growth, 8 mg/L is considered healthy. In terms of aquaculture, the minimum required level of Dissolved Oxygen is 5 mg/L. The set limit of DENR has classified 5 mg/L as Class C water. Dissolved Oxygen in all sampling stations exceeds the set limit value for class C water. The levels of dissolved oxygen are favorable for irrigation water of greenhouse crops. The sampling stations are also conducive for aquaculture activities.

2.10.1.2 Temperature

Temperature plays an important role in predicting the levels of other water quality parameters, such as dissolved oxygen levels, pH, and survival of other organisms such as phytoplankton. (Fondriest, 2014). The level of temperature affects the speed at which biochemical reactions take place.

The recorded temperatures were in the range of Class C water in accordance to the set guidelines of DENR. The recorded temperature is between 23.8 - 24.4 degrees Celsius.

2.10.1.3 Conductivity

Conductivity is a good parameter in which water quality can be assessed. Water can transport electricity just like metals if it has salts in it. Conductivity is an indirect measure of saltiness of water and pollution since industrial and human waste water often has high conductivity. Low conductivity ranging from 0 to 200 (C-µS/cm) is considered as clean or background conditions. 200 to 1000 is the normal range for most major rivers. Conductivity outside this range could indicate that the water is not suitable for certain species of fish or bugs. High conductivity (1000 to 10,000 µS/cm) is an indicator of saline conditions. Waters that have been heavily impacted by industry can fall into this range.

The values of conductivity for all sites falls within the clean conditions which can maintain aquatic life and be used for irrigation purposes.

2.10.1.4 Total Dissolved Solids

Total Dissolved Solids are different from Total Suspended Solids. Dissolved solids refer to the minerals that are dissolved in water.

The quantity of total dissolved solids in drinking water influences its taste. TDS levels beyond a certain threshold can cause water to taste bitter, salty, or brackish. However, total dissolved solids levels have a considerably greater impact on animals than on people. Higher amounts of total dissolved solids in bodies of water, such as rivers, frequently affect aquatic life. TDS alters the mineral content of water, which is critical for the survival of many creatures. Furthermore, dissolved salt can dry aquatic creatures' skin, which can be lethal. It can raise the temperature of the water, making it unsuitable for many species.

The levels of TDS of the sampling stations were at levels of being classified as safe and can be used for irrigation and be treated for drinking. Any level below 500 is considered safe for drinking.

2.10.1.5 Turbidity

Turbidity is directly related to Total Suspended Solids. Turbidity is the measure of how cloudy the water is in terms of its appearance. Thus, the cloudier the water is means there are more suspended solids in the water. The relation between NTU and Suspended Solids follows that for every 1 mg/L is equivalent to 3 NTU units.

The following values of turbidity for all stations are within the safe mark for treatable drinking water and irrigation having very low NTU units.

2.10.1.6 Chlorophyll

Chlorophyll allows plants and algae to photosynthesize by way of sunlight for their growth. Higher chlorophyll concentrations may mean higher algae biomass which degrades the water quality of a waterbody. (Indicators: Chlorophyll a | US EPA, 2022). The tested sampling sites did not have any high amounts of chlorophyll concentrations which means that the water on the sites is clean and safe.

2.11 Infrastructure

The province of Surigao del Sur has begun a number of infrastructure development projects, including the construction and rehabilitation of roads, bridges, ports, airports, and other public facilities. The Surigao del Sur Circumferential Road is one of the major projects underway in the province, with the goal of improving connectivity and promoting trade and commerce with other areas in the region. The development of the Bislig Airport is another significant infrastructure project that will improve access to the province for tourists and investors. In addition, there are plans to improve the province's water supply and sanitation systems, as well as to build new public facilities such as schools and hospitals.

Surigao del Sur infrastructure development is also guided by sustainable development principles, with a focus on minimizing the negative impacts of infrastructure on the environment and local communities. Initiatives to promote the use of renewable energy, reduce carbon emissions, and protect biodiversity and natural resources are among those included.

Primary roads are within the Cantilan, Carrascal and Madrid, while secondary and tertiary roads are the most common type of road network present in the project area (**Figure 2.25**).

The secondary road network refers to a complex system of interconnected roadways that are larger in scale than local roads but not as extensive as major highways. These roads serve as links between different towns and municipalities, providing easy access to essential services. On the other hand, tertiary roads are smaller in size and primarily connect villages, or barangays, to the aforementioned secondary roads. These tertiary roads provide entry to built-up areas and encroachments within the CANTIS. In the watershed, these road networks mainly provide access of the residential dwellings and mining sites. To reference to the stability of the watershed, human settlements might induce a manageable affect to the watershed thus, mitigating strategies could be used to minimize their impact. This involves implementing measures to control erosion, managing waste effectively, and carrying out reforestation initiatives systematically. However, the presence of mining sites has a significant impact. Mining activities contribute to soil erosion, water contamination, and habitat degradation, potentially disrupting the watershed and affecting both its ecological aspects and the continuity of water supply.

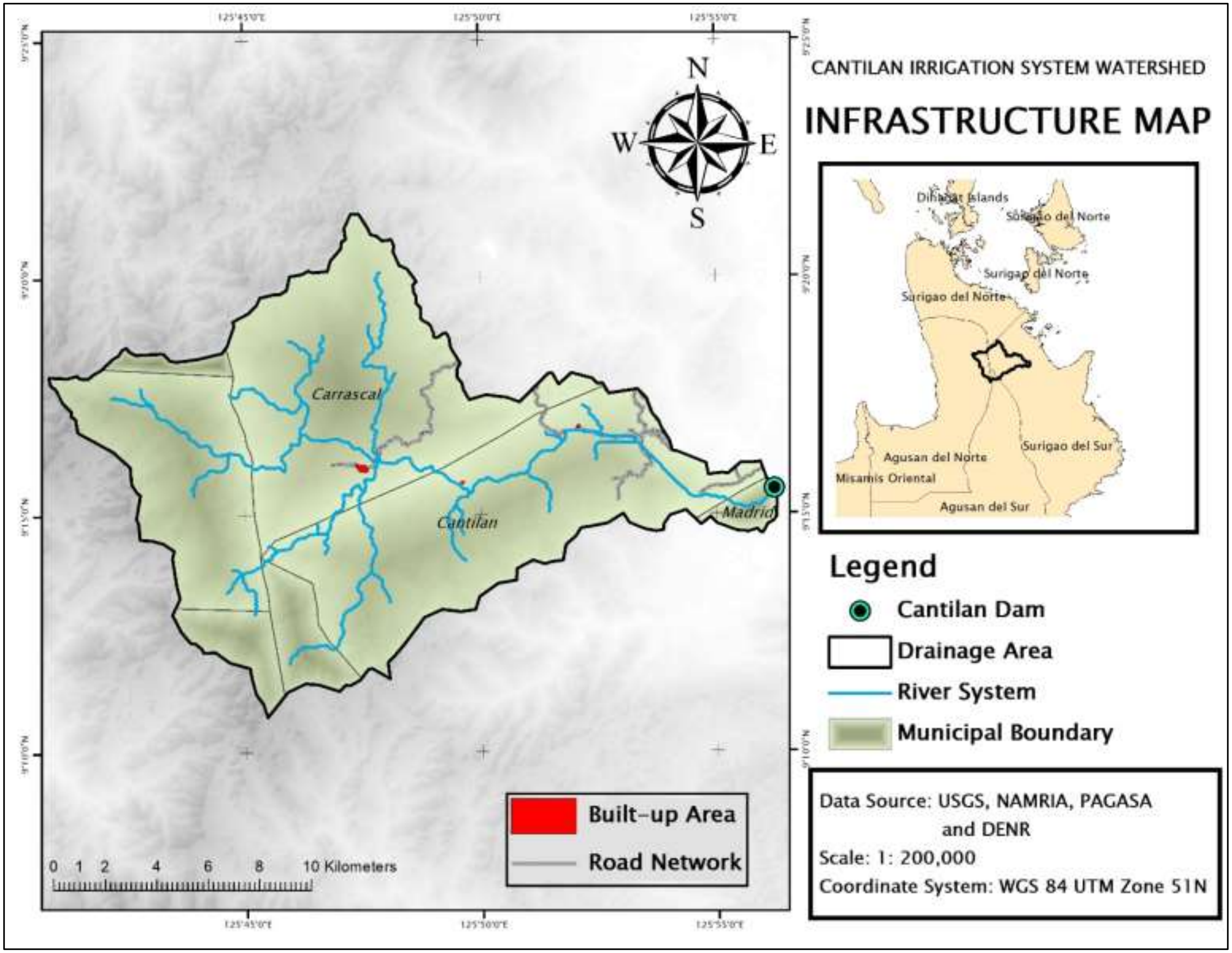


Figure 2-25 Infrastructure Map

2.12 Meteorology

Surigao del Sur is a province in the Philippines located in the eastern part of Mindanao Island. The climate is tropical, with two distinct seasons: wet and dry. Surigao del Sur is also in the typhoon belt, making it vulnerable to severe weather events like typhoons and tropical storms. Landslides and flooding are common in the province, particularly in low-lying areas and those with steep slopes.

2.12.1 Climate Type

Like most parts of Mindanao, Cantilan enjoys a tropical climate. It has an average monthly precipitation of 308.66 mm during its wettest season from November to March. The dry season falls between April and September with brief afternoon showers and thunderstorms. The municipality of Cantilan has one major river (Carac-an River) lined by a narrow strip of patchy mangroves. Silt loading into the coast of Cantilan through this river is minimal, however, mining activities in the neighboring town of Carrascal may increase siltation on coral reefs and seagrass beds.

Like the rest of the province of Surigao del Sur the climate of Cantilan falls under Type II (**Table 2.42 & Figure 2.26**) climatic type characterized by year-round distribution of rainfall, although there is a distinct rainy season which generally begins in the month of November and ends in March. Months with low rainfall are from July to October with September as the driest month. Wet months are from November to June with January as the wettest month. In recent years, however, the climatic behavior of the province had been variable with a more prominent rainy season and increased frequency and severity of storms.

Table 2-42 Climate Type of CANTIS

Climate Type	Area (ha.)	Percent Share
Type II Climate	23,763.69	100%

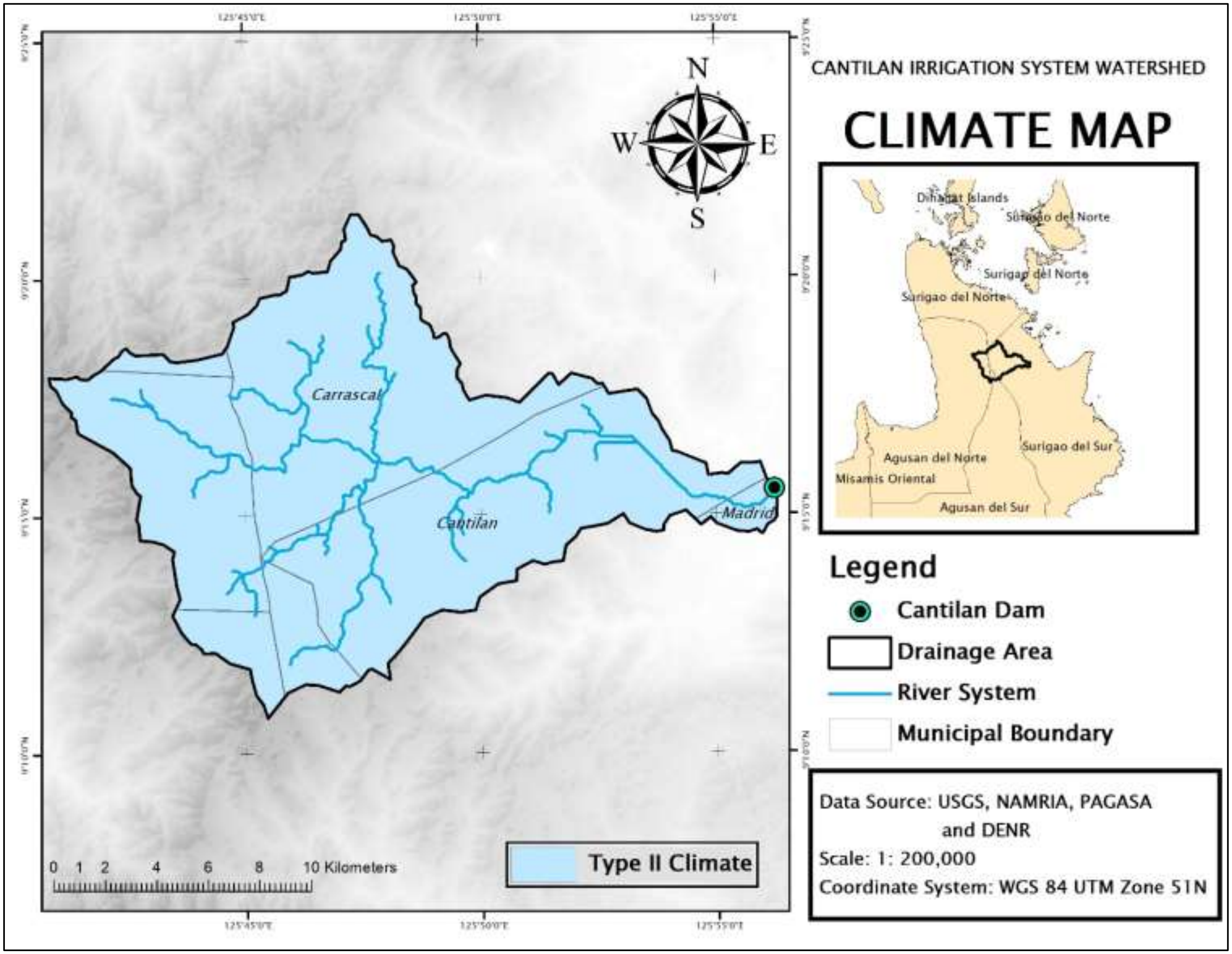


Figure 2-26 Climate Map

2.12.2 Temperature

Throughout the year, the average temperature in Surigao del Sur ranges from 23 to 32 degrees Celsius (73.4 to 89.6 degrees Fahrenheit). April and May are typically the hottest months, with average temperatures ranging from 26 to 32 degrees Celsius (78.8 to 89.6 degrees Fahrenheit). Meanwhile, December and January are typically the coolest months, with average temperatures ranging from 23 to 28 degrees Celsius (73.4 to 82.4 degrees Fahrenheit).

The coldest month was recorded in February with 17.5°C. The mean annual temperature recorded at Butuan Synoptic Station was 27.5°C while the warmest month was recorded in July with 37.7°C (DOST-PAG-ASA, Butuan City).

2.12.3 Rainfall

The province receives an average annual rainfall of 2,000 to 4,000 millimeters, with the most precipitation falling during the wet season, which typically lasts from June to November. Surigao del Sur experiences frequent and heavy rainfall during this period, which frequently causes floods and landslides.

Surigao del Sur, on the other hand, has a dry season from December to May, with lower rainfall amounts. Even during this season, however, the province may still see some rain due to weather disturbances and other factors (**Table 2.43**).

Table 2-43 Number of Rainy Days recorded at Butuan Synoptic Station

Month	2013		2014		2015	
	Rainfall (Mm)	No. of Rainy Days	Rainfall	No. of rainy days	Rainfall	No. of Rainy Days
January	1077.8	27	1372.1	27	715.8	23
February	666.6	24	331.8	19	391.8	21
March	379.9	22	540.8	24	233.8	20
April	474.7	21	77.7	12	156.3	16
May	264.7	16	271.6	24	96.2	8
June	380.9	16	89.2	17	297.8	19
July	384.0	19	166.8	14	157.1	7
August	393.2	18	173.2	11	180.5	13
September	46.8	9	189.7	10	344.8	23

Month	2013		2014		2015	
	Rainfall (Mm)	No. of Rainy Days	Rainfall	No. of rainy days	Rainfall	No. of Rainy Days
October	376.7	20	145.1	15	155.6	12
November	528.8	24	242.5	19	755.0	28
December	392.5	23	1034.3	22	375.9	24
Total	**5366.6**	**239**	**4634.8**	**214**	**3860.6**	**214**
Average	**447.22**	**20**	**386.2**	**18**	**321.7**	**18**

2.12.4 Climatological Extremes

The annual and monthly summary of extreme climatic events of temperature, rainfall, and wind speed is shown in the Butuan Synoptic Station record. Annual extreme high temperatures of 37.8°C were recorded on April 18, 1992 and May 25, 1992, while the coldest temperature of 17.5°C was recorded on February 6, 1982. The annual average of massive rainfall is 271.6 mm, which occurred on January 4, 1985, and the annual average of wind speed is 30 meters per second, which occurred on August 31, 1997 and September 5, 1990 (**Table 2.44**).

Table 2-44 Climatological Extremes

Month	Temperature (°c)				Greatest Daily Rainfall (Mm)		Strongest Winds (Mps)			Sea Level Pressures (Mbs)			
	High	Date	Low	Date	Amount	Date	Spd	Dir	Date	High	Date	Low	Date
JAN	35.4	01-16-1998	18.3	01-04-1991	271.6	01-04-1985	18	ESE	01-03-1983	1020.7	01-27-1983	999.9	01-05-1999
FEB	35.3	02-18-1998	17.5	02-26-1992	160.4	02-08-2007	18	E	02-27-1983	1020.5	02-23-1983	1002.0	02-28-2011
MAR	35.8	03-23-1992	18.5	03-09-1987	119.7	03-06-2008	18	E	03-01-1983	1022.4	03-02-1984	1002.0	03-25-1982
APR	37.8	04-18-1992	20.0	04-22-1990	168.0	04-03-1994	22	NW	04-24-1991	1020.5	04-14-1993	1002.8	04-23-1999
MAY	37.8	05-25-1992	18.0	05-26-1990	58.2	05-08-2001	15	WNW	05-07-2000	1016.5	05-12-1998	999.0	05-16-1989
JUNE	37.6	06-20-1998	18.5	06-16-1990	118.0	06-20-2013	22	N	06-18-1990	1016.8	06-20-1987	1000.7	06-17-2007
							22	SE	06-01-2015				
JULY	37.7	07-03-1992	17.5	07-07-1980	108.8	07-15-1983	22	NW	07-22-1982	1017.0	07-03-1987	999.6	07-03-2001
AUG	36.1	08-30-1992	19.0	08-11-1990	93.9	08-11-1990	30	WNW	08-31-1997	1017.5	08-18-9193	999.4	08-01-1989
SEP	36.4	09-20-1991	19.0	09-23-1983	131.8	09-10-1995	30	W	09-05-1990	1018.2	09-10-1993	999.5	09-09-1989
OCT	36.3	10-25-1987	20.0	10-06-1989	107.4	10-24-2003	24	N	10-03-1990	1019.1	10-05-1987	999.8	10-10-1989
NOV	35.5	11-26-1982	18.5	11-08-1989	191.4	11-29-1988	19	NNW	11-18-1989	1017.7	11-29-1992	998.2	11-05-1996
DEC	35.2	12-20-1998	18.5	12-21-1986	171.8	12-25-1993	26	SE	12-04-2012	1020.0	12-30-1992	999.5	12-26-1993
ANNUAL	**37.8**	**04-18-1992**	**17.5**	**02-26-1992**	**271.6**	**01-04-1985**	**30**	**WNW**	**08-31-1997**	**1022.4**	**03-02-1984**	**998.2**	**11-05-1996**
	37.8	**05-25-1992**	**17.5**	**07-07-1980**			**30**	**W**	**09-05-1990**				
Period of Record	**1980 - 2016**				**1980 - 2016**		**1980 - 2016**			**1980 - 2016**			

2.12.5 Climatological Normals

Butuan Synoptic Station recorded an annual temperature of 37.8 degrees Celsius. May and April have the highest average temperature of 37.8 degrees Celsius, while December has the lowest average temperature of 35.2 degrees Celsius. Butuan Synoptic Station has an average relative humidity of 81%. June to September are typically the wettest months, with average relative humidity ranging from 83% to 85%. During the northeast monsoon season (November to April), the prevailing winds at Butuan Synoptic Station are from the northwest to north northwest, and from the west northwest to the north during the southwest monsoon season (May to October). The average wind speed is 23.83 mps (**Table 2.45**).

Table 2-45 Climatological Normals

MONTH	RAINFALL		TEMPERATURE						VAPOR PRESS. (mbs)	RH (%)	MSLP (mbs)	WIND		CLOUD AMT. (okta)	NO. OF DAYS W/	
	AMOUNT (mm)	NO. OF RD	MAX (°C)	MIN (°C)	MEAN (°C)	DRY BULB (°C)	WET BULB (°C)	DEW POINT (°C)				DIR (16pt)	SPD (mps)		TSTM	LTNG
JAN	318	21	30.2	22.5	26.3	25.9	24.4	23.8	29.5	88	1012	NW	1	6	2	2
FEB	225	16	30.8	22.5	26.6	26.2	24.3	23.6	29.1	85	1013	NW	1	6	2	1
MAR	145.4	16	31.8	22.8	27.3	26.9	24.7	23.9	29.6	84	1012	NW	1	6	4	2
APR	109.7	13	33.1	23.5	28.3	27.8	25.4	24.6	30.8	82	1011	ESE	1	5	7	6
MAY	115.5	10	33.7	24.2	28.9	28.4	25.9	25.1	31.7	82	1011	ESE	1	5	14	14
JUN	154	17	33.1	24	28.5	28	25.7	24.9	31.4	83	1010	ESE	2	6	14	15
JUL	143.9	16	32.6	23.7	28.2	27.7	25.5	24.7	31.1	84	1010	NNW	2	6	13	16
AUG	105.6	13	32.9	23.9	28.4	28	25.5	24.6	30.9	82	1010	NNW	2	6	11	16
SEP	126.3	14	32.9	23.7	28.3	27.9	25.5	24.7	31	82	1011	NNW	2	6	14	18
OCT	178.4	16	32.4	23.6	28	27.6	25.5	24.8	31.2	84	1011	NW	2	6	15	17
NOV	197.9	18	31.7	23.4	27.5	27	25.2	24.6	30.8	86	1011	NW	1	6	9	12
DEC	238.2	20	30.8	22.9	26.9	26.4	24.8	24.2	30.2	88	1012	NW	1	6	4	6
ANNUAL	**2057.8**	**194**	**32.2**	**23.4**	**27.8**	**27.3**	**25.2**	**24.5**	**30.6**	**84**	**1011**	**NW**	**1**	**6**	**109**	**125**

2.13 Biological Resources

2.13.1 Biological Resources in Cantilan Irrigation System Watershed (Primary data)

Biodiversity and ecological balance rely heavily on biological resources. They provide habitat and food for a wide variety of species, which are important components of ecosystem functions like nutrient cycling, pollination, and pest control. Ecosystems would become unbalanced without these resources, resulting in a slew of environmental issues. Furthermore, biological resources have a high economic value. They provide raw materials for a variety of industries, including construction and paper production, as well as medicinal plants for pharmaceuticals. These industries contribute significantly to the economy by creating jobs and boosting local communities. Food security also requires biological resources. They lay the groundwork for food production, which includes crops, livestock, and fisheries. They also supply genetic resources for crop improvement, such as the development of disease-resistant varieties. Food production would be severely limited without these resources, resulting in food shortages and malnutrition.

This section (2.12) discusses the results of the original data collected by the study team firsthand from the field. The primary data gathering involves direct observations, surveys, conducted by the team to gather information on species composition, abundance, distribution, habitat characteristics, and ecological interactions.

2.13.1.1 Flora

Information on forest plants and land resources was from DENR Regional and Field Offices. The main references are Biodiversity Assessment and Monitoring System (BAMS) reports and general or indicative management plan of the CANTIS watershed. Expected data from the indicative management plan include current forest resources, particularly inventory of flora in different land uses, estimates of corresponding biomass and many others. Published floristic studies in the area will also be considered.

Secondary data was augmented by performing rapid field appraisals (e.g., preferential cum quadrat sampling technique) in identified important locations (**Figure 2.27**). There are six (6) 20x20m sampling plots that was established along selected rivers, specifically in the downstream, midstream, and upstream portions, relative to the location of the NIA dam including the southern portions of the watershed to represent the general floral composition of the area. In each sampling plot, species identification and count were recorded for trees, while species identification was noted for other plant types (e.g., crops, shrubs and grasses).

Additionally, the dominant crops, keystone species and endangered floral species were recorded within ocular reach in the sampling areas.

Noteworthy Species includes the species endemism, indigeneity, and conservation status of identified plants were based on the International Union for Conservation of Nature (IUCN) and DAO 2017-11 (Updated National List of Threatened Philippine Plants and their Categories), and Leonard Co's Digital Flora of the Philippines (Pelser, Barcelona, & Nickrent, 2011).

The floral composition assessment of CANTIS involved primary data gathering in six sampling plots, which had a combined area of 0. 4 hectares or 2,400 square meters, along transect lines that also included fauna resources. To describe the current state of flora and fauna in the area, SECI performed rapid field appraisal in identified important locations. In general, a preferential cum Quadrat Sampling Technique was used where six (6) 20x20m sampling plots was established in the downstream, midstream, and upstream portions, relative to the location of the NIA dam. In each sampling plot, species identification and count were recorded for trees, while species identification was noted for other plant types (e.g., crops, shrubs, and grasses) (**Table 2.46**).

The location of each sampling plot was recorded using a handheld GeoCam application that utilized the World Geodetic Systems 1984 (WGS 84) datum/reference, which is a standard geo-tagging and locational survey reference.

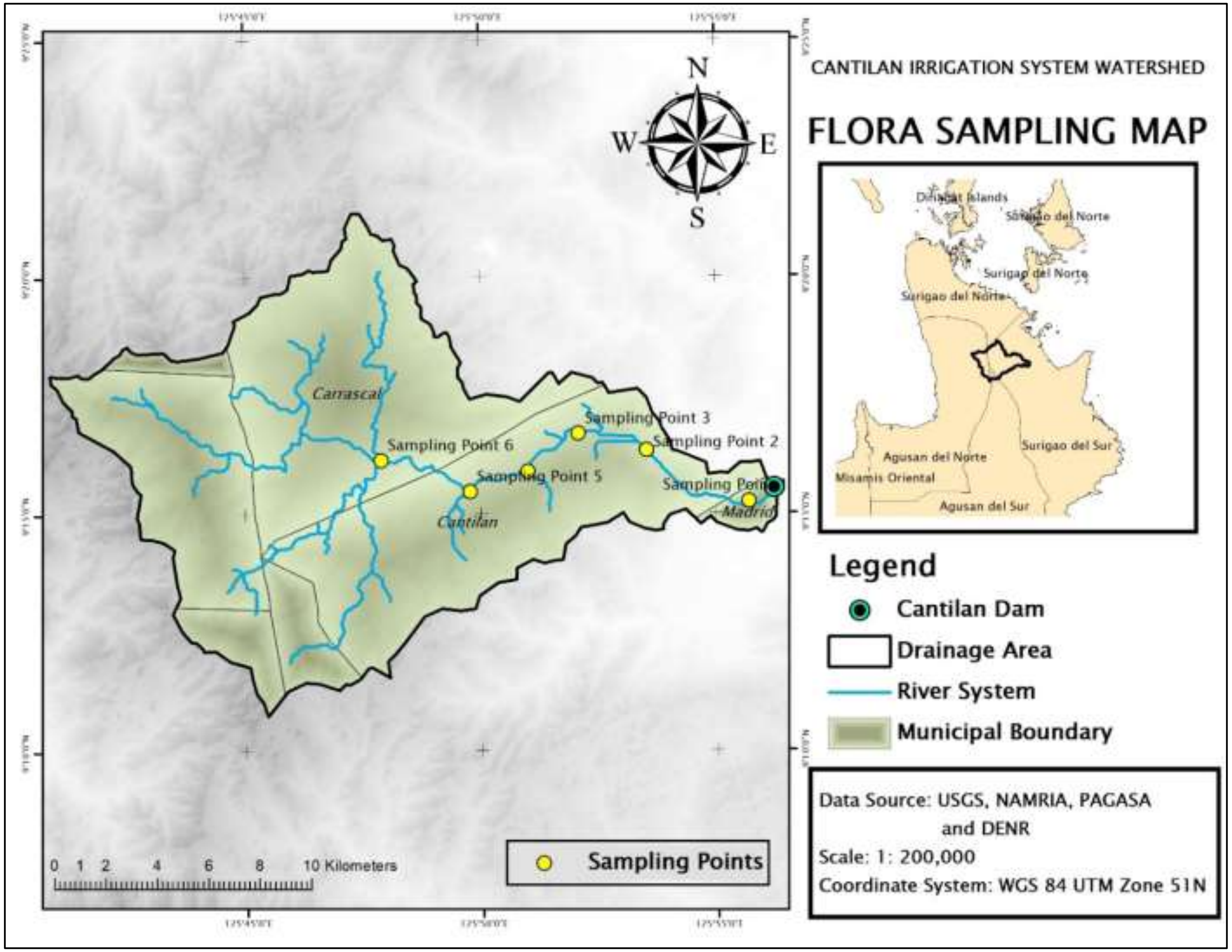


Figure 2-27 Flora Sampling Map

Table 2-46 Flora of CANTIS

Species	Common Name	No. of Individuals	Density	Dominance	No. of Quadrats Occurred	Frequency	Rden	Rdom	RF	IV	*pi*	*ln(pi)*	*pi*lnpi*
Brachystegia leonensis	Naga	1	0.0004	0.0177	1	0.1667	1.1236	0.7524	1.7857	3.6617	0.0112	-4.4886	-0.0504
Aleurites moluccana	Lumbang		0.0000		0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000		0.0000
Alstonia macrophylla	Batino	2	0.0008	0.0569	2	0.3333	2.2472	2.4243	3.5714	8.2429	0.0225	-3.7955	-0.0853
Annona muricata	Guayabano	2	0.0008	0.0982	2	0.3333	2.2472	4.1798	3.5714	9.9984	0.0225	-3.7955	-0.0853
Areca catechu	Bunga		0.0000		0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000		0.0000
Arenga pinnata	Kaong	1	0.0004	0.0452	1	0.1667	1.1236	1.9260	1.7857	4.8353	0.0112	-4.4886	-0.0504
Artocarpus blancoi	Antipolo	4	0.0017	0.1257	3	0.5000	4.4944	5.3501	5.3571	15.2016	0.0449	-3.1023	-0.1394
Artocarpus ovatus	Anubing	3	0.0013	0.1275	1	0.1667	3.3708	5.4303	1.7857	10.5868	0.0337	-3.3900	-0.1143
Bambusa vulgaris	Kawayang Kiling	1	0.0004	0.0000	1	0.1667	1.1236	0.0000	1.7857	2.9093	0.0112	-4.4886	-0.0504
Cananga odorata	Ilang-ilang	1	0.0004	0.0254	1	0.1667	1.1236	1.0834	1.7857	3.9927	0.0112	-4.4886	-0.0504
Ceratopteris calomelanos	Pakong sundang	1	0.0004	0.0000	1	0.1667	1.1236	0.0000	1.7857	2.9093	0.0112	-4.4886	-0.0504
Cocos nucifera	Niyog	3	0.0013	0.0716	2	0.3333	3.3708	3.0496	3.5714	9.9918	0.0337	-3.3900	-0.1143
Combretum indicum	Rangoon creeper		0.0000		0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000		0.0000
Cordia myxa	Assyrian plum	2	0.0008	0.0491	1	0.1667	2.2472	2.0899	1.7857	6.1228	0.0225	-3.7955	-0.0853
Costus speciosus	Tubang-usa		0.0000		0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000		0.0000
Cratoxylum sumatranum	Paguringon	3	0.0013	0.0763	1	0.1667	3.3708	3.2502	1.7857	8.4067	0.0337	-3.3900	-0.1143
Dendrocnide meyeniana	Lipang kalabau	2	0.0008	0.0431	1	0.1667	2.2472	1.8358	1.7857	5.8687	0.0225	-3.7955	-0.0853
Diplazium esculentum	Pako		0.0000		0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000		0.0000
Diplodiscus paniculatus	Balobo	1	0.0004	0.0177	1	0.1667	1.1236	0.7524	1.7857	3.6617	0.0112	-4.4886	-0.0504
Dipterocarpus glandiflorus	Apitong	1	0.0004	0.0254	1	0.1667	1.1236	1.0834	1.7857	3.9927	0.0112	-4.4886	-0.0504
Dracontomelon dao	Dao	1	0.0004	0.0415	1	0.1667	1.1236	1.7689	1.7857	4.6782	0.0112	-4.4886	-0.0504
Durio zibethinus	Durian	1	0.0004	0.0284	1	0.1667	1.1236	1.2071	1.7857	4.1164	0.0112	-4.4886	-0.0504
Dysoxylum gaudichaudianum	Igyo	1	0.0004	0.0491	1	0.1667	1.1236	2.0899	1.7857	4.9992	0.0112	-4.4886	-0.0504
Etlingera elatior	Torch ginger		0.0000		0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000		0.0000
Falcataria falcata	Falcata	1	0.0004	0.0254	1	0.1667	1.1236	1.0834	1.7857	3.9927	0.0112	-4.4886	-0.0504

Species	Common Name	No. of Individuals	Density	Dominance	No. of Quadrats Occurred	Frequency	Rden	Rdom	RF	IV	*pi*	*ln(pi)*	*pi*lnpi*
Ficus minahassae	Hagimit	1	0.0004	0.0284	1	0.1667	1.1236	1.2071	1.7857	4.1164	0.0112	-4.4886	-0.0504
Ficus nota	Tibig		0.0000		0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000		0.0000
Ficus ulmifolia	Is-is		0.0000		0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000		0.0000
Pterocarpus indicus for. *indicus*	Narra	2	0.0008	0.0402	1	0.1667	2.2472	1.7120	1.7857	5.7449	0.0225	-3.7955	-0.0853
Gliricidia sepium	Kakauate	10	0.0042	0.2649	4	0.6667	11.2360	11.2787	7.1429	29.6575	0.1124	-2.1861	-0.2456
Gmelina arborea	Yemane	4	0.0017	0.1144	2	0.3333	4.4944	4.8686	3.5714	12.9344	0.0449	-3.1023	-0.1394
Gnetum gnemon	Bago	1	0.0004	0.0201	1	0.1667	1.1236	0.8560	1.7857	3.7653	0.0112	-4.4886	-0.0504
Justicia carnea	Brazilian Plume		0.0000		0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000		0.0000
Bambusa vulgaris	Kawayang Kiling	1	0.0004	0.0000	1	0.1667	1.1236	0.0000	1.7857	2.9093	0.0112	-4.4886	-0.0504
Leucaena leucocephala	Ipil-ipil		0.0000		0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000		0.0000
Mangifera indica	Mangga	3	0.0013	0.0629	3	0.5000	3.3708	2.6784	5.3571	11.4063	0.0337	-3.3900	-0.1143
Melanolepis multiglandulosa	Alim	4	0.0017	0.0963	2	0.3333	4.4944	4.0995	3.5714	12.1653	0.0449	-3.1023	-0.1394
Nauclea orientalis	Bangkal	2	0.0008	0.0509	2	0.3333	2.2472	2.1668	3.5714	7.9854	0.0225	-3.7955	-0.0853
Nephelium lappaceum	Rambutan	2	0.0008	0.0402	2	0.3333	2.2472	1.7120	3.5714	7.5307	0.0225	-3.7955	-0.0853
Orania palindan	Palindan	3	0.0013	0.0763	2	0.3333	3.3708	3.2502	3.5714	10.1924	0.0337	-3.3900	-0.1143
Pandanus sp.	Pandan	1	0.0004	0.0000	1	0.1667	1.1236	0.0000	1.7857	2.9093	0.0112	-4.4886	-0.0504
Pandanus amaryllifolius	Pandan banguhan		0.0000		0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000		0.0000
Phragmites australis	Common reed		0.0000		0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000		0.0000
Piper aduncum	Buyo-buyo	13	0.0054	0.2807	3	0.5000	14.6067	11.9508	5.3571	31.9147	0.1461	-1.9237	-0.2810
Pittosporum pentandrum	Mamalis		0.0000		0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000		0.0000
Premna odorata	Alagau		0.0000		0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000		0.0000
Psidium guajava	Guava	1	0.0004	0.0284	1	0.1667	1.1236	1.2071	1.7857	4.1164	0.0112	-4.4886	-0.0504
Pterocymbium tinctorium	Taluto	1	0.0004	0.0201	1	0.1667	1.1236	0.8560	1.7857	3.7653	0.0112	-4.4886	-0.0504
Sandoricum koetjape	Santol	2	0.0008	0.0569	1	0.1667	2.2472	2.4209	1.7857	6.4538	0.0225	-3.7955	-0.0853
Schizostachyum lumampao	Buho	1	0.0004	0.0314	1	0.1667	1.1236	1.3375	1.7857	4.2468	0.0112	-4.4886	-0.0504
Senna alata	Ringworm bush		0.0000		0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000		0.0000

Species	Common Name	No. of Individuals	Density	Dominance	No. of Quadrats Occurred	Frequency	Rden	Rdom	RF	IV	*pi*	*ln(pi)*	*pi*lnpi*
Shorea sp.		1	0.0004	0.0201	1	0.1667	1.1236	0.8560	1.7857	3.7653	0.0112	-4.4886	-0.0504
Swietenia macrophyla	Mahogany	4	0.0017	0.1923	2	0.3333	4.4944	8.1856	3.5714	16.2515	0.0449	-3.1023	-0.1394
Tabernaemontana globosa	Bayag usa		0.0000		0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000		0.0000
Triplaris cumingiana	Palosanto		0.0000		0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000		0.0000
Total		**89**	**0.0371**	**2.3488**		**9.3333**	**100**	**100**	**100**	**300**	**1**	**0**	**3.2963**

Table 2-47 Importance Values and their Ranking

Common Name	Species	IV	Ranking
Buyo-buyo	*Piper aduncum*	31.91	1
Kakauate	*Gliricidia sepium*	29.66	2
Mahogany	*Swietenia macrophyla*	16.25	3
Antipolo	*Artocarpus blancoi*	15.20	4
Yemane	*Gmelina arborea*	12.93	5
Alim	*Melanolepis multiglandulosa*	12.17	6
Mangga	*Mangifera indica*	11.41	7
Anubing	*Artocl.hygtrfarpus ovatus*	10.59	8
Palindan	*Orania palindan*	10.19	9
Guayabano	*Annona muricata*	10.00	10

Plant species presence and abundance can have a significant impact on ecosystem functions such as carbon sequestration, water cycling, and nutrient cycling. Understanding the significance of different plant species allows us to better understand how they contribute to ecosystem function.

Importance value can provide insights into the diversity of plant species in an ecosystem. The potential impacts of environmental changes on plant biodiversity can be better understood by identifying key species and understanding their role in the ecosystem. The Importance Value as a biodiversity parameter can be used on:

- Conservation: Understanding the importance of flora can help with conservation efforts. We can prioritize conservation efforts to protect and preserve the most ecologically significant plant species by identifying key species and understanding their ecological significance.
- Land management: Understanding the value of flora can also help with land management. We can better manage land use practices to minimize negative impacts on important plant species and their associated ecosystems by identifying key species and understanding their ecological significance.

The Importance Value (IV) of each species was calculated using relative values. **Table 2.47** shows the top ten tree species with the highest IV. These species were mostly found in quadrats 20m x 20m. According to the ranking, the most important tree species found on the site is Buyo-buyo (*Piper aduncum*), which has an importance value of 411.88, and the least important species among the top 10 are Palindan (*Orania palindan*) and Guayabano (*Annona muricata*), both of which have an importance value of 150. Importance value refers to the relative importance of a specific plant species in a given ecosystem. The importance value is determined by several factors, including the frequency, abundance, and cover of the species.

Table 2-48 Fernando's Scale of Biodiversity

Relative values	Shannon's Index (H')	Evenness (e)
Very High	3.5 and above	0.75-1.0
High	3.0-3.49	0.5-0.74
Moderate	2.5-2.99	0.25-0.49
Low	2.0-2.49	0.15-0.24
Very Low	1.9 and below	0.05-0.14

Table 2-49 Diversity of Flora Species

H'=	3.30	**Hmax=**	4.49
		Evenness=	0.73

Stand Structure: (Species Composition, Diversity, Abundance and Evenness) A total of 89 individual plant species, consisting of 50 genera and 31 families were recorded across the 6 quadrants of the transect. Family Arecaeae and Moraceae with 5 species had the highest number of species recorded in the area. Diversity indices from the 6 quadrats ranged from 3.30 to 4.49 Shannon Index and Species Richness (**Table 2.49**), respectively. Additionally, the Species Evenness values at 0.73. The diversity is high and high evenness value based on Fernando's Biodiversity Scale **(Table 2.48**). According to BMB and GIZ (2017), the higher the value for any of the diversity indices, the greater the species diversity in the area.

Table 2-50 Taxonomic Families found within CANTIS

Family	Count
Acanthaceae	1
Anacardiaceae	1
Annonaceae	2
Apocynaceae	2
Arecaceae	5
Athyriaceae	1
Brownlowiaceae	1
Combretaceae	1
Cordiaceae	1
Costaceae	1
Dipterocarpaceae	3
Durionaceae	1

Family	Count
Euphorbiaceae	2
Fabaceae	4
Gnetaceae	1
Hypericaceae	1
Lamiaceae	2
Meliaceae	3
Moraceae	5
Myrtaceae	1
Pandanaceae	1
Piperaceae	1
Pittosporaceae	1
Poaceae	3
Polygonaceae	1
Pteridaceae	1
Rubiaceae	1
Sapindaceae	1
Sterculiaceae	1
Urticaceae	1
Zingiberaceae	1

Diversity indices are values which are used to estimate quantitatively the variation in the components of a certain biological entity (Help, Herman, & Soetaert, 1998). The following diversity indices were computed:

1. Number of taxa (S) – number of species

2. Total number of individuals (n)

3. Shannon index (entropy) – diversity index which use the number of individuals and number of taxa as parameters with values ranging from 0 to 4. Zero dictates low value of diversity with single taxon at a community b.2. Importance Value of Species Importance Value (IV) is the sum of the values of the species' relative density, relative dominance, and relative frequency (Razavi, Mattaji, Rahmani, & Naghavi, 2012). The following are the formulas to determine the IV of each species.

4. Density = number of individuals/area sampled Relative density = (Density of species/total density of all species) *100

5. Frequency = Number of plots where species occur/total number of plots sampled Relative Frequency = (Species frequency /Total frequency for all species) *100

6. Dominance = Basal area or volume for species/Area sampled Basal area = (0.7854) *DBH^2 Relative dominance = (Species dominance/Dominance of all species) *100

Importance Value (IV) = Relative density + Relative Frequency + Relative dominance

Noteworthy Species/Threatened Species

Out of 89 taxonomic species recorded in the area, there are five (5) vulnerable species Apitong (*Dipterocarpus grandiflorus*), Dao (*Dracontomelon dao*), Narra (*Pterocarpus indicus forma Indicus, Nephelium lappaceum, Shorea sp.*) classified by DAO 2017-11 and two (2) vulnerable species namely, Is-is (*Ficus ulmifolia*) and Mahogany (*Swietenia macrophylla),* as classified by IUCN. There are two (2) Apitong (*Dipterocarpus grandiflorus*) and Narra (*Pterocarpus indicus* forma *indicus*) endangered and one (1) critically endangered (*Shore sp.*) classified by IUCN.

Table 2-51 Conservation Status of Floral Species in CANTIS

Common Name	Species	Family	DAO 2017-11	IUCN
	Naga	ND	ND	DD
Lumbang	*Aleurites moluccanus*	Euphorbiaceae	OWS	LC
Batino	*Alstonia scholaris*	Apocynaceae	OWS	LC
Guayabano	*Annona muricata*	Annonaceae	LC	LC
Bunga	*Areca catechu*	Arecaceae	OWS	DD
Kaong	*Arenga pinnata*	Arecaceae	LC	DD
Antipolo	*Artocarpus blancoi*	Moraceae	OWS	LC
Anubing	*Artocarpus ovatus*	Moraceae	OWS	DD
Kawayang Kiling	*Bambusa vulgaris*	Poaceae	ND	DD
Ilang-ilang	*Cananga odorata*	Annonaceae	ND	LC
Pakong sundang	*Ceratopteris calomelanos*	Pteridaceae	ND	DD
Niyog	*Cocos nucifera*	Arecaceae	OWS	DD
Rangoon creeper	*Combretum indicum*	Combretaceae	OWS	DD
Assyrian plum	*Cordia myxa*	Cordiaceae	ND	LC
Tubang-usa	*Costus speciosus*	Costaceae	ND	DD

Common Name	Species	Family	DAO 2017-11	IUCN
Paguringon	*Cratoxylum sumatranum*	Hypericaceae	OWS	LC
Lipang kalabau	*Dendrocnide meyeniana*	Urticaceae	OWS	LC
Pako	*Diplazium esculentum*	Athyriaceae	OWS	LC
Balobo	*Diplodiscus paniculatus*	Brownlowiaceae	OWS	LC
Apitong	*Dipterocarpus grandiflorus*	Dipterocarpaceae	VU	EN
Dao	*Dracontomelon dao*	Dipterocarpaceae	VU	LC
Durian	*Durio zibethinus*	Durionaceae	ND	DD
Igyo	*Dysoxylum gaudichaudianum*	Meliaceae	ND	LC
Torch ginger	*Etlingera elatior*	Zingiberaceae	ND	DD
Falcata	*Falcataria falcata*	Fabaceae	ND	DD
Hagimit	*Ficus minahassae*	Moraceae	OWS	DD
Tibig	*Ficus nota*	Moraceae	OWS	LC
Is-is	*Ficus ulmifolia*	Moraceae	OWS	VU
Narra	*Pterocarpus indicus form. indicus*	Fabaceae	VU	EN
Kakauate	*Gliricidia sepium*	Fabaceae	ND	LC
Yemane	*Gmelina arborea*	Lamiaceae	ND	LC
Bago	*Gnetum gnemon*	Gnetaceae	OWS	LC
Brazilian Plume	*Justicia carnea*	Acanthaceae	ND	DD
Ipil-ipil	*Leucaena leucocephala*	Fabaceae	ND	LC
Mangga	*Mangifera indica*	Anacardiaceae	ND	DD
Alim	*Melanolepis multiglandulosa*	Euphorbiaceae	OWS	LC
Bangkal	*Nauclea orientalis*	Rubiaceae	OWS	LC
Rambutan	*Nephelium lappaceum*	Sapindaceae	VU	LC
Palindan	*Orania moluccana*	Arecaceae	ND	DD
Pandan	*Orania palindan*	Arecaceae	LC	LC
Pandan banguhan	*Pandanus amaryllifolius*	Pandanaceae	ND	DD
Common reed	*Phragmites australis*	Poaceae	ND	LC
Buyo-buyo	*Piper aduncum*	Piperaceae	ND	LC
Mamalis	*Pittosporum pentandrum*	Pittosporaceae	OWS	DD
Alagau	*Premna odorata*	Lamiaceae	LC	LC
Guava	*Psidium guajava*	Myrtaceae	ND	LC
Taluto	*Pterocymbium tinctorium*	Sterculiaceae	OWS	LC

Common Name	Species	Family	DAO 2017-11	IUCN
Santol	*Sandoricum koetjape*	Meliaceae	OWS	LC
Buho	*Schizostachyum lumampao*	Poaceae	OWS	DD
Ringworm bush	*Senna alata*	Fabaceae	ND	LC
	Shorea sp.	Dipterocarpaceae	VU	CR
Mahogany	*Swietenia macrophyla*	Meliaceae	ND	VU
Bayag usa	*Tabernaemontana globosa*	Apocynaceae	ND	LC
Palosanto	*Triplaris cumingiana*	Polygonaceae	ND	LC

Economically important species

Timber producing species like Narra *(Pterocarpus indicus* form. *Indicus)*, Dao (*Dracontomelon dao*), Falcata (*Falcataria falcata*), Yemane (*Gmelina arborea*), Mahogany was present in there. While two (2) Poaceae species were found along streambanks.

Invasive species

Mahogany (*Swietenia macrophylla*) is the only one significant invasive species found in CANTIS. Despite being introduced for its timber value, it has spread rapidly and outcompeted native vegetation due to its fast growth. This has resulted in significant ecological implications, including the formation of dense monocultures that reduce biodiversity, alter soil properties, and disrupt native ecosystem processes. The aggressive root system of Mahogany has also been found to cause soil erosion and destabilize slopes, leading to an increased risk of landslides. Additionally, Mahogany's shade tolerance has allowed it to establish itself in different forest types, causing displacement of native species and could negatively impact the overall ecological balance of the watershed ecosystem.

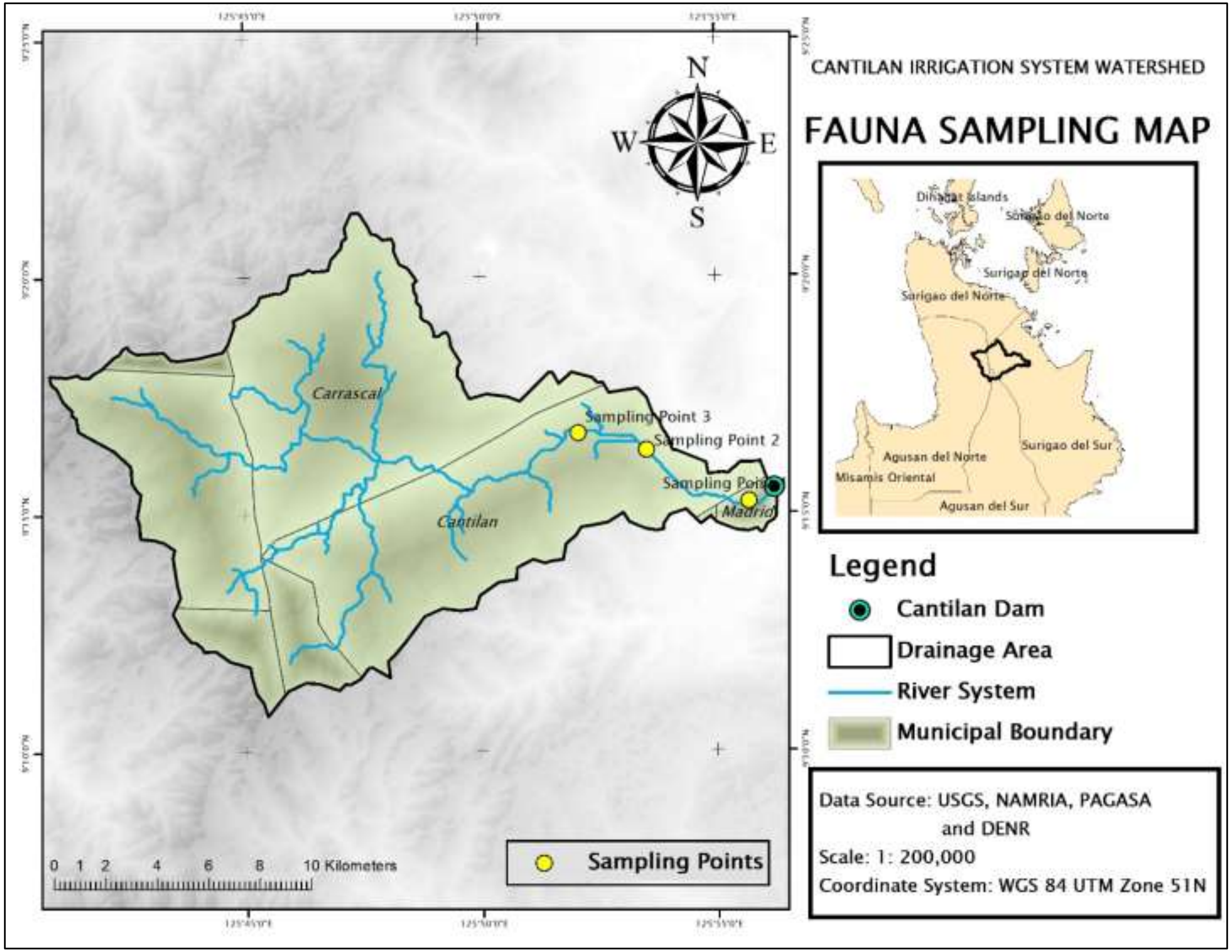
2.13.1.2 Fauna

During the transect walk survey, at least ten different species of fauna were discovered on the project site. Due to the presence of disturbance in the area, a limited number of faunas were identified. Several species where observed including the fishes which are prevailing within the area. (**Table 2.52 & Figure 2.28**).

Table 2-52 Fauna found during Transect Walk

Scientific Name	Common Name
Hexapoda (insects)	
Eurema hecabe	Yellow sulfur
Oxya hyla	Grasshopper
Locusta migratoria	Brown grasshopper
Amyotea malabarica	Predator stink bug
Lebinthus hamus	Cricket
Orthetrum serapia	Freshwater Dragonfly
Aquarius philippinensis	Water Strider
Mollusca	
Corbicula fluminea	Asian Freshwater Clam
Decapoda	
Varuna litterata	Peregrine crab
Scylla serrata	Mud crabs

Scientific Name	Common Name
Portunus pelagicus	Blue swimming crab
Actinoptergyii (fish)	
Chanos chanos	Milkfish
Oreochromis niloticus	Tilapia
Reptilia	
Lamprolepis smaragdina philippinica	Emerald Green Tree Skink
Aves (birds)	
Gallus gallus doesticus	Chicken (Junglefowl)
Oriolus chinensis	Black-naped oriole
Aerodramus mearnsi	Philippine Swiftlet
Gallirallus philippensis	Buff-banded rail
Hypsipetes philippinus	Philippine bulbul
Dicaeum trigonostigma	Orange-bellied Flowerpecker
Todiramphus winchelli	Rufous-lored kingfisher
Ceyx melanurus	Philippine Dwarf Kingfisher
Dicaeum australe austral	Philippine/Red striped Flowerpecker
Aethopyga pulcherrima jefferyi	Mountain/Mettalic-winged Sunbird


CANTILAN IRRIGATION SYSTEM WATERSHED
FAUNA SAMPLING MAP
N
S
E
W
Carrascal
Cantilan
Madrid
Sampling Point 3
Sampling Point 2
Dinagat Islands
Surigao del Norte
Surigao del Norte
Surigao del Norte
Agusan del Norte
Misamis Oriental
Agusan del Sur
Surigao del Sur
Legend
Cantilan Dam
Drainage Area
River System
Municipal Boundary
Sampling Points
0 1 2 4 6 8 10 Kilometers
Data Source: USGS, NAMRIA, PAGASA and DENR
Scale: 1: 200,000
Coordinate System: WGS 84 UTM Zone 51N

2.13.2 Biological Resources in Cantilan Irrigation System Watershed (Secondary data)

To supplement the Primary Data Gathering, secondary data is collected from the LGUs. Secondary data is crucial in biodiversity assessment studies as it provides historical perspectives, enables large-scale analyzes, facilitates comparability, and supports long-term monitoring to evaluate conservation strategies.

The Carac-an watershed is a vital drainage basin that are situated within the Cantilan Irrigation System. Therefore, having the following information as secondary data, this section aims to support the results of the Primary Data Gathering presented in the previous sections.

2.13.2.1 Flora

Floral assessment involves the identification and monitoring of ecosystems, habitats, and plant species in a particular area. This floral assessment covers the entire watershed, and the collected information that will serve as secondary data will be presented in the following sub-sections.

The modified belt-transect method was used for the Protected Area Suitability Assessment (PASA) for Carac-an Watershed Forest Reserves (CWFR) in October-December 2021, which encompassed the Carac-an River Watershed and the Watershed Management Planning Team. A 2-kilometer transect was used as the baseline, with 20mx20m quadrats for species level laid out every 250m (**Table 2.53**).

The area is home to at least 45 flora species from 22 families, 15 of which are endemic to the Philippines. According to DENR Administrative Order No. 2017-11 "Updated National List of Threatened Philippine Plants and Their Categories," 15 of the species recorded are threatened. There are 3 are Critically Endangered (CR) all identified as dipterocarp, the Yakal (*Shorea astylosa),* Bagtikan *(Parashorea malaanonan),* and Dalingdingan *(Hopea foxworthyi);* 1 is Endangered, the Magkono (*Xanthostemon verdugonianus);* 8 are Vulnerable: Almon (*Shorea almon),* Cedar *(Toona calantas),* Red Lauan *(Shorea negronensis),* White Lauan *(Shorea contorta)*, Guijo (*Shorea guiso);* Narig (*Vatica mangachapoi);* Tanguile (*Shorea polysperma*); and Makaasim (*Syzygium nitidum*); and 3 Other Threatened Species (OTS): Lanutan (*Mitrephora lanotan),* Ata-ata (*Diospyros mindanensis),* and Duguan (*Myristica philippensis).*

Table 2-53 Floral Species found in CANTIS

Family Name	Scientific Name	Local Name	Frequency	Total Height (m)			Relative Abundance	Conservation Status	Residency Status
				Min.	Max	Ave.			
Casuarinaceae	*Casuarina equisetifolia*	Agoho	6.00	5.00	6.00	7.00	0.95	OWS	Indigenous
Urticaceae	*Leucosyke capitellata*	Alagasi	1.00	6.00	6.00	6.00	0.16	OWS	Indigenous
Ebenaceae	*Diospyros mindanaensis*	Ata-Ata	2.00	9.00	10.50	12.00	0.32	OTS	Indigenous
Dipterocarpaceae	*Shorea almon*	Almon	10.00	7.00	11.00	15.00	1.59	Vulnerable	Endemic
Gnetaceae	*Gnetum gnemon*	Bago	2.00	6.00	6.00	6.00	0.32	OWS	Indigenous
Dipterocarpaceae	*Parashorea Malaanonan*	Bagtikan	19.00	6.00	10.50	15.00	3.02	CR	Indigenous
Malvaceae	*Commersonia bartramia*	Banitlong	1.00	6.00	6.00	6.00	0.16	OWS	Indigenous
Callophylaceae	*Calophyllum soulattri*	Bitanghol	17.00	4.00	7.00	10.00	2.70	OWS	Indigenous
Polygalaceae	*Xanthophyllum excelsum*	Bokbok	19.00	4.00	9.50	15.00	3.02	OWS	Indigenous
Rutaceae	*Citrus maxima*	Buongon	1.00	6.00	8.00	10.00	0.16	OWS	Indigenous
Meliaceae	*Toona calantas*	Cedar	23.00	5.00	9.50	14.00	3.66	Vulnerable	Indigenous
Dipterocarpaceae	*Hopea foxworthyi*	Dalingdingan	1.00	7.00	7.00	7.00	0.16	CR	Endemic
Lamiaceae	*Teijsmanniodendron ahemianum*	Dangola	2.00	6.00	6.50	7.00	0.32	OWS	Indigenous
		Djagaw	3.00	6.00	6.50	7.00	0.48		

Family Name	Scientific Name	Local Name	Frequency	Total Height (m)			Relative Abundance	Conservation Status	Residency Status
				Min.	Max	Ave.			
Myristicaceae	*Myristica philippinensis*	Duguan	6.00	6.00	8.00	10.00	0.95	OTS	Endemic
Sapotaceae	*Manilkara merrilliana*	Duyok-duyok	3.00	7.00	10.50	14.00	0.48	OWS	Indigenous
Euphorbiaceae	*Endpospermum peltatum*	Gubas	15.00	5.00	11.50	18.00	2.38	OWS	Indigenous
Dipterocarpaceae	*Shorea guiso*	Guijo	7.00	5.00	10.00	15.00	1.11	Vulnerable	Indigenous
Rubiaceae	*Pavetta indica*	Gusukan	2.00	5.00	7.00	9.00	0.32	OWS	Indigenous
Moraceae	*Ficus minahassae*	Hagimit	1.00	6.00	6.00	6.00	0.16	OWS	Indigenous
Rubiaceae	*Neunaulea formicaria*	Hambabal-od	1.00	7.00	7.00	7.00	0.16	OWS	Endemic
Euphorbiacaea	*Macaranga aleuritoides*	Hamindang	10.00	5.00	7.50	10.00	1.59	OWS	Introduced
Lauraceae	*Cinnamomum mercadoi*	Kalingag	1.00	15.00	15.00	15.00	0.16	OWS	Endemic
Lamiaceae	*Vitex quamata*	Kolipapa	3.00	5.00	5.50	6.00	0.48	OWS	Indigenous
Annonaceae	*Mitrephora lanotan*	Lanutan	3.00	7.00	9.50	12.00	0.48	OTS	Endemic
Myrtaceae	*Xanthosemon verdugonianus*	Mangkono	8.00	3.00	6.00	9.00	1.27	Endangered	Endemic
Fabaceae	*Pterocarpus sp.*	Magoebor	15.00	5.00	12.50	20.00	2.38	OTS	Indigenous
Myrtaceae	*Syzygium lineatum*	Magotambis	2.00	10.00	11.50	13.00	0.32	OWS	Endemic
Myrtaceae	*Syzygium nitidum*	Makaasim	2.00	5.00	6.00	7.00	0.32	Vulnerable	Indigenous
Rubiaceae	*Canthium dococcum*	Malakape	1.00	3.00	3.00	3.00	0.16	OWS	Indigenous
Casuarinaceae	*Gymnostoma sumatranum*	Mariang Buhok	8.00	5.00	6.50	8.00	1.27	OWS	Indigenous

Family Name	Scientific Name	Local Name	Frequency	Total Height (m)			Relative Abundance	Conservation Status	Residency Status
				Min.	Max	Ave.			
Dipterocarpaceae	*Shorea palosapis*	Mayapis	77.00	3.00	11.50	18.00	12.24	OWS	Endemic
Dipterocarpaceae	*Vatica mangachapoi*	Narig	29.00	5.00	11.50	18.00	4.61	Vulnerable	Indigenous
Callophylaceae	*Calophyllum soulattri*	Pamitaogon	17.00	5.00	10.00	15.00	2.70	OWS	Indigenous
Myrtaceae	*Leptospermum amboinense*	Payospos	14.00	5.00	7.50	10.00	2.23	OWS	Indigenous
Dipterocarpaceae	*Shorea negronenis*	Red Lauan	67.00	3.00	12.50	22.00	10.65	Vulnerable	Endemic
Myrtaceae	*Syzygium brevistylum*	Sagimsim	59.00	5.00	8.50	12.00	9.38	OWS	Indigenous
Phyllanthaceae	*Antidesma bunius*	Sahaan	3.00	6.00	7.00	8.00	0.48	OWS	Indigenous
Dipterocarpaceae	*Shorea polysperma*	Tanguile	1.00	7.00	7.00	7.00	0.16	Vulnerable	Endemic
Myrtaceae	*Tristania micrantha*	Tiga	17.00	3.00	7.50	12.00	2.70	OWS	Endemic
Moraceae	*Artocarpus Blancoi*	Tugopo	7.00	6.00	8.00	10.00	1.11	OWS	Endemic
Fagaceae	*Lithocarpus llanosii*	Ulaian	47.00	5.00	8.50	12.00	7.47	OWS	Indigenous
Rubiaceae	*Nauclea orientalis*	Wakatan	44.00	4.00	8.00	12.00	7.00	OWS	Indigenous
Dipterocarpaceae	*Shorea contorta*	White Lauan	29.00	4.00	9.50	15.00	4.61	Vulnerable	Endemic
Dipterocarpaceae	*Shorea atylosa*	Yakal	23.00	6.00	13.00	20.00	3.66	CR	Endemic

2.13.2.2 Fauna

Methods used for faunal assessments within the Carac-an River Watershed include opportunistic sampling, modified line transect, mist-netting, live-trapping, and observations for evidence of animal remains or foot prints.

The results revealed a 3.825 diversity index. At least 45 terrestrial vertebrate species from the classes Aves, Mammalia, Reptilia, and Amphibia have found refuge in the watershed. There are 38 avian species in 25 families, 8 of which are endemic, and two of which are threatened – the Critically Endangered Philippine Hanging Parrots (*Loriculus philippensis*) and the Vulnerable Philippine Duck (*Anas luzonica*).

In addition, 42 terrestrial invertebrates, including insects, arachnids, and diclopods, were recorded across sites. Aquatic vertebrates and invertebrates were also discovered (**Table 2.54**).

Table 2-54 Faunal Species found in CANTIS

Family Name	Scientific Name	Common/English Name	Freq.	Relative Abundance	Conservation Status*	Residency Status
VERTEBRATES						
BIRDS						
Artamidae	*Phapitreron leocutis*	White-eared brown dove	18	1.243953006	OWS	Endemic
Artamidae	*Spilopelia chinensis*	Spotted Dove	19	1.313061507	OWS	Indigenous
Alcedinidae	*Alcedo atthis*	Common Kingfisher	45	3.109882516	OWS	Endemic
Estrildidae	*Lonchura atricapilla*	Chestnut munia	135	9.329647547	OWS	Indigenous
Apodidae	*Collocalia sp.*	Swiftlets	37	2.557014513	OWS	Indigenous
Laniidae	*Lanius cristatus*	Brown Shrike	68	4.699378023	OWS	Indigenous
Artamidae	*Geopelia striata*	Zebra Dove	9	0.621976503	OWS	Indigenous
Artamidae	*Artamus leucorynchus*	White breasted wood swallow	113	7.809260539	OWS	Indigenous
Pycnonotidae	*Hysipetes philippinus*	Philippine Bulbul	46	3.178991016	OWS	Endemic
Ardeidae	*Nycticorax nycticorax*	Black Night Heron	5	0.345542502	OWS	Indigenous
Caprimulgidae	*Caprimulgiformes manillensis*	Philippine Night Jar	6	0.414651002	OWS	Endemic
Nectariniidae	*Cinnyris jugalaris*	Olive-backed sunbird	73	5.044920525	OWS	Indigenous
Ardeidae	*Ixobrychus flavicollis*	Black Bittern	2	0.138217001	OWS	Indigenous
Ardeidae	*Ardea intermedia*	Intermediate Egret	25	1.727712509	OWS	Indigenous
Anatidae	*Anas luzonica*	Philippine Wild Duck	60	4.146510021	Vulnerable	Endemic
Alcedinidae	*Halcyon smymensis*	White throated Kingfisher	4	0.276434001	OWS	Indigenous
Sturnidae	*Sarcops calvus*	Coleto	1	0.0691085	OWS	Indigenous
Sturnidae	*Aplonis panayensis*	Asian Glossy Starling	83	5.736005529	OWS	Indigenous
Passeridae	*Passer domesticus*	House sparrow	58	4.00829302	OWS	Indigenous

Family Name	Scientific Name	Common/English Name	Freq.	Relative Abundance	Conservation Status*	Residency Status
Corvidae	*Corvus macrorhynchos*	Crow	23	1.589495508	OWS	Indigenous
Erebidae	*Gesonia sp.*	Brown Moth	9	0.621976503	OWS	Indigenous
Ardeidae	*Bubulcus ibis*	Cattle Egret	2	0.138217001	OWS	Indigenous
Accipitridae	*Haliastur indus*	Brahminy Kite	4	0.276434001	OWS	Indigenous
Rallidae	*Gallirallus torquatus*	Barred Rail	2	0.138217001	OWS	Indigenous
Meropidae	*Merops philippinus*	Blue-tailed Bee eater	11	0.760193504	OWS	Indigenous
Cuculidae	*Centropus viridis*	Philippine Coucal	3	0.207325501	OWS	Endemic
Picidae	*Yungipicus maculatus*	Wood pecker	2	0.138217001	OWS	Indigenous
Psittaculidae	*Loriculus philippensi*	Philippine Hanging parrot	4	0.276434001	CR	Endemic
Hirundinidae	*Hirundo rustica*	Barn Swallow	2	0.138217001	OWS	Indigenous
Accipitridae	*Spilornis holospilus*	Phil. Serpent eagle	2	0.138217001	OWS	Indigenous
Alcedinidae	*Alcedo argentata*	Southern Silvery kingfisher	4	0.276434001	OWS	Indigenous
Rhipiduridae	*Rhipidura nigritorguis*	Philippine Pied Fantail	5	0.345542502	OWS	Endemic
Ardeidae	*Ixobrychus cinnamomeus*	Cinnamon Bittern	4	0.276434001	OWS	Indigenous
Columbidae	*Streptopelia tranquebarica*	Red turtle dove	4	0.276434001	OWS	Indigenous
Ardeidae	*Egretta garzetta*	Little egret	1	0.0691085	OWS	Indigenous
Oriolidae	*Oriolus chinensis*	Black-naped oriole	1	0.0691085	OWS	Indigenous
Pycnonotidae	*Pycnonotus goiavier*	Yellow vented bulbul	5	0.345542502	OWS	Indigenous
Dicaeidae	*Dicaeum sp.*	Flowerpecker	3	0.207325501	OWS	Indigenous
Rhinolophidae	*Rhinolophus sp.*	Horseshoe bat	14	0.967519005	OWS	Indigenous
Tragulidae	*Rattus sp.*	Mouse	2	0.138217001	OWS	Indigenous

Family Name	Scientific Name	Common/English Name	Freq.	Relative Abundance	Conservation Status*	Residency Status
AMPHIBIANS						
Ranidae	*Lithobates catesbeianus*	Bullfrog	1	0.0691085	OWS	Indigenous
Dicrocylossidae	*Fejervarja limnocharis*	Common Paddy Field Frog	6	0.414651002	OWS	Indigenous
REPTILES						
Scincidae	*Lamprolepis smaragdina*	Green Tree skink	2	0.138217001	OWS	Indigenous
Varanidae	*Varanus flavescens*	Yellow Monitor Lizard	2	0.138217001	Vulnerable	Indigenous
Scinidae	*Eutropis sp.*	Sun skink	1	0.0691085	OWS	Indigenous
FISH						
Cichlidae	*Oreochromis niloticus*	Nile tilapia	7	0.483759502	OWS	Indigenous
Loricariidae	*Pterygoplichthys sp.*	Janitor Fish	5	0.345542502	OWS	Indigenous
Lctaluridae	*Ictalurus punctatus*	Channel Catfish	6	0.414651002	OWS	Indigenous
Anguillidae	*Anguilia marmorata*	Giant Mottle Eel	9	0.621976503	OWS	Indigenous
Channidae	*Fishi cusmudicus*	Mud Fish	3	0.207325501	OWS	Indigenous
Oxudercidae	*Acanthogobius sp.*	Goby	7	0.483759502	OWS	Indigenous
Mugilidae	*Mugil cephalus*	Blue-tail mullet	18	1.243953006	OWS	Indigenous
Cyprinidae	*Barbodes binotatus*	Spotted Barb	6	0.414651002	OWS	Indigenous
Toxotidae	*Toxotes jaculatrix*	Banded Archerfish	12	0.829302004	OWS	Indigenous
INVERTEBRATES						
INSECTS						
Lycaenidae	*Celastrina argiolus*	Holly butterfly	18	1.243953006	OWS	Indigenous
Lycaenidae	*Acytolepis puspa*	Coomon Hedge Blue Moth	1	0.0691085	OWS	Indigenous
Heperiidae	*Potanthus niobe*	Skipper Butterfly	4	0.276434001	OWS	Indigenous

Family Name	Scientific Name	Common/English Name	Freq.	Relative Abundance	Conservation Status*	Residency Status
Pieridae	*Eurema hecabe*	Common Grass yellow butterfly	34	2.349689012	OWS	Indigenous
Noctuidae	*Chasmina sp.*	White Moth	31	2.142363511	OWS	Indigenous
Acidideae	*Omocetus viridulus*	Common Green Grasshopper	38	2.626123013	OWS	Indigenous
Libellulidae	*Orthetrum sabina*	Orange skimmer Butterfly	6	0.414651002	OWS	Indigenous
Nymphalidae	*Ypthima sp.*	Five-Ring Butterfly	23	1.589495508	OWS	Indigenous
Nymphalidae	*Symbrenthia lilea*	Common Jester	10	0.691085003	OWS	Indigenous
Lilellulidae	*Nuerothemis terminata*	Red-winged dragonfly	21	1.451278507	OWS	Indigenous
Nymphalidae	*Junonia atlites*	Gray fansy	9	0.621976503	OWS	Indigenous
Libellulidae	*Oreochromis niloticus*	Slender Skimmer Butterfly	3	0.207325501	OWS	Indigenous
Chlorcyphidae	*Rhinocypha sp.*	Damselfly	5	0.345542502	OWS	Indigenous
Libellulidae	*Diplacodes trivialis*	Ground Skimmer dragonfly	15	1.036627505	OWS	Indigenous
Nymphalidae	*Idea leuconoe*	Large tree nymph	4	0.276434001	OWS	Indigenous
Nymphalidae	*Nymphalidae*	Blue Moon butterfly	5	0.345542502	OWS	Indigenous
Nymphalidae	*Graphium agamemnon*	Tailed jay	9	0.621976503	OWS	Indigenous
Libellulidae	*Neurothemis sp.*	Paddyfield parasol	1	0.0691085	OWS	Indigenous
Nymphalidae	*Idea leuconoe*	Rice paper butterfly	3	0.207325501	OWS	Indigenous
Alydidae	*Xylocopa latipes*	Carpenter Bee	14	0.967519005	OWS	Indigenous
Calliphoridae	*Calliophora vomitoria*	Blue bottle fly	1	0.0691085	OWS	Indigenous
Ephydridae	*Ephydra hians*	Flies	4	0.276434001	OWS	Indigenous

Family Name	Scientific Name	Common/English Name	Freq.	Relative Abundance	Conservation Status*	Residency Status
Coccinellidae	*Coccinella novemnotata*	Nine Spotted bug	14	0.967519005	OWS	Indigenous
Scarabaeidae	*Anomala cuprea*	Oriental beetle	5	0.345542502	OWS	Indigenous
Pyrrhocoridae	*Dysdercus cingulatus*	Red cotton stainer	8	0.552868003	OWS	Indigenous
Limacodidae		Caterpillar	34	2.349689012	OWS	Indigenous
Curculionoidea	*Rhinotia sp.*	Weevils	16	1.105736006	OWS	Indigenous
Alydidae	*Leptocorisa oratorius*	Rice ear bug	1	0.0691085	OWS	Indigenous
Formicidae	*Echinopla sp.*	Blue ant	3	0.207325501	OWS	Indigenous
Formicidae	*Anoplolepis gracilipes*	Yellow crazy ant	21	1.451278507	OWS	Indigenous
Formicidae	*Polyrhachis sp.*	Ants	1	0.0691085	OWS	Indigenous
Alydidae	*Leptocorisa oratoria*	Rice ear bug	2	0.138217001	OWS	Indigenous
Cicadidae	*Creatonotos gangis*	Cricket	4	0.276434001	OWS	Indigenous
ARACHNIDS						
Oxyopidae	*Peucetia sp.*	Green Lynx spider	4	0.276434001	OWS	Indigenous
Nephilinae	*Nephila sp.*	Giant Golden Orb spider	4	0.276434001	OWS	Indigenous
DICLOPOD						
Spirostreptidae	*Archispirostreptus gigas*	Giant Milipede	12	0.829302004	OWS	Indigenous
MALACOSTRACA						
Gecarcinucidae		Crablets	15	1.036627505	OWS	Indigenous
Palaemonidae		Freshwater shrimps	12	0.829302004	OWS	Indigenous
GASTROPODS						
Pachychilidae	*Faunus ater*	Banisil Shell	16	1.105736006	OWS	Indigenous
Ampullariidea	*Pomacea canaliculata*	Golden apple snail	17	1.174844506	OWS	Indigenous
MAMMALS						

Family Name	Scientific Name	Common/English Name	Freq.	Relative Abundance	Conservation Status*	Residency Status
Rhinolophidae	*Rhinolophus sp.*	Horseshoe bat	14	0.967519005	OWS	Indigenous
Tragulidae	*Rattus sp.*	Mouse	2	0.138217001	OWS	Indigenous

2.14 Air and Noise

An ambient air quality survey was undertaken to check whether ambient air quality before and after the construction phase of the project are up to par with the National Ambient Air Quality Standards (NAAQS) of the Department of Environment and Natural Resources (DENR); and to come up with potential mitigating measures to decrease the chances of exceeding the parameters set by DENR.

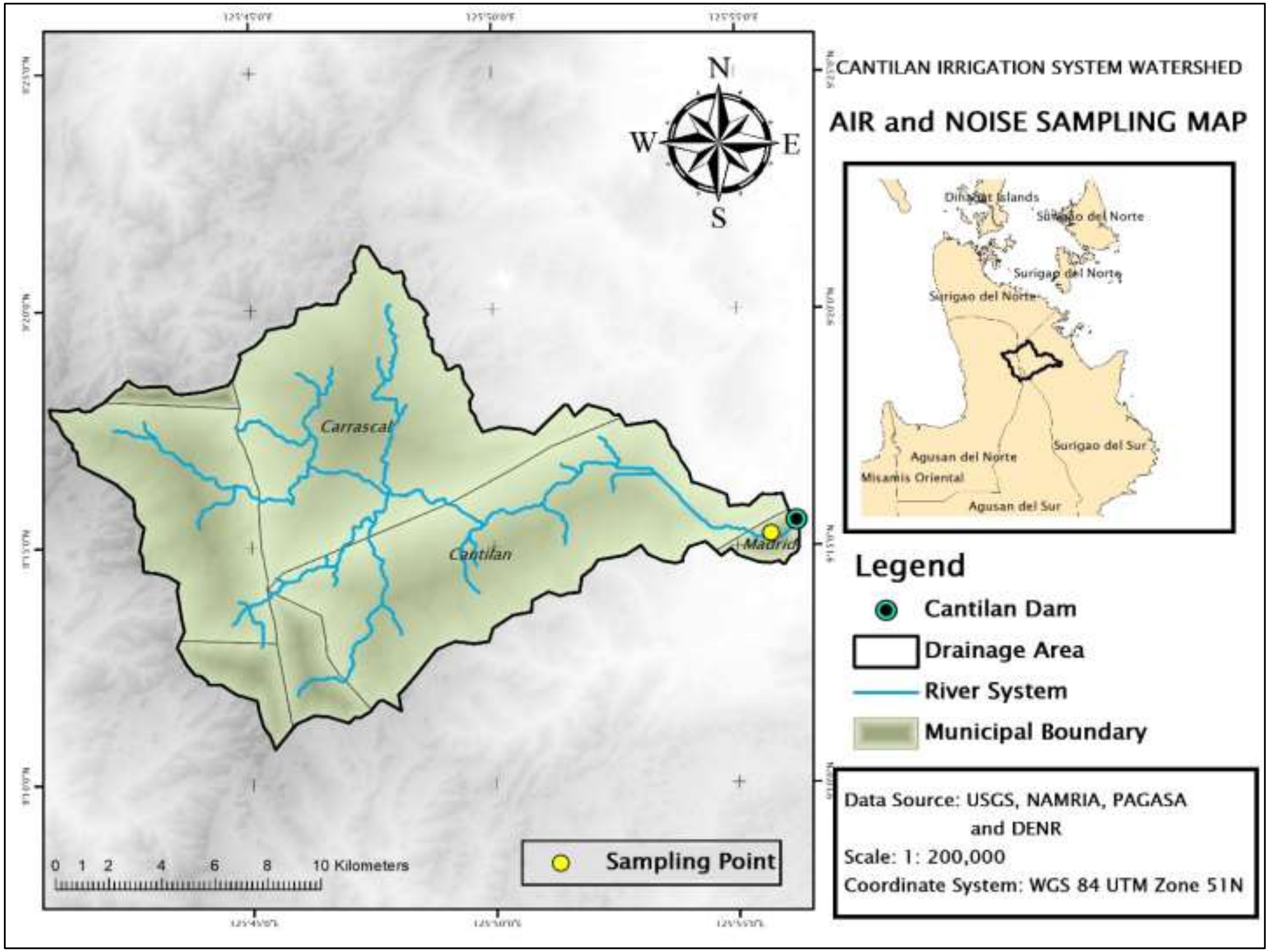


Figure 2-29 Air and Noise Sampling Map

On-site monitoring of 1 sampling station (**Figure 2.29**) for ambient air quality monitoring was conducted last November 17, 2022 to measure the concentration of Particulate Matter 10 (PM10), Total Suspended Particulate (TSP), Sulfur Dioxide (SO2), and Nitrogen Dioxide (NO2).

Table 2-55 Methods of Sampling Analysis

Air Quality Parameter	Procedure	Sampling Equipment	Method Of Analysis
Particulate Matter – 10 microns (PM10)	USEPA, 40 CFR 50, Appendix J	Staplex PM10 Sampler	Gravimetric Method
Total Suspended Particulate (TSP)	USEPA, 40 CFR 50, Appendix B	Staplex High Volume Sampler	Gravimetric Method
Sulfur Dioxide (SO_2)	USEPA, 40 CFR 50, Appendix A	SKC Aircheck Sampler	Pararosaniline Method
Nitrogen Dioxide (NO_2)		SKC Aircheck Sampler	Colorimetric, Greiss Saltzman

Table 2-56 Ambient Air Sampling

Station	SO2 CONC. (MG / NM3)	NO2 (MG / NM3)	PM10 (MG / NM3)	TSP (MG / NM3)
1	<4.56	0.29	41.25	108.02
DENR NAAQ Standards	100	200	200	300

The US EPA "Quality Assurance Handbook for Air Pollution Measurement Systems, Environmental Management Bureau, Department of Environment and Natural Resources, Philippine Environmental Policies, Laws and Regulations handbook was used as a guide to achieve the quality assurance objectives of producing data that are complete, representative and of known precision and accuracy.

The ambient air sampling results are presented in table. Above results of analysis are compared to the National Ambient Air Quality Standards (NAAQS) for Source Specific Air Pollutants from Industrial Operations. These standards are specified in the Implementing Rules and Regulations of the Philippine Clean Air Act of 1999. During sampling on November 17, 2022, the facility is at normal operation. The weather was partly cloudy and prevailing light wind (**Table 2.55-2.56**).

For the gaseous pollutants, sulfur dioxide (SO2) and nitrogen dioxide (NO2), shows the concentrations level are greater than <4.56 μg/Nm3 for SO2 and 0.29 to 12.16 μg/Nm3 for NO2 for the 1-hour time averaging sampling. These values are well within DENR ambient standards of 100 μg/Nm3 for SO2 and 200 μg/Nm3 for NO2 for 1-hr sampling.

It was observed that the present 1-hour ambient ground level concentration of particulate matter (PM10) is 41.25 µg/Nm3. This is within the allowable limit of DENR standard of 200 µg/Nm3.

The dispersed emissions that may arise from the reclamation activities can affect the air quality in the area, hence, in order to mitigate or lessen the anticipated impact related to air quality, the existing air quality in the project area was determined using the DENR standard methods and procedures for sampling and analysis in accordance to the Philippine Clean Air Act (PCAA) of 1999 and its implementing rules and regulations (DAO 2000-81).

Noise level monitoring was conducted at four (4) locations within the vicinity. The measurement was performed for about one (1) hour and 24 hours. The noise sampler was handheld at about thirty degrees (30°) from the plane directly pointing at four (4) compass points to evaluate the noise level within the area. The noise level measurement results are presented in table and then were compared to the quality standards for noise (**Table 2.57**).

Table 2-57 NPCC Maximum Allowable Noise Level in General Areas

Category/Class				
AA	**A**	**B**	**C**	**D**
45	50	60	65	70

Description per Category:

- **Class AA** - A section or contiguous area which requires quietness, such as area within 100 meters from school sites, nursery schools, hospital and special home for the aged.
- **Class A** - A section or contiguous area which is primarily used for residential purposes.
- **Class B** - A section or contiguous area which is primarily a commercial area.
- **Class C** - A section or contiguous area primarily reserved as a light industrial area.
- **Class D** - A section or contiguous area primarily reserved as a heavy industrial area.

Based on the result of noise level monitoring, the sampling station exceeds the allowable noise level of class A for Morning (7:00AM – 8:00AM) which is set at 45 dBA.

Same result was observed during the Afternoon (1:00PM – 2:00PM) as all stations recorded noise level above 45 dBA. For the noise level monitoring result during Evening (7:00PM – 8:00PM), all of the stations exceeded 45 dBA.

For the Nighttime (1:00AM – 2:00AM) noise level monitoring period, the 2 monitoring hours exceeded the allowable limit of 45 dBA for class AA area (**Table 2.58**).

Table 2-58 Noise Level Monitoring Results

Location	Time	Noise Level, Dba	Category of the Area	DENR (DBA)
(Downstream)	0700H-0800H	48.9	Class AA	45
(Downstream)	1300H-1400H	52.3	Class AA	45
(Downstream)	1900H-2000H	40.23	Class AA	45
(Downstream)	0100H-0200H	16.25	Class AA	45

3. SOCIOECONOMIC PROFILE

3.1 Socio-economic Characterization (Secondary Data)

A watershed's socioeconomic profile is an important factor to consider when assessing its significance and developing sustainable management strategies. Demographics, economic activities, and resource access can all have an impact on how people use and interact with the watershed. Understanding these factors can aid in identifying potential conflicts and ensuring that management strategies are tailored to the needs of the communities whose livelihoods are heavily reliant on the watershed.

The results of the socio-economic survey are provided in sub-sections of this Chapter. The data collected by the survey team was compiled. Along with field monitoring studies and secondary data, these were used to identify environmental and social problems. The following analyses were carried out based on the compiled information on demography, economic, financial, and physical characteristics of the community.

3.1.1 Population and Population Density

The Carac-an River is one of the major rivers tapped for irrigation water resources, which is located in the Municipalities of Cantilan, Carrascal, and Madrid, Surigao Del Sur. The population of Surigao Del Sur is 642,255 based on the 2020 Census of Philippine Statistics Authority. This accounts for about 22.9 percent of the total population in Caraga Region, 2.45 percent of the overall population in Mindanao Region, or 0.59 percent of the Philippine population in 2020. With these figures, the population density is computed at 130 inhabitants per square kilometer or 337 inhabitants per square mile.

The 2020 population of the province is higher by 50,005 from the population of 592,250 in 2015, and 80,803 more than the population of 561,219 in 2010. Moreover, it is higher by 140,214 compared with the population of 501,808 in 2000 (**Table 3.1**).

Table 3-1 Population Data

Census Year	Census Reference Date	Total Population
2000	May 1, 2000	501,808
2010	May 1, 2010	561,219
2015	August 1, 2015	592,250
2020	January 1, 2020	642,255

Source: *Philippine Statistics Authority*

The population of Surigao Del Sur has increased by 1.72 percent annually from 2015 to 2020. Among the seventeen municipalities and two cities comprising Surigao Del Sur, Bislig had the biggest population in 2020 with 99,290 persons, followed by Tandag City with 62,669 persons, Barobo with 53,146 persons, San Miguel with 41,809 persons, and

Tagbina with 41,051 persons. Bayabas had the smallest population with 8,979 people. Tandag and Bislig are the two cities in the province, while the rest are municipalities (**Table 3.2**).

Table 3-2 Population by Municipality in Surigao del Sur

City/Municipality	2020 Total Population
Barobo	53,146
Bayabas	8,979
Bislig	99,290
Cagwait	21,747
Cantilan	34,060
Carmen	11,720
Carrascal	24,586
Cortes	17,924
Hinatuan	43,841
Lanuza	13,642
Lianga	33,869
Lingig	35,142
Madrid	16,653
Marihatag	19,441
San Agustin	22,855
San Miguel	41,809
Tagbina	41,051
Tago	39,831
Tandag	62,669

Source: *Philippine Statistics Authority*

The Cantilan Irrigation System covers the geopolitical jurisdictions of three (3) municipalities in the Province of Surigao Del Sur (**Table 3.3**). The municipalities are Cantilan, Carrascal, and Madrid. In terms of population, Municipality of Cantilan had the highest number with 34,060 in 2020 followed by Municipality of Carrascal with 24,586 and Madris with 16,653. While, for the population growth rate from 2015 to 2020, the Municipality of Madrid is the highest among the three with 1.91 percent followed by Carrascal with 1.90 percent and Cantilan with 1.66 percent. The table below shows the 2020 population and population density of the three municipalities.

Table 3-3 Population Density of CANTIS

Municipality	2020 Population	2015 Population	Land Area (Km^2)	Population Density Per Km^2 (2020)
Cantilan	34,060	31,492	240.1	142
Carrascal	24,586	22,479	265.8	92
Madrid	16,653	15,223	141.2	118

3.2 Socio-economic Characterization (Primary Data)

3.2.1 Demographic Profile of the Respondents

The demographic profile presented is based on the Socio-Economic Survey results. A watershed's demographic profile refers to the characteristics of the people who live within its boundaries. Population size, age distribution, gender, education level, income, and cultural diversity are all factors to consider. Understanding a watershed's demographic profile can help you assess its importance and identify strategies for long-term management.

There was a total of 292 respondents responded (**Table 3.4)** in the socioeconomic survey conducted for CANTIS – 155 respondents from Municipality of Cantilan (53.08%), 82 respondents from Municipality of Carrascal (28.08%), and 55 respondents from Municipality of Madrid (18.84%).

Table 3-4 Respondents' Profile

Municipality	Number of Respondents	Percent Share
Cantilan	155	53.08%
Carrascal	82	28.08%
Madrid	55	18.84%
Total	**292**	**100.00%**

3.2.1.1 Civil Status

The majority of the respondents were already married (62.33%), 22.95% of the respondents were separated, widower, and living-in. While 14.73% of the respondents were still single (**Table 3.5**).

Table 3-5 Civil Status

Civil Status	Number	Percent Share
Single	43	14.72%
Married	182	62.33%
Widow/widower	12	4.11%
Separated	16	5.48%
Live-in	39	13.36%
Total	**292**	**100.00%**

3.2.1.2 Nativity

The results showed that almost all of the respondents from the survey are native in the area. While only 3.21% are migrated in the locality due to marriage and other reasons (**Table 3.6**).

Table 3-6 Nativity

Native in Place	Number	Percent Share
No	259	88.70%
Yes	33	11.30%
Total	**292**	**100.00%**

3.2.2 Age Distribution of the Socio-Economic Survey Respondents

The table below shows the age distribution of the respondents interviewed for the socioeconomic survey. The result shows that the highest number of respondents answered the survey were in the bracket of 40-60 years old (59.59%), followed by 20-40 years old (21.23%), majority of the respondents are in the bracket of working group. While 19.18% of respondents are in the age bracket of 0-20 and 60-80 years old which lies on the youngest and oldest cohort (**Table 3.7**).

Table 3-7 Age Distribution Profile

Number of Years	Number of Respondents	Percent Share
0-20	23	7.88%
20-40	62	21.23%
40-60	174	59.59%
60-80	33	11.30%
Total	**292**	**100.00%**

3.3 Household

Cantilan

The total number of household population of Cantilan in the 2015 Census was 7,058 with an average of 4.5 members per household (**Table 3.10**).

Carrascal

The total number of household population of Carrascal in the 2015 Census was 5018 with an average of 4.5 members per household.

Madrid

The total number of household population of Madrid in the 2015 Census was 3504 with an average of 4.5 members per household.

Table 3.10 Number of Household per Municipality

Municipality/ City	Total Number of Households	Household Size
Cantilan	7058	4.5
Carrascal	5018	4.5
Madrid	3504	4.3

3.4 Livelihood and Sources of Income

Cantilan

From the past, the municipality has an industrial area, covering about 4.00 hectares and increase on the following years. The local revenue from industrial establishments decreased in 2015 due to the low demand of industrial products. Industrial establishment operators/owner reported in their financial statements decreased gross sales. In 2018, however, the industrial establishments recovered. There was an increasing demand in their products and new businesses, like bakeshops, arise in the municipality.

The municipality has abundant sources of raw materials for producing industrial products. Trees, which is used as a raw material for plywood, is found in barangay Pag-antayan (SUCECOR). Oil Minerals, which is used as a raw material for Nickel. Hardwood trees, which provide good lumber for the manufacturing of furniture and fixtures.

In commerce and trade, the Municipality of Cantilan, is considered as the key commercial area of the CarCanMadCarLan area. It is a convergent area for the rest of the four (4) neighboring municipalities. Commerce and trading are very much thriving in the area. The town is competing with Madrid, as developments in Cantilan are more vibrant as producers of goods and services coming a long way from other towns and provinces frequently supply the area.

Carrascal

Carrascal, known for its mining economy, is home to a number of large-scale mining firms. Further, the Municipality is an ideal candidate site of proposed wind power projects is located approximately 300-meter masl in the mining area near Carrascal. It is accessible from a highway under perpetual reconstruction and further made accessible by exploration roads constructed by mining companies.

Madrid

Agriculture is one of the primary economic activities of the municipality of Madrid with farming and livestock raising as its main source of living. The majority of the household in Municipality of Madrid is engaged in farming that makes its primary economic activity, but the main driver of the economy of the municipality is in trading and other services. In the municipality trading sector controls the economic condition in terms of profit. Supply of agricultural products is bought in by traders which offer much lower price than that of the retailer. Supply gap of other prime agricultural products are sourced out from the neighboring provinces in Mindanao. In terms of production, coconut occupies a large percentage of the agricultural land.

The total land area planted to coconut is 1500 hectares which represents 25.45 percent of the total production area. It has predominantly grown in all parts of the municipality and serves as the main source of cash for farmers and landowners. Income from coconut production supported the basic need of most farm families but has been in the downtrend due to the fluctuating price of copra and low productivity caused by lack of production technologies. Rice is the most produced crop in the area. It has more 1200 hectares of agricultural land devoted to rice production in an irrigated area and 225 hectares are rainfed. Land holdings of small rice farmers are generally limited, ranging from 0.5 hectares to 1.0 hectares. Corn has been produced in more than 900 hectares of agricultural land. Root crops production included camote, cassava, gabi and ubi; these serve as cash crops of the farmer.

Peanuts and banana are another emerging commodity with potential economic importance. These commodities are grown abundantly in Barangay Bagsac, San Roque and Bayogo.

Livestock and poultry productions are one of the livelihoods in the municipality, it provides alternative source of income to farmers.

Further, the majority of the economic activity in Madrid is engaged in wholesale and retail and the most common types of trading in Madrid are sari-sari stores, food vending, rice retailing and vending of agricultural products. There are also individuals who are producing at the same time selling their products. Commercial activity is largely concentrated in the Poblacion area where commercial establishments are mostly located.

The majority of the commercial activity mostly falls during market days where goods from the rural barangays and neighboring municipalities are displayed.

There are small-scale industries scattered throughout the urban barangays and the outskirts of the Poblacion area. Most of these industries are considered cottage industries with meager capitalization such as rice and corn mills and furniture shops. Most of the raw materials are locally produced and others come from neighboring towns. Finished products of these industries are sold to Surigao City and to the neighboring towns. There are also welding shops and Hollow Blocks Manufacturers.

3.5 Labor and Employment

Cantilan

The table below shows the number of gainful workers aged 15 years old and above – stratified by occupation group. A significant number of the labor force in Cantilan was involved in work related to agriculture, fishery, and forestry (23.87%) followed by service and sales workers (14.75%). High paying jobs such as managers, professionals, and technicians make up only 6.59%% of the labor force (**Table 3.8**).

Carrascal

The table below shows the number of gainful workers aged 15 years old and above – stratified by occupation group. A significant number of the labor force in Carrascal was involved in work related to plant and machine operators and assemblers (24%) followed by elementary occupations (21.08%). High paying jobs such as managers, professionals,
and technicians make up only 6.17% of the labor force (**Table 3.9**).

Madrid

The table below shows the number of gainful workers aged 15 years old and above – stratified by occupation group. A significant number of the labor force in Madrid was involved in work related to agriculture, forestry, and fishery (28.07%) followed by elementary occupations (21.08%). High paying jobs such as managers, professionals, and technicians make up only 8.75% of the labor force (**Table 3.10**).

Table 3-8 Gainful Workers 15 years old and over by Major Occupation Group in Cantilan

	TOTAL GAINFUL WORKERS 15 YEARS OLD AND OVER	AGE GROUP										
		15 - 19	20 - 24	25 - 29	30 - 34	35 - 39	40 - 44	45 - 49	50 - 54	55 - 59	60 - 64	65 and over
TOTAL	11,858	483	1,377	1,538	1,378	1,353	1,324	1,260	1,027	817	569	732
Managers	782	4	25	51	84	117	130	106	79	68	54	64
Professionals	737	2	69	123	93	85	83	90	87	73	23	9
Technicians and Associate Professionals	519	2	70	84	77	53	50	60	53	33	21	16
Clerical Support Workers	546	5	140	139	76	59	38	30	23	23	9	4
Service and Sales Workers	1,749	87	277	262	199	200	212	184	124	94	56	54
Skilled Agricultural Forestry and Fishery Workers	2,831	113	162	220	204	266	296	331	323	292	225	399
Craft and Related Trades Workers	1,142	18	99	149	130	147	157	154	88	72	53	75
Plant and Machine Operators and Assemblers	1,079	19	92	146	184	165	150	120	94	51	38	20
Elementary Occupations	2,442	232	439	357	325	254	202	185	156	111	90	91
Armed Forces Occupations	28	-	4	7	5	6	6	-	-	-	-	-
Other Occupation Not Elsewhere Classified	-	-	-	-	-	-	-	-	-	-	-	-
Not Reported	3	1	-	-	1	1	-	-	-	-	-	-

Table 3-9 Gainful Workers 15 years old and over by Major Occupation Group in Carrascal

	TOTAL GAINFUL WORKERS 15 YEARS OLD AND OVER	AGE GROUP										
		15 - 19	20 - 24	25 - 29	30 - 34	35 - 39	40 - 44	45 - 49	50 - 54	55 - 59	60 - 64	65 and over
TOTAL	7,589	299	1,064	1,153	1,000	860	741	723	607	488	346	308
Managers	469	1	16	37	45	48	53	67	63	56	42	41
Professionals	309	2	46	51	44	37	32	26	29	27	14	1
Technicians and Associate Professionals	398	4	48	68	64	55	61	37	25	18	13	5
Clerical Support Workers	507	15	142	141	72	52	26	22	12	16	8	1
Service and Sales Workers	728	34	107	102	96	84	63	91	65	49	19	18
Skilled Agricultural Forestry and Fishery Workers	1,173	25	66	70	87	91	112	150	139	142	127	164
Craft and Related Trades Workers	564	7	45	76	74	78	84	63	57	30	31	19
Plant and Machine Operators and Assemblers	1,822	70	277	336	297	253	171	158	111	86	42	21
Elementary Occupations	1,600	139	313	268	221	160	136	108	106	63	48	38
Armed Forces Occupations	16	-	4	4	-	2	2	1	-	1	2	-
Other Occupation Not Elsewhere Classified	-	-	-	-	-	-	-	-	-	-	-	-
Not Reported	3	2	-	-	-	-	1	-	-	-	-	-

Table 3-10 Gainful Workers 15 years old and over by Major Occupation Group in Madrid

	TOTAL GAINFUL WORKERS 15 YEARS OLD AND OVER	AGE GROUP										
		15 - 19	20 - 24	25 - 29	30 - 34	35 - 39	40 - 44	45 - 49	50 - 54	55 - 59	60 - 64	65 and over
TOTAL	5,449	136	540	694	669	609	563	573	492	431	315	427
Managers	477	-	17	34	50	51	66	66	59	54	34	46
Professionals	338	1	37	54	48	40	35	38	46	30	6	3
Technicians and Associate Professionals	172	-	21	30	23	15	21	21	13	13	8	7
Clerical Support Workers	187	-	47	54	36	23	10	6	1	5	4	1
Service and Sales Workers	677	28	110	122	90	89	69	48	35	38	25	23
Skilled Agricultural Forestry and Fishery Workers	1,530	3	45	75	110	132	149	188	204	185	169	270
Craft and Related Trades Workers	453	6	48	68	66	56	42	56	39	33	15	24
Plant and Machine Operators and Assemblers	448	7	38	60	82	81	77	45	28	14	7	9
Elementary Occupations	1,149	91	171	194	161	121	93	104	65	58	47	44
Armed Forces Occupations	14	-	5	2	3	1	-	1	1	1	-	-
Other Occupation Not Elsewhere Classified	-	-	-	-	-	-	-	-	-	-	-	-
Not Reported	4	-	1	1	-	-	1	-	1	-	-	-

3.5.1 Unemployment based on the Respondents of Socio-Economic Survey Results

As shown in **Table 3.11** below, 30.14% of the respondents are still students while 15.41% are house caretakers/housekeepers as their reason for unemployment mismatching their skills and nature of profession. Around 1.71% of the respondents does not meet the required age for work, 3.77% were not physically fit and with existing medical condition to work, 4.11% did not have enough experience to fit their target jobs, and around 10.62% responded that there are no available in the market that fit their profession.

Table 3-11 Unemployment

Reason for Unemployment for Some of Family Members	Number of Respondents	Percent Share
Age qualification/overage	5	1.71%
House caretaker/housekeeper	45	15.41%
Lack of experience or qualification	12	4.11%
No available jobs	31	10.62%
Others	47	16.10%
Physically unfit for work/health reason	11	3.77%
Still a student	88	30.14%
Did not answer	53	18.15%
Total	**292**	**100**

3.5.2 Occupation

Based on the socio-economic survey results, the major occupation of the respondents was farming with 70.89% and the remaining 8.22% were private employees, 1.71% government employees, 2.74% were working overseas, and no current jobs comprise 16.44% (**Table 3.12**).

Table 3-12 Occupation

Occupation	Number	Percent Share
Farming	207	70.89%
Regular Private Employee	24	8.22%
Government Employed	5	1.71%
OFW	8	2.74%
None	48	16.44%
Total	**292**	**100.00%**

3.5.3 Economic and Financial Indicators

Economic and financial indicators are used to assess a watershed's economic sustainability and its potential to generate economic benefits for the communities that rely on it. Discussion below focuses on the economic and financial conditions of the socio-economic survey respondents.

3.5.3.1 Household monthly income

The survey showed 93.49% of the respondents were earning 1-10,000 pesos monthly. The results also indicate that the respondents fall into the poverty line (**Table 3.13**).

Table 3-13 Monthly Income

Monthly Household Income	Number of Respondents	Percent Share
1-10,000	273	93.49%
10,001-20,000	17	5.82%
20,001-30,000	2	0.68%
30,001-40,000	-	-
40,001-50,000	-	-
More than 50,000	-	-
Total	**292**	**100.00%**

3.5.3.2 Economic Status Perception

Individuals' or communities' subjective perceptions of their economic well-being or financial status are referred to as economic status perception. Income, employment status, education level, and access to resources are all factors that can influence it. Understanding economic status perception can help assess a watershed's social sustainability and identify potential areas of concern or opportunities for improvement.

The respondents were asked about their financial/economic status perception. Surprisingly, they have assessed their situation as living in the middle class in contrary to their monthly household income.

Table 3-14 Status Perception

Economic Status/Situation	Number of Respondents	Percent Share
Average	98	33.56%
Poor	170	58.22%
Very poor	24	8.22%

Economic Status/Situation	Number of Respondents	Percent Share
Well-off	-	-
Total	**292**	**100.00%**

3.5.4 Physical Indicators

Physical indicators are measures that are used to assess the ecological health and quality of the physical environment of a watershed. These indicators can assist in identifying potential areas of concern and prioritizing management actions to protect and restore the ecological health of the watershed. Below are discussions of physical indicators of the socio-economic survey respondents.

3.5.4.1 Farm Lot Ownership

Out of the 292 respondents, majority of the farmers were caretakers of the farm (61.30%), 13.7% were renting. On the other hand, 5.82% of the farmers owned their farmlands and 19.18% were tenants (**Table 3.15**).

Table 3-15 Farm Ownership

Farm Lot Ownership	Number of Respondents	Percent Share
Caretaker	179	61.30%
Tenant	56	19.18%
Owned	17	5.82%
Rented	40	13.70%
Total	**292**	**100.00%**

3.5.4.2 Tenurial instrument of farm lot

Majority of the respondent are not aware of the tenurial instruments of their lands (94.18%), and only 5.82% of the farmers have privately-owned farm (**Table 3.16**).

Table 3-16 Farm Tenurial Instruments

Tenurial Instrument of Farm Lot	Number of Respondents	Percent Share
Certificate of Ancestral Domain Title (CADT)	-	-
Titled (private)	17	5.82%
No answer	275	94.18%
Total	**292**	**100.00%**

3.5.4.3 House Ownership

The house ownership survey results showed that majority of the respondents owned their houses. While 9.24% of the respondents are only caretaker of their houses (**Table 3.17**).

Table 3-17 House Ownership

Ownership of your House	Number of Respondents	Percent Share
Caretaker	27	9.24%
Owned	233	79.79%
Rented	32	10.96
Total	**292**	**100.00%**

3.5.5 School-Age Children Attending School based on Socio-Economic Survey Results

Based on the socio-economic survey results, the table below shows that there 20.55% of the respondent had no school-age children attending school, and approximately 79.45% of the respondents had children attending school ranging from 1-6 children attending (**Table 3.18**).

Table 3-18 School Age Children Attending School

No. School-Age Children Attending School	Number of Respondents	Percent Share
None	60	20.55%
1	82	28.08%
2	56	19.18%
3	37	12.67%
4	21	7.19%
5	14	4.79%
6	22	7.53%
Total	**292**	**100.00%**

3.5.6 Highest Educational Attainment

The respondents were asked of their highest educational attainment, 21.57% were elementary undergraduate, 29.79% finished elementary level, 15.75% of the respondents finished high school level, 7.19% are college undergraduate, and only 4.79% of the respondents graduated from college (**Table 3.19**).

Table 3-19 Educational Attainment

Highest Educational Attainment	Number of Respondents	Percent Share
No Formal Education	5	1.71%
Undergrad Elementary	63	21.57%
Elementary Graduate	87	29.79%
Undergraduate Highschool	56	19.18%
Highschool Graduate	46	15.75%
Undergraduate College	21	7.19%
College Graduate	14	4.79%
Post-Graduate Level	0	0
Total	**292**	**100.00%**

3.6 Infrastructure (Transportation, Infrastructure, Communication, and Utilities)

Cantilan

Transportation and Roads

The most widely used mode of transportation in Cantilan was land and sea transportations. For those who lived in inlands uses multi- cab, jeepneys, motorized tricycle, single motorcycle locally known as "habal- habal", pedalled tricycle or "sikad-sikad" and even privately own vehicles. For those who lived in coastal areas uses motorized banca. Traffic congestion is not a problem in Cantilan excluding from peak hours.

Road network facilities the mobility of goods, services, and people. There are 4 classifications of roads present in Cantilan. The national road traverses Cantilan going to Carrascal at the northern portion and the south leading to Madrid and other towns. The national road has 12.61 kilometers in length. The national road is considered as secondary highway. 100 percent of the national highway is already concreted.

The provincial road stretches more than 32.788 kilometres mostly linking remote barangays of Cantilan and has facilitated the economic development of the area. More than 89 percent of the provincial road is gravel surfaced. The provincial road has a very significant role in Cantilan and its tourism area as well. Provincial roads formed a linear pattern stemming from the national highway linking to the innermost rural barangays.

The municipal roads located at the Poblacion area have a total length of 13.03 kilometers. Approximately, 98% of the municipal road networks are already concreted. The road network in the urban barangay formed a blocked pattern. Municipal road network has an entrance and exit in going to the urban core. While the Barangay roads has a total length of 113.49 kilometers. Barangay roads formed a linear pattern from the existing provincial road only. Most of the barangay roads are still unpaved and gravel- surfaced.

Water

The town has a Local Water District operating in the area serving 2,314 households for domestic and commercial use. The average consumption supply reaches 15 cubic meters. For 17 barangays in Cantilan there are already 13 barangays served by the local water district. Barangays like Cabas-an, General Island, Cabangahan and Lobo was not served due to its distance from the source.

Other households especially in the rural areas have their shallow wells and open dug wells. Jetmatic pumps and electric-powered motor pumps are complementing for the water needs of the population.

Every year Cantilan Water District is upgrading its facilities to ensure its capability to meet future water requirements of the people of Cantilan particularly, in the urban core.

Madrid

Transportation and Roads

The municipality is linked through a National Highway to other municipality and links with the towns of Cantilan in the north and Carmen on the south, all of the province of Surigao del Sur. The national highway is currently serving an increasing number of municipal travels. Land-based traffics are increasing in both directions.

Although, widening of some segments of the national highway is not yet completed that's why it did not sufficient to solve traffic congestions, especially the portion which runs across the commercial area in Barangay Quirino wherein the roads are congested especially during market days.

The municipal roads have a total length of 4.91 kms, representing 87.6% or 4.30 kms are concreted and 0.61 km or 12.4% as gravel. Although most of the streets within the municipality are narrow but it is adequate to correspond to traffic circulation.

The urban roads are consisting of 12 road segments with a total road length of 4.91 kms. representing 14.35 of the total road networks of the municipality. As presented in Table 3.3.1 only 4.30 kms. (87.57%) are concrete while the remaining 0.61 kms. (12.43%) are gravel. All of these existing roads are in good condition but with some potholes. The rural roads are consisting of 65 road segments with a total road length of 85.83 kms, representing 84.11% of the total road network of the municipality. As presented in Table 3.3.1, only 11.55 kms (11.33%) are concrete while the remaining 90.51 kms (88.67%) are gravel. All of these existing roads are in good condition but with some potholes.

In terms of transport, the Madrid public transport system is consisting of buses, jeepneys, single-motors, motorized trisikads and tri-sikad. The national highway is where the bus, jeepney and single motor terminals are located.

Communication

In terms of communication, the Municipality of Madrid availed two (2) communication facilities (smart and globe) which is the now popularly used by the local population. The Postal Office still cater for mailing services. There is limited internet connectivity provided by wireless broadbands but not fully utilized because of the inconsistent signal in the area.

Water

At present there are already a total of 891 connections installed by the Water District, 871 residential, 18 commercial and 2 for industrial. Barangays Qurino, Linibunan, and Barangay Magsaysay were already served by Madrid Water District but in other barangays such as San Roque, Bayogo, and San Vicente has also their existing Barangay Water Works System but are operationalize in a Level II Category (Communal Faucet).

Electric

The electric power supply of Madrid is being served by SURSECO II; source comes from the National Power Corporation. It is serving all the 14 Barangays of the Municipality. There are already 3,724 connections; 3,359 residential; 3 industrials; 252 commercials.

3.6.1 Natural Indicators

Natural indicators are measures that are used to assess the ecological health and quality of the natural environment of a watershed. These indicators can assist in identifying potential areas of concern and prioritizing management actions to protect and restore the ecological health of the watershed. Discussions below are the natural indicators based on the socio-economic survey results.

3.6.1.1 Main Sources of Irrigation

All of the respondents were dependent on the National Irrigation System provided by National Irrigation Administration (**Table 3.20**).

Table 3-20 Irrigation Water Source

Main Source of Irrigation for Farming	Number of Respondents	Percent Share
Communal Irrigation System	-	-
National Irrigation System	292	100%
None/Rainfed	-	-
Pump Irrigation from Open Source, E.G., River (PISO)	-	-
Shallow Tube Well/Small Farm Reservoir (SFR)	-	-
Did not answer	-	-
Total	**292**	**100.00%**

3.6.1.2 Main Sources of Water Supply

Out of the 292 respondents, only 30.48% of them were using faucets as their main source of water supply and majority of the respondents were using deep well in the area (**Table 3.21**).

Table 3-21 Domestic Water Supply

Main Source of Water Supply for Domestic Use	Number of Respondents	Percent Share
Bottled Water/Refilling Station	-	-
Deep Well / Dug Well (Balon)	187	64.04%
Faucet (Local Water System)	89	30.48%
From River	16	5.48%
Hand Pump/Jetmatic	-	-
Piped Water/Community Taps	-	-
Piped Well/Tube Well	-	-
Stream/ Spring	-	-
Total	**292**	**100.00%**

3.6.1.3 Main Sources of Drinking Water

Deep well was the main source of drinking water of the 292 respondents in the area based from the survey results (**Table 3.22**).

Table 3-22 Sources of Drinking Water

What is the Source of Drinking Water of Your Household	Number of Respondents	Percent Share
Bottled water/refilling station	-	-
Deep well/Dug well (balon)	187	64.04%
Faucet (local water system)	89	39.48%
From river	16	5.48%
Hand pump/jetmatic	-	-
Piped water/community taps	-	-
piped Well/tube well	-	-
Stream/ spring	-	-
Total	**292**	**100.00%**

3.6.1.4 Ownership on agricultural land for livelihood

A total of 40 respondents said that they own the land they till while the others are either tenant, caretaker, or others (**Table 3.23**).

Table 3-23 Agri Land Ownership

Status of Ownership on Agricultural Land for Livelihood	Number of Respondents	Percent Share
Caretaker	89	30.48%
Others	-	-
Owned	40	13.70%
Rented	46	15.75%
Tenant (sharing)	10	3.42%
Did not answer	107	36.64%
Total	**292**	**100.00%**

3.6.1.5 Application of Soil and Water Conservation Technologies

The table below shows that 100% of the respondents were applying various soil and water conservation technologies. Mostly, they are practicing fallow period and rainwater harvesting technique (**Table 2.34**).

Table 3-24 Soil and Water Conservation Technologies

Do You Apply Soil and Water Conservation Technologies E.G. Contour Farming?	Number of Respondents	Percent Share
No	-	-
Yes	292	100%
Total	**292**	**100.00 %**

3.6.1.6 Types of Farming System

All the respondents were practicing monocropping in terms of type of farming. This indicates that mass production of their agricultural produce was the main concern for the farmers (**Table 3.25**).

Table 3-25 Farming System

Types of Farming System	Number of Respondents	Percent Share
Mixed cropping	-	-
Mono cropping	292	100%
Total	**292**	**100.00%**

3.6.1.7 Perception on the status of forest in the community

A total of 292 respondents believed that they have no remaining forest stands in their community (**Table 3.26**).

Table 3-26 Perception on Forest Status

Do you have Remaining Forest in your Community?	Number of Respondents	Percent Share
No	292	100%
Yes	-	-
Total	**292**	**100.00%**

3.6.2 Religion of the Socio-Economic Survey Respondents

The survey results showed that the prominent religion in the area where majority of the respondents are Roman Catholic (65.75%) and the rest are other religions (**Table 3.27**).

Table 3-27 Religion

Religion	Number	Percent Share
Roman Catholic	192	65.75%
Evangelicals	29	9.93%
Iglesia Ni Cristo	28	9.58%
Islam	4	1.37
Other Religious Affiliations	39	13.36
Total	**292**	**100.00%**

3.7 Tourism and Recreation

There are numerous tourism spots can be found outside the delineated watershed area, however, most of it are underdeveloped and not given attention by the Local Government Unit either due to lack of fund, conflict of interest and insurgency. If prioritized, the tourism sector will promote sustainable livelihood for the communities within the area (**Table 3.28-3.30**).

Table 3-28 Tourism and Recreational Area in Cantilan

Name of Tourism/ Recreation Spot	Nature/Activity in The Tourism Area	Location
Flores Coves	Swimming	Brgy. General Island, Cantilan, SDS
Inijakan Beach Club	Swimming and Camping	Brgy. General Island, Cantilan, SDS
Rockgem Treasure Island	Swimming and Camping	Brgy. General Island, Cantilan, SDS
Double B Resort	Swimming	Brgy. General Island, Cantilan, SDS
Huyamao White Beach Resort and Campsite	Swimming and Camping	Brgy. General Island, Cantilan, SDS
Ayoke Beach	Swimming and Camping	Brgy. General Island, Cantilan, SDS
Cantilan Natures Park	Swimming	Brgy. San Pedro, Cantilan, SDS
Consuelo Beach	Swimming	Brgy. Consuelo, Cantilan, SDS

Name of Tourism/ Recreation Spot	Nature/Activity in The Tourism Area	Location
Cantilan Tribunal Building	Sight-seeing	Brgy. Linintian, Cantilan, SDS
Cantilan Park	Leisure	Brgy. Magosilom, Cantilan, SDS
Danao Lake	Swimming	Brgy. General Island, Cantilan, SDS
Baybay II	Swimming and Surfing	Brgy. Magosilom, Cantilan, SDS
San Pedro Beach	Swimming	Brgy. San Pedro, Cantilan, SDS
Sipangpang Falls	Trekking, Camping and Swimming	Brgy. Cabangahan, Cantilan, SDS

Table 3-29 Tourism and Recreational Area in Madrid

Name of Tourism/ Recreation Spot	Nature/Activity in The Tourism Area	Location
La Vecchia Spiaggia	Swimming and Sight- seeing	Brgy. Union, Madrid, SDS

Table 3-30 Other Potential Areas for Tourism

Name	Location	Remarks
Loksohon Cave	Cabas-an, Cantilan	A potential area for Eco-tourism development providing recreational activities (white water rafting, cliff jumping/diving, spelunking) for local and foreign tourists and visitors.
Tiangban Cave		
Hanginan Cave		
Laksohon Cave 1	Bayogo, Madrid	A potential area for Eco-tourism development providing recreational activities (white water rafting, cliff jumping/diving, spelunking) for local and foreign tourists and visitors.
IP Cultural Area	Lobo, Cantilan	A major cultural tourism destination where tourists can experience ethnic tribal/ community immersion thus promoting culture preservation.

3.8 Social Indicators of the Respondents

Social indicators are measures used to assess community well-being and the quality of life of people who live within a watershed. In terms of social sustainability, these indicators can assist in identifying areas of concern and opportunities for improvement.

3.8.1 Membership to 4Ps

Out of 292 respondents, 27.74% were not a member of Pantawid Pamilyang Pilipino Program (4Ps) of the government. While the remaining 72.26% were members of the government program (**Table 3.31**).

Table 3-31 Membership to 4Ps

Membership to 4ps	Number of Respondents	Percent Share
No	81	27.74%
Yes	211	75.90%
Total	**249**	**100.00%**

3.8.2 Human Capital Indicators

Human capital indicators are measures that assess people's knowledge, skills, and abilities within a watershed. These indicators can aid in identifying potential opportunities for improving education and workforce development within the watershed, which can lead to long-term economic growth and sustainability.

3.8.2.1 Training or seminars on climate-related disaster management

A total of 292 respondents (100%) said that they have not attended a single training related to climate-disaster management (**Table 3.32**).

Table 3-32 Trainings and Seminars Attended

Attended Any Training or Seminars on Climate-Related Disaster Management	Number of Respondents	Percent Share
No	292	100%
Yes	-	-
Total	**292**	**100.00 %**

3.8.3 Traditional (indigenous) knowledge on disaster management

Indigenous knowledge about disaster management survey results showed that there are 11.3% of the respondents practicing indigenous knowledge on disaster management while 88.7% of the respondents were not knowledgeable on indigenous knowledge on disaster management (**Table 3.33**).

Table 3-33 Indigenous Knowledge

Presence of traditional (indigenous) knowledge on disaster management	Number of Respondents	Percent Share
No	259	88.70%
Yes	33	11.3%
Total	**292**	**100.00%**

3.8.4 Indigenous People

Republic Act 8371, or the Indigenous Peoples' Rights Act (IPRA) of 1997, declares that "the State shall protect the rights of Indigenous Cultural Communities/Indigenous Peoples (ICC/IPs) to their ancestral domains to ensure their economic, social, and cultural well-being and shall recognize the applicability of customary laws governing property rights or relations in determining the ownership and extent of ancestral domain."

One of the said rights of the ICC/IPs is the right to ancestral domains, which are territories that cover both the physical environment and the spiritual bonds to it. There is also the indigenous concept of ownership, which "generally holds that ancestral domains are private but community property which belongs to all generations and therefore cannot be sold, disposed, or destroyed" (RA 8371). It should be of note that the said concept of ownership covers sustainable traditional resource rights as well.

The Cantilan RIS based on the survey of 292 respondents, there were no indigenous people within CANTIS nor there are area existing Ancestral Domain Claim and/or Application of Certificate of Ancestral Domain Title. This is still subject for validation with the National Commission on Indigenous People (**Table 3.34**).

Table 3-34 IP Groups in CANTIS

Belong to an IP Group	Number	Percent Share
No	292	100%
Yes	0	0%
Total	**292**	**100.00%**

3.9 Gender and Development

Gender and Development (GAD) is an approach that acknowledges the social and cultural roles, rights, and inequalities between genders. Its objective is to address these disparities and promote gender equality in all aspects of development. The inclusion of GAD in vulnerability assessments of watersheds is crucial as it highlights the differential impacts of vulnerabilities on men and women. It enables the identification of gender-specific risks and the design of targeted interventions to mitigate these vulnerabilities.

In the communities within the watershed, implementing gender-sensitive disaster coping mechanisms is vital to address the vulnerabilities experienced by different gender groups. These mechanisms should consider the specific needs of men, women, and children, including factors such as access to information, decision-making power, and resource allocation. Engaging women in disaster preparedness and response planning, providing gender-specific training, and promoting inclusive decision-making processes can contribute to building resilient forest communities.

3.9.1 Discrimination of Women and Children

The survey results show that 33.87% (105) of the respondents believe that there will be a discrimination in terms of facilities that will cater to the needs of women and children. On the other hand, 51.93% (147) of the respondents believe that there will be a discrimination in terms of hiring skilled, technical and managerial workers (**Table 3.35**).

Table 3-35 Discrimination of Women and Children

Aspects that will result to possible discrimination of women and children	Respondents	Percent Share
Employment of skilled workers	56	18.06
Employment of managerial and technical workers	91	29.35
Construction of facilities that will serve women`s & children`s needs	105	33.87
Others	58	18.71
Total	**310**	**100.00**

3.9.2 Jobs for Women

According to the survey, 86.77% of the respondents believe that women should have job roles in the technical aspect, management, and maintenance during the plan implementation (**Table 3.36**).

Table 3-36 Jobs for Women

Possible Job of Women During Plan Implementation	Respondents	Percent Share
Actual Implementation	26	8.39
Technical Aspect	81	26.13
Management	91	29.35
Maintenance	97	31.29
Others	15	4.84
Total	**310**	**100.00**

3.9.3 Exploitation of Women and Children

According to the survey, 50.97% (158) of the respondents perceived women and children as the sole breadwinner. Meanwhile, 20.97% (65) believed that women and children were involved in heavy and fatiguing works and 28.06% (87) believed that women and children are suppressed in terms of personal needs (**Table 3.37**).

Table 3-37 Exploitation of Women and Children

Different ways of exploitation of women and children	Respondents	Percent Share
Women and children being the sole breadwinner in the family	158	50.97
Women and children involving in strenuous works	65	20.97
Women and children deprived of their personal needs	87	28.06
Total	**310**	**100.00**

3.9.4 Improved RIS Impact on Minimizing Exploitation

According to the survey, 49.68% of the respondents believe that there will be a significant impact in minimizing the exploitation of women and children with the improved river irrigation system. Meanwhile, 30.32% responded that even with the improved river irrigation system, there will be no minimization of exploitation of women and children. Around 20% said that they have no idea what the improved RIS might bring (**Table 3.38**).

Table 3-38 Improved RIS Impact on Minimizing Exploitation

Do you think that the improvement of the river irrigation system would minimize exploitation of women and children?	Respondents	Percent Share
Yes	154	49.68
No	94	30.32
No Idea	62	20.00
Total	**310**	**100.00**

3.9.5 Problems Encountered by Residents

According to the survey, 54.20% of the respondents encountered forest denudation and insufficient water supply as one of their problems. Meanwhile, 15.81% of the

respondents encountered degraded water quality and 4.84% of the respondents encountered noise and pollution in their area (**Table 3.39**).

Table 3-39 Problems Encountered by Residents

Problems Encountered by Residents	Respondents	Percent Share
Forest Denudation	84	27.10
Degradation of Water Quality	49	15.81
Insufficient Water Supply	84	27.10
Noise & Pollution	15	4.84
Others	78	25.16
Total	**310**	**100.00**

3.9.6 Reasons for Problems Encountered

The above-mentioned problems encountered by the respondents were perceived to have different reasons. The majority (31.61%) believed that improper solid waste disposal is one of the reasons why they've encountered environment-related problems. Meanwhile, 29.35% said that weak policy implementation and political willingness were major factors in their environment degradation and 15.48% said that land conversion, mining, quarrying, etc., were the reasons for environment-related problems (**Table 3.40**).

Table 3-40 Reasons for Problems Encountered

Reasons for the Problems Encountered	Respondents	Percent Share
Policy Implementation	91	29.35
Degrading Land Practices	48	15.48
Improper Solid Waste Disposal	98	31.61
Others	73	23.55
Total	**310**	**100.00**

3.9.7 Necessary Projects

More than half (194 or 62.58%) of the respondents said that ALS (Alternative Livelihood System) should be included in the plan and upon project implementation. While 45 or 14.52% of the respondents said GAD Corner is also necessary and be included in the plan (**Table 3.41**).

Table 3-41 Necessary Projects

Necessary Projects for the Benefit of Women	Respondents	Percent Share
Alternative Livelihood System	194	62.58
GAD Corner	45	14.52
Others	71	22.90
Total	**310**	**100.00**

3.9.8 Effects of Management Plan

Out of 310 respondents, 87 or 28.06% perceived that the plan implementation will provide employment for women and children, while 135 or 43.55% said that it will bring sufficient and good quality water supply. While 56 or 18.06% believed that the implementation of the plan will boost the tourism and economy in the area (**Table 3.42**).

Table 3-42 Effects of Management Plan

How will the management plan affect residents?	Respondents	Percent Share
Improvement of Tourism Spots	16	5.16
Good for the Economy	40	12.90
Sufficiency of Water Supply	81	26.13
Employment	87	28.06
Improved Quality of Water Supply	54	17.42
Others	32	10.32

How will the management plan affect residents?	Respondents	Percent Share
Total	**310**	**100.00**

3.9.9 Perception of Women Working upon Implementation of the Plan

Surprisingly, there were 19 respondents or 6.13% who were not in favor in hiring women upon implementation of the plan. While bulk of the responses (248 or 80%) show that were in favor of women working upon implementation of the plan (**Table 3.43**).

Table 3-43 Perception of Women Working upon Implementation of the Plan

Those who are in favor of women working upon implementation of the plan	Respondents	Percent Share
In Favor	248	80.00
Not in favor	19	6.13
No Answer	43	13.87
Total	**310**	**100.00**

3.10 Demographic Profile

In conjunction with primary data collection, the acquisition of secondary data from Local Government Units (LGUs) holds significant importance in studying the socioeconomic profile. It provides valuable historical context, facilitates large-scale analysis, enables comparative assessments, and supports long-term monitoring to evaluate project strategies. The demographic profiling being conducted focuses on specific local areas within CANTIS. Subsequently, the secondary data collected will be presented in subsequent sub-sections, contributing to a comprehensive understanding of the socioeconomic dynamics in the studied regions.

3.10.1 Age Structure

Cantilan

Based on the 2015 Census, the population of age under 1 is almost one fourth (1/4) of ages 1 to 4 and the ages 60 above is the declining fertility of the municipality. The sex ratio of Cantilan hovers around ≈ 0.9209 which shows the majority of female population in the municipality. Of the total population, under 1-14 age group comprises 36.10 percent, ages 15- 64 embraces 55.93 percent and 65 years and above accounts to 5.18 percent.

With this age grouping where the greater number of people is in the productive age group (ages 15-64) the dependency ratio is placed at 81 dependents per 100 persons in the working ages. The median age of the population in Cantilan is approximately 24.91 which indicates that half of the entire population are aged less than 25 and other half are over the age of 25.

The youth dependency ratio of Cantilan falls around 50.84, while the old dependency ratio is 11.21 with a total dependency ratio of 62.05. This means that there are 62 dependents from young and old age to every 100 of the working population (**Table 3.44**).

Table 3-44 Population by Age and Sex in Cantilan

Age Group	Both Sexes	Male	Female
All Ages	**31,492**	**15106**	**16386**
Under 1	867	416	451
1 – 4	3247	1558	1689
5 – 9	3789	1818	1971
10 – 14	4343	2084	2259
15 – 19	3430	1646	1784
20 – 24	2133	1023	1110
25 – 29	2079	997	1082
30 – 34	1984	952	1032
35 – 39	1830	878	952
40 – 44	1537	737	800
45 – 49	1437	689	748
50 – 54	1241	595	646
5 – 59	1096	526	570
60 – 64	848	407	441
65 – 69	624	299	325
70 – 74	441	211	230
75 – 79	325	156	169
80 above	241	114	127

Carrascal

Based on the 2015 Census, the age group with the highest population in Carrascal is 1 to 4, with 2,362 individuals. While the lowest age group population is 75 to 79 with 197 individuals.

Combining age groups together, those aged 14 and below, consisting of the young dependent population which includes infants/babies, children, and young adolescents/teenagers, make up an aggregate of 33.42 percent (7,512). Those aged 15 up to 64, roughly, the economically active population and actual or potential members of the work force, constitute a total of 61.77 percent (13,886). Finally, the old dependent population consisting of the senior citizens, those aged 65 and over, total 4.81% (1,081) in all.

The computed Age Dependency Ratios mean that among the population of Carrascal, there are 54 youth dependents to every 100 of the working age population; there are 8 aged/senior citizens to every 100 of the working population; and overall, there are 62 dependents (young and old age) to every 100 of the working population. The median age of 24 indicates that half of the entire population of Carrascal are aged less than 24 and the other half are over the age of 24 (**Table 3.45**).

Table 3-45 Population by Age and Sex in Carrascal

Age Group	Both Sexes	Male	Female
All Ages	**22479**	**11707**	**10772**
Under 1	588	301	287
1 – 4	2362	1232	1130
5 – 9	2360	1220	1140
10 – 14	2202	1181	1021
15 – 19	2143	1084	1059
20 – 24	2156	1134	1022
25 – 29	1884	1010	874
30 – 34	1658	892	766
35 – 39	1365	743	622
40 – 44	1244	624	620
45 – 49	1144	615	529
50 – 54	914	493	421
55 – 59	772	406	366
60 – 64	606	316	290
65 – 69	378	172	206
70 – 74	280	126	154
75 – 79	197	79	118
80 above	226	79	147

Madrid

According to the 2015 Census, the age group with the highest population in Madrid is 5 to 9, with 1,628 individuals. Conversely, the age group with the lowest population is 75 to 79, with 211 individuals.

Combining age groups together, those aged 14 and below, consisting of the young dependent population which includes infants/babies, children and young adolescents/teenagers, make up an aggregate of 31.53 percent (4,800). Those aged 15 up to 64, roughly, the economically active population and actual or potential members of the work force, constitute a total of 60.38 percent (9,192). Finally, old dependent population consisting of the senior citizens, those aged 65 and over, total 8.09 percent (1,231) in all. The computed Age Dependency Ratios mean that among the population of Madrid, there are 52 youth dependents to every 100 of the working age population; there are 13 aged/senior citizens to every 100 of the working population; and overall, there are 66 dependents (young and old age) to every 100 of the working population. The median age of 26 indicates that half of the entire population of Madrid are aged less than 26 and the other half are over the age of 26 (**Table 3.46**).

Table 3-46 Population by Age and Sex in Madrid

Age Group	Both Sexes	Male	Female
All Ages	**15,223**	**7687**	**7536**
Under 1	307	151	156
1 – 4	1289	685	604
5 – 9	1628	837	791
10 – 14	1576	827	749
15 – 19	1366	706	660
20 – 24	1180	596	584
25 – 29	1098	584	514
30 – 34	1007	542	465
35 – 39	917	459	458
40 – 44	837	440	397
45 – 49	845	438	407
50 – 54	739	360	379
55 – 59	661	307	354
60 – 64	542	260	282
65 – 69	402	177	225
70 – 74	366	157	209
75 – 79	211	83	128
80 above	252	78	174

3.10.2 Education

In the context of socioeconomic profile, education lays the groundwork for human capital development and determines employment opportunities, income levels, and social mobility. Individuals' educational attainment is frequently utilized as a predictor of their potential economic output and success. Access to high-quality education provides individuals with the skills they need to adapt to labor-market demands and contribute to economic progress. Based on the data collected from the LGUs and NGAs, the following are the Educational Attainment of the population present within Cantilan.

Cantilan

Table 3-47 Total Population 5 Years Old and Over by Highest Grade/Year Completed, Cantilan

Highest Grade/Year Completed	Total Population 5 Years Old and Over
No Grade Completed	621
Pre-School	944
Special Education	1
Elementary	9,649
1st - 4th Grade	4,680
5th - 6th Grade	1,787
Graduate	3,182
High School	9,192
Undergraduate	4,566
Graduate	4,626
Post-Secondary	664
Undergraduate	10
Graduate	654
College Undergraduate	3,210
Academic Degree Holder	3,892
Post Baccalaureate	59
Not Stated	-
Total	**28,232**

Carrascal

Table 3-48 Total Population 5 Years Old and Over by Highest Grade/Year Completed, Carrascal

Highest Grade/Year Completed	Total Population 5 Years Old and Over
No Grade Completed	433
Pre-School	663
Special Education	3
Elementary	7,316
1st - 4th Grade	3,757
5th - 6th Grade	1,286
Graduate	2,273
High School	7,081
Undergraduate	3,383
Graduate	3,698
Post-Secondary	321
Undergraduate	34
Graduate	287
College Undergraduate	2,180
Academic Degree Holder	1,519
Post Baccalaureate	13
Not Stated	-
Total	**19,529**

Madrid

Table 3-49 Total Population 5 Years Old and Over by Highest Grade/Year Completed, Madrid

Highest Grade/Year Completed	Total Population 5 Years Old and Over
No Grade Completed	420
Pre-School	352
Special Education	-
Elementary	4,994
1st - 4th Grade	2,369
5th - 6th Grade	850
Graduate	1,775
High School	4,629
Undergraduate	2,185
Graduate	2,444
Post-Secondary	359
Undergraduate	25

Highest Grade/Year Completed	Total Population 5 Years Old and Over
Graduate	334
College Undergraduate	1,221
Academic Degree Holder	1,620
Post Baccalaureate	32
Not Stated	-
Total	**13,627**

3.10.3 Religious Sectors

Religious beliefs and practices can influence socioeconomic outcomes through shaping attitudes about employment, wealth accumulation, and giving. Furthermore, religious institutions frequently play an important role in community social support, welfare services, and educational efforts. The presence of strong religious sectors can create social cohesiveness, improve community resilience, and contribute to a population's overall socioeconomic well-being. Based on the data collected from the LGUs and NGAs, the following are the Religious Groups present within Cantilan (**Table 3.50**).

Table 3-50 Religious Group present in CANTIS

Religious Affiliation	Both Sexes	Male	Female
Aglipay	300	151	149
Association of Fundamental Baptist Churches in the Philippines	454	238	216
Bible Baptist Church	2,813	1,441	1,372
Buddhist	10	6	4
Church of Christ	517	261	256
Church of Jesus Christ of the Latter-Day Saints	778	407	371
Evangelical Christian Outreach Foundation	40	23	17
Evangelicals (Philippine Council of Evangelical Churches)	28,879	14,762	14,117
Faith Tabernacle Church (Living Rock Ministries)	61	35	26
Good News Christian Churches	217	117	100
Iglesia ni Cristo	21,882	11,298	10,584
Iglesia sa Dios Espiritu Santo, Incorporated	33	20	13
International One-Way Outreach	540	282	258
Islam	2,396	1,231	1,165
Jehovah's Witness	5,523	2,746	2,777
Jesus is Lord Church	1,090	548	542
Lutheran Church of the Philippines	1	1	0
Miracle Revival Church of the Philippines	104	52	52
Missionary Baptist Churches of the Philippines	125	66	59

Religious Affiliation	Both Sexes	Male	Female
National Council of Churches in the Philippines	10,430	5,465	4,965
Philippine Benevolent Missionaries Association	23	13	10
Philippine Ecumenical Christian Church	3,049	1,600	1,449
Philippine Grace Gospel	257	142	115
Philippine Independent Catholic Church	2,193	1,119	1,074
Roman Catholic, including Catholic Charismatic	440,623	227,533	213,090
Seventh Day Adventist	15,710	7,954	7,756
Union Espiritista Cristiana de Filipinas, Incorporated	2	1	1
United Church of Christ in the Philippines	4,693	2,340	2,353
United Pentecostal Church (Philippines), Incorporated	6,606	3,359	3,247
Victory Chapel Christian Fellowship	153	79	74
Other Baptists	712	358	354
Other Protestants	1,010	521	489
Other Religious Affiliations	35,687	18,366	17,321
Tribal Religions	5,269	2,771	2,498
None	29	18	11
Not Reported	41	41	0
Total	**592,250**	**305,365**	**286,885**

4. VULNERABILITY ASSESSMENT

Vulnerability assessment is an important tool for understanding and managing potential risks and impacts to the ecological and social systems of a watershed. The assessment process entails identifying potential hazards, assessing their likelihood and potential consequences, and developing risk-reduction or risk-mitigation strategies. Vulnerability assessments can assist in identifying areas of the watershed that are most vulnerable to human activities or natural events such as drought, flooding, or pollution. Understanding the potential risks and impacts to the watershed allows stakeholders to develop effective management strategies to protect and restore the ecological health of the watershed and the communities that rely on it. On producing flood and the landslide hazard maps in the Geographic Information Systems (GIS) software, topography, land use, soil composition, rainfall data is utilized as parameters. Identification of areas vulnerable to landslides and floods done by overlaying the said variables. The hazard maps generated for CANTIS using local open-source models such Project NOAH and Geohazard PH.

4.1 Flooding

As defined by the National Operational Assessment of Hazards (NOAH) Center, flooding is characterized by the submerging of normally dry land due to the overflow of water from rivers or other water bodies brought about by heavy rainfall. The level of susceptibility generated by Project NOAH is categorized into low, and high. Flood susceptibility map shows the likelihood or potential for flooding in a given area based on factors such as topography, soil type, land use, rainfall patterns, and drainage systems. GIS (Geographic Information System) software and remote sensing data such as satellite imagery, digital elevation models, and other sources of information were used to create this map. Data collection, analysis, and modeling are used to identify areas prone to flooding and classify them based on the level of risk or hazard. The consolidated data from various agencies, including the DENR, the Department of Science and Technology (DOST), and local government units (LGUs), were used to generate the flooding susceptibility map.

As seen in the Flood Hazard Susceptibility Map and table, areas along the tributaries within the drainage area are susceptible to flooding. Further, these areas with varying levels of susceptibility (low and high) can be found in the municipalities of Cantilan, Carrascal, and Madrid. In order to identify the vulnerability of the said areas, results gathered during the stakeholder workshops was used.

The identified level of vulnerability will then be utilized to quantify risk and identify priority areas for flood mitigation. A watershed's vulnerability to flooding can have serious consequences for the ecosystem, human activities, and the economy. It is critical to develop flood risk management strategies in vulnerable watersheds, such as land-use planning, floodplain mapping, and the construction of flood control infrastructure.

- Property damage: A flood-prone watershed risks causing damage to buildings, infrastructure, and personal property. Floodwater can also endanger human safety and health.
- Flooding can have a significant economic impact on a watershed, including damage to agricultural land, infrastructure, and income loss from tourism and recreation activities.
- Water quality: Flooding can contaminate water in a watershed by transporting pollutants and sediment into bodies of water. This has the potential to harm aquatic ecosystems as well as human health.
- Property damage: A flood-prone watershed risks causing damage to buildings, infrastructure, and personal property. Floodwater can also endanger human safety and health.
- Flooding can have a significant economic impact on a watershed, including damage to agricultural land, infrastructure, and income loss from tourism and recreation activities.
- Water quality: Flooding can contaminate water in a watershed by transporting pollutants and sediment into bodies of water. This has the potential to harm aquatic ecosystems as well as human health.

Based on the data provided in the tabulated form (**Table 4.1**) and the Flood Hazard Map (**Figure 4.1**), it is observed that approximately 75.05% (17,834.92 hectares) of the CANTIS Watershed exhibits minimal vulnerability to flooding. This signifies that an abundance of precipitation flowing over the terrain during rainfall events tends to accumulate and gain force, resulting in floods at a relatively lower magnitude. On the other hand, 14.73% of the watershed falls under moderate classification and around 10.22% (2.427.93 ha.) is categorized as areas with high flooding susceptibility.

Table 4-1 Flooding Susceptibility

Level	Area (Ha.)	Percent Share
High	2,427.93	10.22%
Moderate	3,500.82	14.73%
Low	17,834.92	75.05%
Total	**23,763.69**	**100%**

A variety of factors influence an area's susceptibility to flooding, including topography, soil type, land use, and rainfall patterns.

Susceptibility is low:

- Flooding is less likely in areas with low-lying, flat topography than in areas with steep slopes or high elevations.

- Flooding is less likely in areas with well-draining soil, such as sandy or loamy soil, than in areas with poorly draining soil, such as clay or compacted soil.
- Flooding is less likely in areas with low-intensity rainfall patterns than in areas with high-intensity rainfall patterns.
- Areas with a low flood history are less vulnerable to future flooding than areas with a high flood history.

Susceptibility is moderate:

- Flooding is more likely in areas with gently sloping topography because they can still collect and hold water.
- Flooding is more likely in areas with moderate drainage capacity soil, such as silt or loam.
- Flooding is more likely in areas with moderate-intensity rainfall patterns.
- Areas that have experienced occasional flooding in the past are moderately vulnerable to future flooding.

Susceptibility is high:

- Flooding is more likely in areas with steep slopes or high elevations because water can easily run off and accumulate in lower areas.
- Flooding is more likely in areas with poor drainage capacity, such as clay or compacted soil.
- Flooding is more likely in areas with high-intensity rainfall patterns.

Areas that have experienced frequent flooding in the past are especially vulnerable to future flooding.

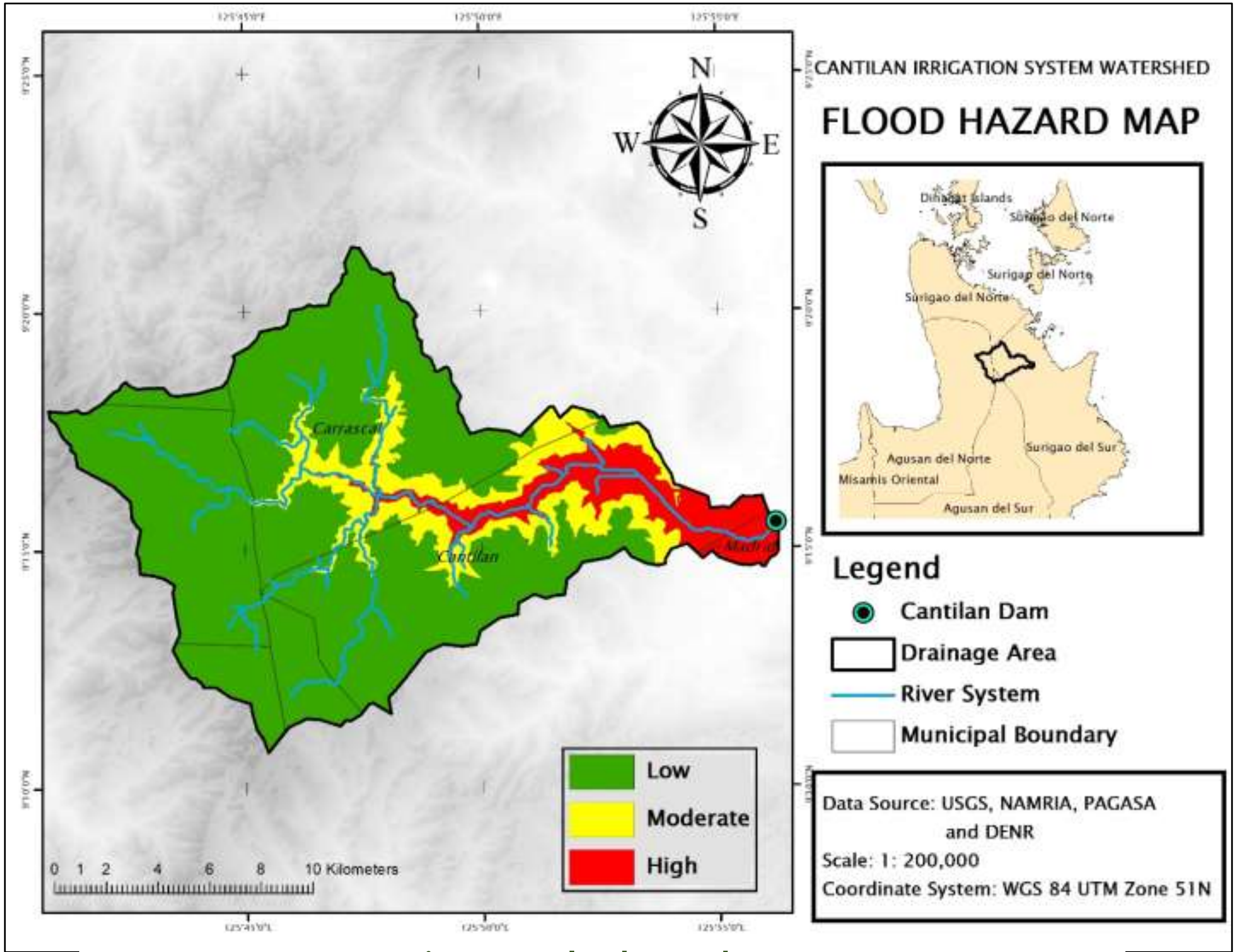


Figure 4-1 Flood Hazard Map

4.2 Landslide

Landslides are caused by one or a combination of heavy rainfall, strong earthquakes, and human activity. These events and/or activity may cause movement of the earth due to gravity. Based on various factors such as topography, geology, rainfall, and land use. The map was analyzed and modeled using GIS software to identify areas that are more likely to experience landslides.

Table 4-2 Landslide Susceptibility

Landslide Susceptibility	Area (ha.)	Percent Share
High	8,311.14	34.97%
Moderate	10,764.44	45.30%
Low	4,688.12	19.73%
Total	**23,763.69**	**100%**

In the Cantilan Irrigation System (**Table 4.2**), not all covered municipalities/city have areas susceptible to landslides. As observed on the Landslide Susceptibility Map and Table, there are areas that are not susceptible to landslides. The areas classified under low landslide susceptibility cover 4,688.12 hectares or 19.73% of the total land area. Areas with moderate landslide susceptibility make up for around 45.30% (10,764.44 ha.). Additionally, 34.97% (8,311.14 ha.) of the watershed has high vulnerability for landslide occurrences. This is consistent with the observation of the slope. The following are the examples of adverse effects of landslide in community-dwelled watershed:

- Can cause significant damage to structures, infrastructure, and personal property. This can have a significant economic impact as well as endanger human safety and health.
- Can cause significant damage to terrestrial and aquatic habitats, resulting in the loss of important habitats for wildlife and fisheries.
- Can cause soil erosion and sedimentation, both of which can have a negative impact on water quality and aquatic ecosystems.
- Watersheds that are prone to landslides require more emergency response resources, such as evacuation plans and the development of warning systems. This can be expensive and time-consuming.
- Climate change: Changes in precipitation patterns and increased storm intensity can increase the likelihood of landslides occurring, making watersheds more vulnerable to them.

A watershed's susceptibility to landslides can have serious consequences for the ecosystem, human activities, and the economy. Land-use planning, slope stabilization measures, and the development of early warning systems are all important strategies for managing the risk of landslides in vulnerable watersheds (**Figure 4.2**).

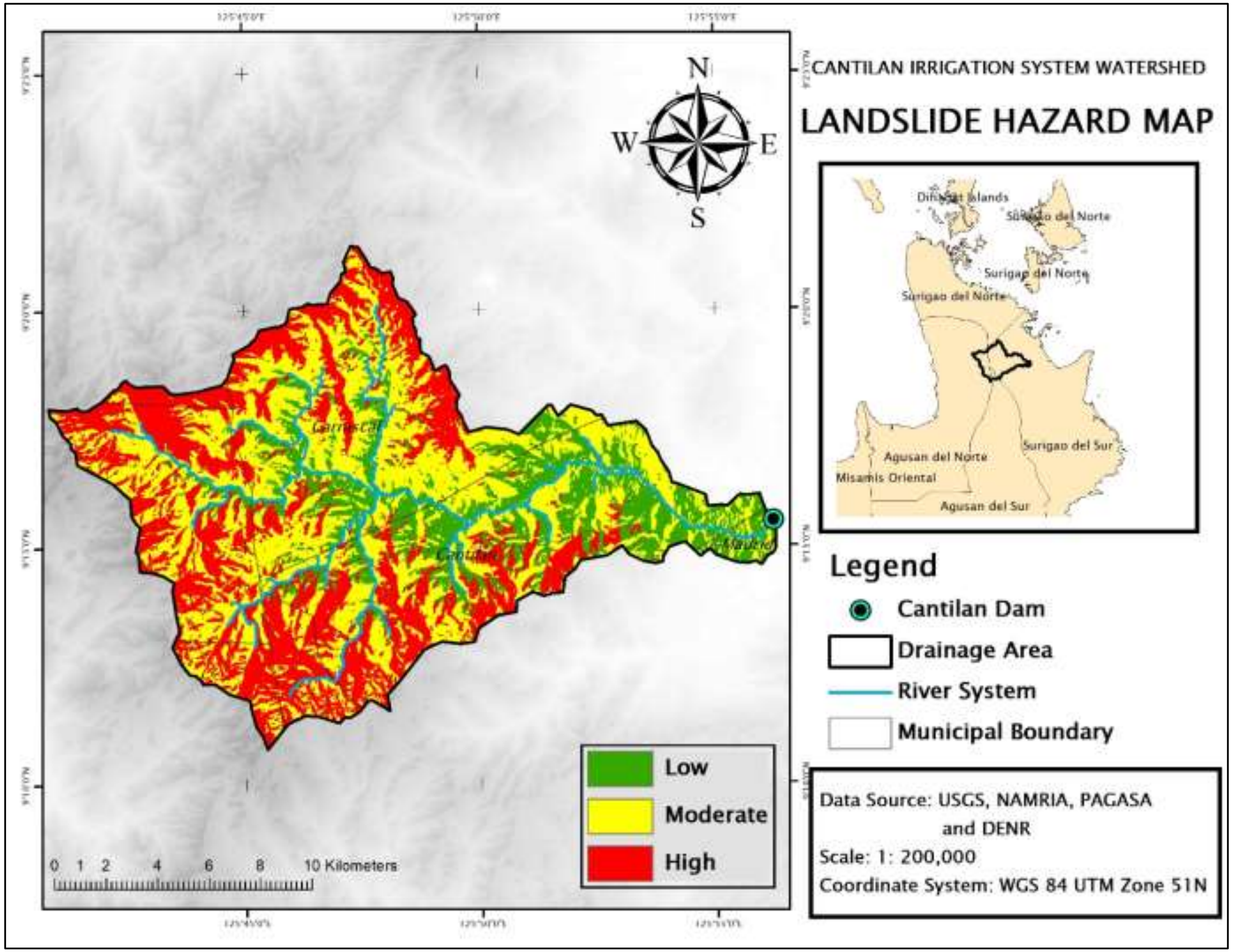


Figure 4-2 Landslide Hazard Map

A variety of factors influence an area's susceptibility to landslides, including topography, geology, soil type, and vegetation cover.

Susceptibility is low:

- Landslides are less likely in areas with gentle, flat topography than in areas with steep slopes.
- Landslides are less likely in areas with well-consolidated and stable soil than in areas with loose, unconsolidated soil.
- Areas with dense and stable vegetation cover, such as forests or grasslands, are less vulnerable to landslides than areas with sparse or unstable vegetation cover.
- Areas with a low or no history of landslides are less vulnerable to future landslides.

Susceptibility is moderate:

- Landslides are more likely in areas with moderate slopes.
- Landslides are moderately likely in areas with partially consolidated or partially unstable soil.
- Landslides are moderately likely in areas with partially dense or partially stable vegetation cover.
- Areas with a history of landslides are moderately vulnerable to future landslides.

Susceptibility is high:

- Landslides are especially dangerous in areas with steep slopes or high elevations.
- Landslides are more likely in areas with highly unstable or unconsolidated soil.
- Landslides are more likely in areas with sparse or unstable vegetation cover, such as clear-cut forests or areas with invasive species.
- Landslides are more likely to occur in areas that have a history of frequent or recent landslides.

4.3 Soil Erosion

Soil erosion is the process by which soil is removed from its original location and transported to another location by wind or water. Natural soil erosion occurs, but it can be accelerated by human activities such as farming, deforestation, and construction. Through creating a spatial database of the area with ArcGIS software and using the data from the spatial database, the USLE model was used to calculate the potential soil erosion for each location in the area based on the specific values for each factor.

The data on rainfall erosivity, soil erodibility, and slope length includes information like soil type, land use, rainfall intensity, and slope were then converted into GIS format files.

The soil susceptibility map was modeled using the combined values of soil erosion map factors.

The effects of soil erosion to the environment could be the following:

- Reduced soil fertility: Soil erosion can lead to the loss of topsoil, the soil's most nutrient-rich layer. Reduced soil fertility can have a negative impact on agricultural productivity and ecosystem health.
- Water quality: Soil erosion can cause sediment deposition in bodies of water, which can have a negative impact on water quality and aquatic ecosystems.
- Flooding is made more likely by soil erosion, which reduces the soil's ability to absorb and hold water.
- Soil erosion can result in the loss of important habitats for wildlife and fisheries.
- Soil erosion can release carbon stored in the soil, increasing greenhouse gas emissions and exacerbating climate change.

Soil erosion is a consequential environmental hazard that can harm the ecosystem, human activities, and the economy. It is critical to implement soil erosion management practices such as conservation tillage, contour farming, and the use of cover crops. In CANTIS, there is 23,288.33 ha with erosion rate 0 – 220.59 tons per year and approximately 500 ha with 220.59 – 4,706.02 tons per year erosion rate (**Table 4.3 & Figure 4.3-4.4**).

Table 4-3 Soil Erosion Rate

Soil Erosion (Tons per Year)	Area (ha.)	Percent of Drainage Area to Total
0 - 220.59	23,228.33	97.75%
1213.27 - 4706.02	48.13	0.20%
220.59 - 1213.27	487.24	2.05%
Total	**23,763.69**	**100.00%**

Low susceptibility:

- Areas with low slope gradients are less susceptible to soil erosion than areas with steep slopes.
- Areas with high vegetation cover are less susceptible to soil erosion than areas with little or no vegetation cover.
- Areas with soil that has high clay content are less susceptible to soil erosion than areas with sandy soils.
-

- Areas with a low intensity of rainfall are less susceptible to soil erosion than areas with high-intensity rainfall.

Medium susceptibility:

- Areas with moderate slope gradients are moderately susceptible to soil erosion. This means that the risk of soil erosion is higher than in areas with gentle slopes, but lower than in areas with steep slopes.
- Areas with moderate vegetation cover are moderately susceptible to soil erosion. This means that the risk of soil erosion is higher than in areas with high vegetation cover, but lower than in areas with little or no vegetation cover.
- Areas with soil that has moderate clay content are moderately susceptible to soil erosion. This means that the risk of soil erosion is higher than in areas with high clay content, but lower than in areas with sandy soil.
- Areas with moderate-intensity rainfall are moderately susceptible to soil erosion. This means that the risk of soil erosion is higher than in areas with low-intensity rainfall, but lower than in areas with high-intensity rainfall.

High susceptibility:

- Areas with steep slope gradients are more susceptible to soil erosion than areas with gentle slopes.
- Areas with little or no vegetation cover are more susceptible to soil erosion than areas with high vegetation cover.
- Areas with sandy soil are more susceptible to soil erosion than areas with soil that has high clay content.
- Areas with high-intensity rainfall are more susceptible to soil erosion than areas with low-intensity rainfall.

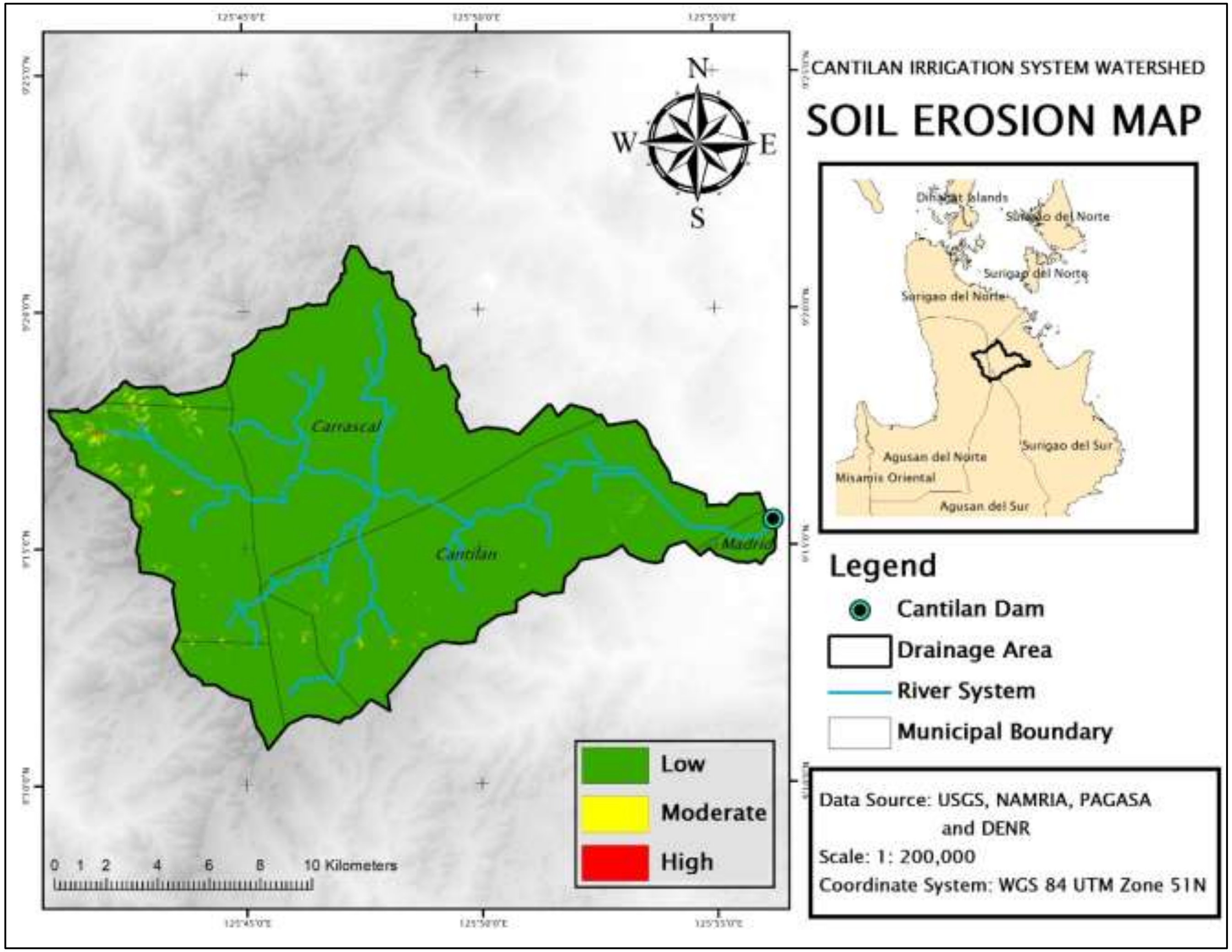


Figure 4-3 Soil Erosion Map

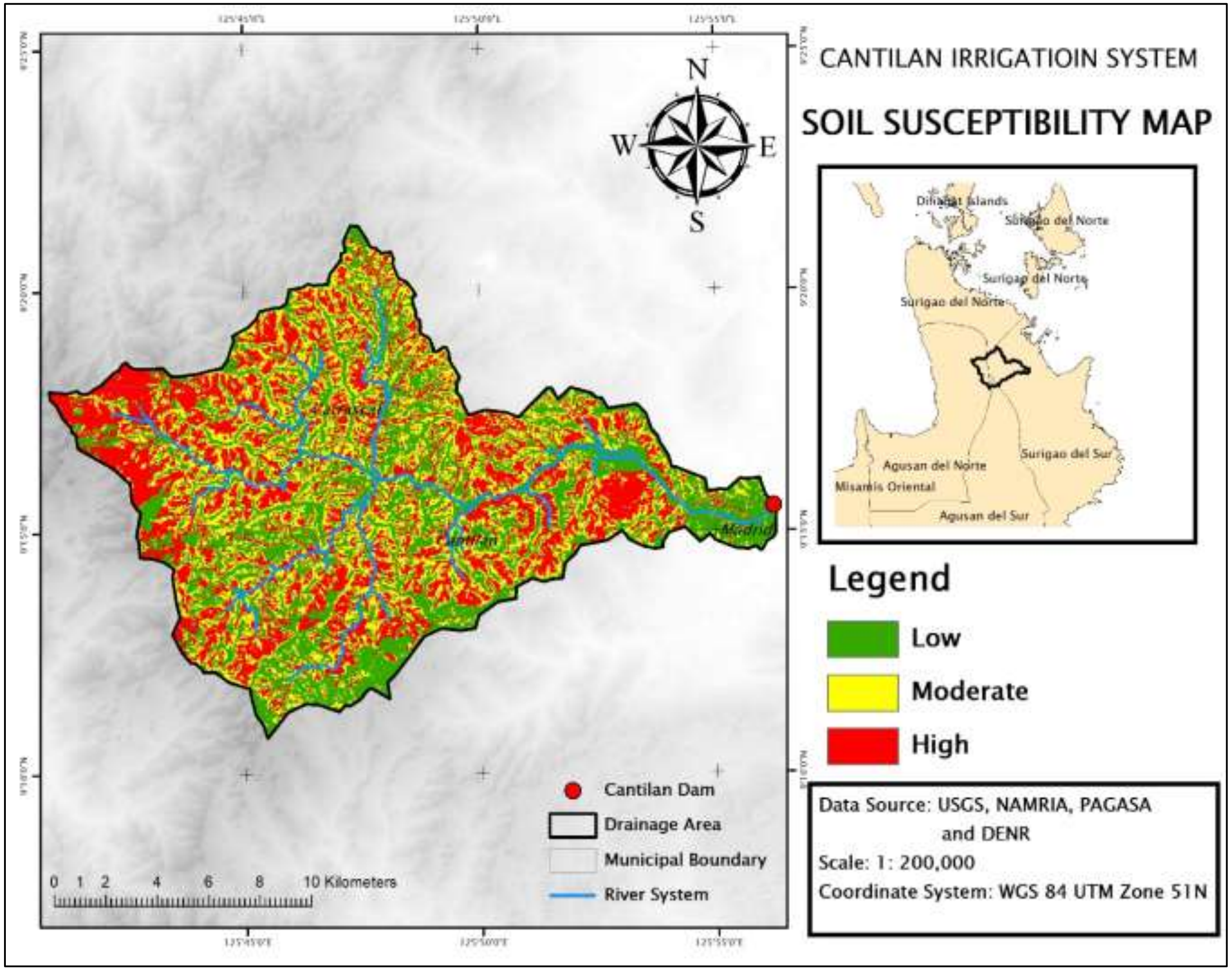


Figure 4-4 Soil Susceptibility Map

4.4 Sediment Transport

Sediment in irrigation water can come from a variety of sources, such as erosion from the land, the breakdown of organic matter in the water, or from runoff from nearby roads or construction sites. Sediment particles can vary in size and density, from large rocks and pebbles to fine sand and silt.

Sedimentation has reduced the storage capacity of the country's major reservoirs affecting water supplies for domestic, industrial, irrigation and power generation purposes. Between 1973 and 1998, an estimated 20-30% reduction in area irrigated during the dry season by a number of irrigation systems (DENR 1999).

The sediment transport of CANTIS is computed using Arc Geographical Information System (GIS). The sediment transport map was created using both field observations and modeling. Field observations include measuring the sediment load and transport rate in the river system, as well as collecting data on the watershed's topography and land use. As shown in the table below, a very significant area of the watershed (95.52%) transports 0 to 12.36 tons of sediments per year. The rest of the watershed's sediment transport widely varies from 12.36 to 791.59 tons per year (**Table 4.4**).

This information is then fed into a model that simulates sediment movement through the river system. The model takes into account factors such as sediment particle size, river flow rate, and riverbed and bank characteristics. The sediment transport map (**Figure 4.5**) shows the areas of the river system where sediment is transported and deposited, as well as the magnitude of the sediment load in each area.

Table 4-4 Sediment Transport per Year

Tons per Year	Area (ha)	Percent Share
0 - 12.36	22,936.64	95.52%
12.36 - 46.38	557.76	2.35%
46.38 - 95.85	163.51	0.69%
95.85 - 160.79	50.48	0.21%
160.79 - 241.18	24.58	0.10%
241.18 - 337.04	16.99	0.07%
337.04 - 466.91	7.51	0.03%
466.91- 615.34	4.39	0.02%
615.34 - 791.59	1.81	0.01%
Total	**23,763.69**	**100%**

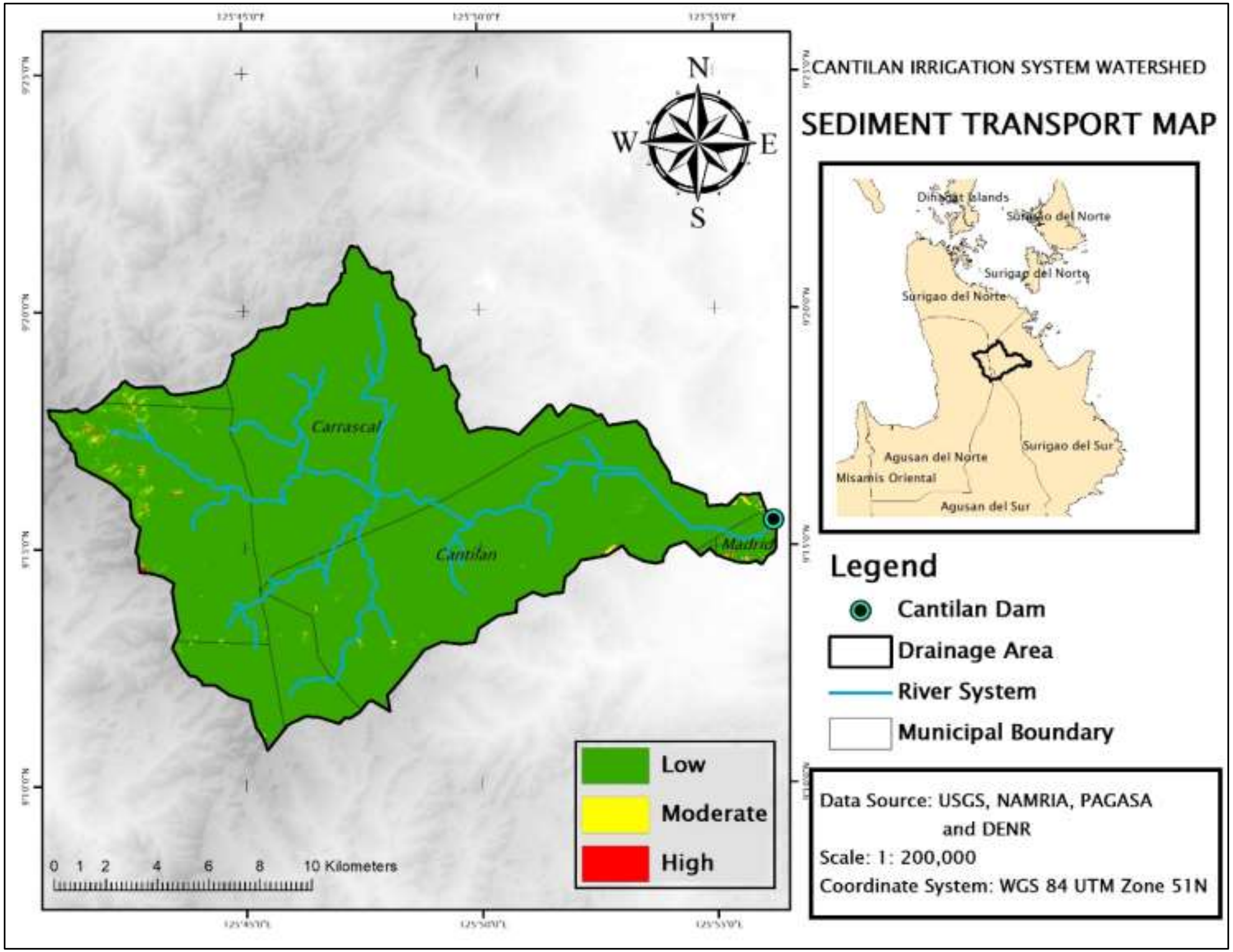


Figure 4-5 Sediment Transport Map

4.5 Forest Fire

Forest fire is one of the major disasters that distresses the terrestrial environment, and it causes economic disturbances for people and communities in areas prone to forest fires. Information on forest fire risk zones is therefore essential for effective and sound decision-making in forest management. Forest wildfires in the Philippines are all human-caused (carelessness, negligence, accident, and incendiary). There have been no known wildfires caused by lightning. Some forest fires are caused by kaingin, which is a man-made process of burning the land cover of the area and cutting the trees to be planted with crops and other fruit plants. The process of generating forest fires susceptibility map entails gathering and analyzing data on various factors that contribute to forest fires, such as weather patterns, vegetation cover, topography, and human activity. Data is then analyzed with GIS (Geographic Information System) software to produce a spatial database of the area. The spatial database is then used to generate a fire susceptibility map, which depicts the areas which are susceptible to forest fires.

An analysis of the CANTIS reveals that 2,737.15 hectares, or 11.50% of the land, are highly susceptible to forest fires. Furthermore, a significant portion of the watershed, 64.23% (15,263.59 hectares), exhibits a moderate level of susceptibility. In contrast, 5,762.94 hectares (24.25%) have a low susceptibility to forest fires. This distribution emphasizes the varying levels of fire risk throughout the area, highlighting the need for targeted fire management strategies and mitigation measures to address the higher susceptibility areas (**Table 4.5 & Figure 4.6**).

Table 4-5 Fire Susceptibility

Fire Hazard Susceptibility	Area (ha)	Percent Share
Low	5,762.94	24.25%
Moderate	15,263.59	64.23%
High	2,737.15	11.50%
Total	**23,763.69**	**100%**

Susceptibility is low:

- Fires are less likely in areas with high humidity, low temperatures, and frequent rainfall.
- Fire is less likely in areas with moisture-rich and fire-resistant vegetation cover, such as broadleaf forests or wetlands.
- Fires are less likely in areas with low population densities and low levels of human activity.

Susceptibility is moderate:

- Fires are more likely in areas with moderate temperatures, occasional rainfall, and moderate humidity.

- Semi-arid or mixed-vegetation areas, such as savannas or grasslands, are moderately susceptible to fire.
- Rural areas with agriculture or grazing are moderately susceptible to fire because of their moderate population densities and moderate levels of human activity.

Susceptibility is high:

- Hot and dry climates, low humidity, and infrequent rainfall make areas prone to fire.
- Areas with highly flammable vegetation cover, such as coniferous forests or chaparral, are particularly vulnerable to fire.
- Fire is especially dangerous in areas with high population densities and high levels of human activity, such as urban areas with industrial or recreational activities.

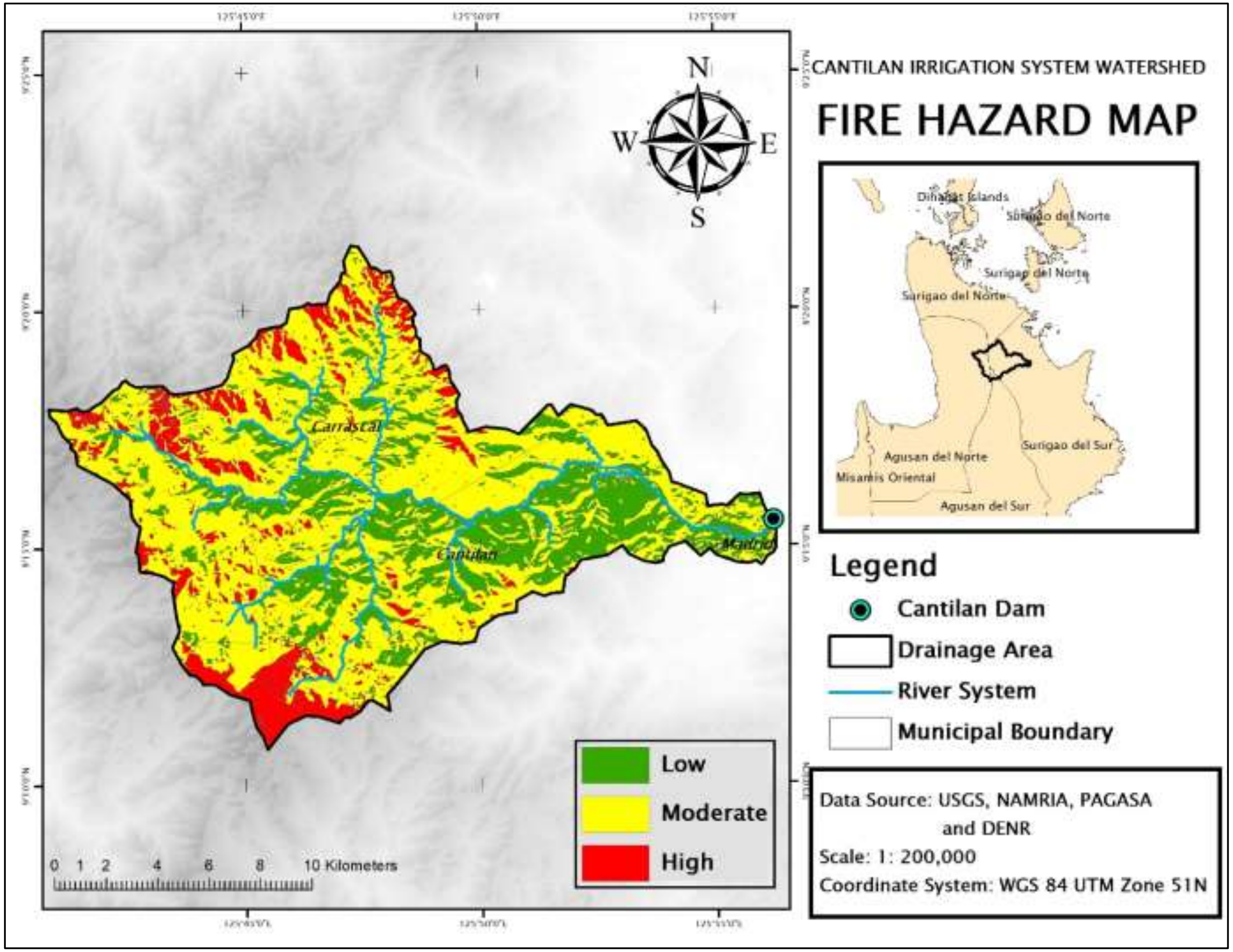


Figure 4-6 Fire Hazard Map

4.6 Water Pollution

The quality of the rivers within the watershed is influenced by different natural and man-made sources, stemming from activities undertaken by the communities near the river systems.

Several factors affect water quality from toxic chemicals brought by anthropogenic activities and high populations of certain microorganisms which may induce health hazards to the effects of fishing, boating, irrigation, and other recreational activities.

These factors can all have a harmful impact on the health of the water bodies and ecosystem which may lead to making water unfit for human consumption. Major causes of the deterioration of rivers are as follows:

1. Domestic Waste - Improper solid waste management and direct discharge of domestic waste to the water bodies from the settlements occupying the riverbanks may lead to river quality degradation.

2. Domestic Livestock Waste - Direct discharge of wastewater from backyard livestock by the residents along the rivers contributes to the deterioration of the physical and biological conditions of the river systems.

3. Industrial Waste - Discharges of public markets and industrial effluents are also identified as sources of pollution which directly affects the quality of the water bodies.

4. Natural sources - Siltation due to soil erosion during heavy rains and typhoon can affect the water body's physical and chemical conditions.

Water conductivity serves as an effective parameter for assessing water pollution due to its responsiveness to dissolved ions and pollutants. Higher conductivity readings indicate the presence of more contaminants, reflecting the water body's overall quality and potential environmental impact. Clean or uncontaminated conditions are defined as conductivity values ranging from 0 to 200 (C-S/cm). Most major rivers have a usual range of 200 to 1000.

Three sampling points were chosen for the Water Quality Analysis in CANTIS, and the water conductivity readings obtained were 165.56 C-S/cm, 178.83 C-S/cm, and 183.83 C-S/cm, respectively. These readings are in the low conductivity category, suggesting that water pollution could be minimal within the watershed.

4.7 Encroachment

Encroachment in watersheds refers to human activities that encroach on or occupy watershed areas critical to the ecosystem's functioning, such as floodplains, wetlands, and riparian zones. Encroachment can have serious and long-term consequences in watershed management.

Encroachment was visually assessed by visiting forested areas near residential communities. Those areas with tenurial instruments (CSC, CBFMA, PACBRMA, etc.) will also be visited to evaluate if expansion or encroachment in protection zones is evident. Encroachment has negative effects on watersheds, including:

1. Reduced water quality: It can lead to increased pollution and contamination of water resources, which can have serious consequences for aquatic habitats and the health of people who rely on the watershed for drinking water.

2. Flooding risk increases: It can destroy natural floodplains and wetlands, which act as natural flood buffers. During heavy rain events, this can increase the risk of flooding and damage to surrounding areas. Encroachment can lead to the loss of important habitat for plants and animals, resulting in decreased biodiversity and long-term effects on ecosystem functioning.

3. Soil erosion and sedimentation: Encroachment can cause increased soil erosion and sedimentation, which can harm aquatic habitats and reduce the watershed's capacity to hold and filter water.

4. Natural disaster risk: It can increase the risk of natural disasters such as landslides, mudflows, and flash floods, which can have serious consequences for human communities and the surrounding environment.

Upon conducting a visual assessment of the forested watershed area in CANTIS, it becomes apparent that human settlements are present, primarily located along the riverbanks. These settlements could rely on agriculture as their primary means of sustenance, as evidenced by "kaingin" agricultural practices adjacent to the settlements. The dwellings in these settlements are mostly constructed from wood, with concrete structures being infrequent. However, it is noteworthy that the settlements occupy only around 0.06% (14.94 hectares) of the entire watershed, indicating a limited human footprint. The visual landscape showcases a barely disturbed forest cover, which is indicative of the preservation of natural habitats and ecosystems. This suggests that the forest communities might have demonstrated a noteworthy practice to coexistence and responsible stewardship of the forested watershed.

Apart from the settlements, mining tenements are also visible in the area. These mining operations involve intensive land clearing, resulting in significant alterations to the natural landscape. The visual assessment reveals clear signs of disruption, including excavated areas, exposed earth, and possibly disturbed waterways. The extent of land clearing and the evident intensity of mining activities indicate a potentially high environmental impact, which may have long-term consequences on the ecosystem (**Figure 4.7**).

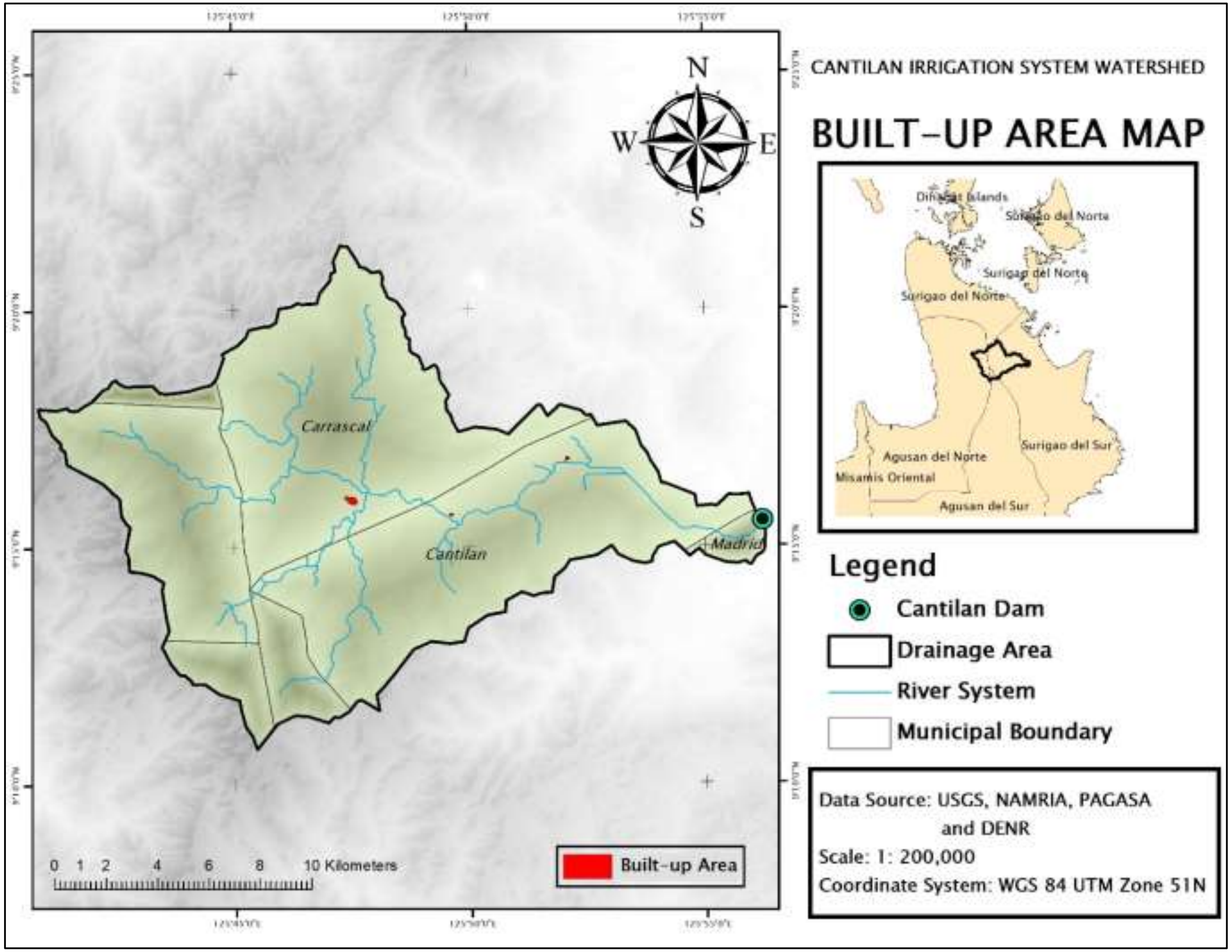


Figure 4-7 Built-Up Areas in CANTIS

5. ANALYSIS OF ENVIRONMENTAL ISSUES, PROBLEMS, AND KEY FINDINGS

The analysis of environmental issues, problems, and opportunities in a watershed is critical. Watersheds are critical ecosystems that provide water for various human activities, support biodiversity, and play an essential role in preserving ecological balance. By conducting a thorough analysis, the pressing environmental issues that pose significant threats to the watershed's sustainability and the welfare of the communities are identified. It allows stakeholders to identify the river irrigation system's weaknesses and threats while also highlighting that there are strengths and opportunities that can be pursued and capitalized on in order to meet the envisioned objectives for CANTIS.

In addition, having a comprehensive understanding of the prospects within the watershed can facilitate the adoption of sustainable measures that encourage the preservation, effective resource utilization, and the protection of the watershed's ecological balance. By acknowledging and tackling these concerns, and seizing the opportunities presented, the ecological well-being of the watershed can be sustained, guaranteeing that the community has continued access to uncontaminated water resources.

This segment of the report furnishes an outline of the environmental difficulties and factors that are pertinent to the stakeholders, as identified through a series of consultations, workshops, interviews and an exhaustive analysis of relevant secondary data and literature.

The analysis that was mainly used in this section is the Strengths, Weaknesses, Opportunities, and Threats (SWOT) Analysis. It is a method that enables the generation of feasible alternative strategies through an assessment of the present conditions, characteristics, and current state and utilization of the project site's resources. This tool was used during the focus group discussion, which was participated by the stakeholders of the project.

5.1 SWOT Analysis

A SWOT analysis is a well-known strategic planning method for categorizing an individual's, group's, or organization's vulnerabilities and strengths and prospective opportunities and threats. SWOT is an adaptive and flexible strategy that allows multiple standpoints to be documented while also directing participants' focus to cooperative action. This strategy helps encourage many people to contribute their ideas and assists them in considering alternative solutions and constraints.

The SWOT analysis assessed the study area's strengths, weaknesses, opportunities, and threats to sustainable irrigation development and rural income. It entails conducting in-depth interviews with key stakeholders to identify problems and opportunities used to design CANTIS development strategies and initiatives (**Figure 5.1**).

5.1.1 Strength

Individuals and groups with a vested interest in managing the watershed have shown strong dedication and resolve in tackling environmental issues, promoting sustainable methods, and safeguarding the forest ecosystem. In terms of pedogeological features and farming potential, the irrigation system benefits from advantageous soil and landform characteristics, which enable efficient water retention, fertile soil, and productive land, facilitating agricultural practices and promoting ecological balance. Also, the inclusion of active and engaged People's Organizations within the river irrigation system empowers local communities to contribute to decision-making processes, resulting in effective and inclusive management methods.

5.1.2 Opportunities

Programs and projects such as the watershed management project can be used to determine the key environmental and social issues to create programs and plans for the rehabilitation, development, and improvement of the irrigation system. The management plan is also an opportunity to create climate change mitigation programs and adaptation measures for the adverse effects of climate change. Plans and programs can provide job opportunities and improve the practices of the end users.

5.1.3 Weaknesses

Poor implementation and monitoring of the existing projects and lack of maintenance of the irrigation facilities were some of the issues that were exposed during the focus group discussion and the field surveys conducted for the project. Some of the stakeholders stated that infrastructures are not well maintained that causes siltation leading to a damaged irrigation system. Another issue raised is that the presence of mining sites affects the increase siltation within the irrigation canals. Natural phenomena such as typhoons and drought also cause damages to the infrastructures.

5.1.4 Threats

The threats that will likely affect the quality of the irrigation service include natural disasters worsened by climate change and human activities such as deforestation and illegal logging. Land conversion from forest land to agricultural and other urban uses can also impact the quality and supply of water from the watershed.
The table below is the collation of the results of the SWOT analysis workshop that commenced with the stakeholders of Cantilan Irrigation System held last December 13, 2022.

Table 5-1 SWOT Analysis

Results

Strengths	Weaknesses
1. High Forest Cover Density of the Watershed 2. The Stakeholders have Strong Political Will 3. Active and Participative People's Organizations within the River Irrigation System 4. Large Irrigable Agricultural Lands 5. Having Existing Government-Implemented Programs 6. Favorable Pedological and Geomorphological Features of the Irrigation System 7. Existing Climate Condition 8. Relationship between National Irrigation Administration and Irrigator's Association 9. High Commercial and Tourism Potential	1. Weak Policy Implementation and Slow Project Execution 2. Lack of Coordination Between the Stakeholders 3. Wildlife Poaching and Hunting 4. Unregulated Sand and Gravel Extraction and Mining Activities 5. Inadequacy of farmers' equipment and agricultural facilities 6. Agricultural Land Expansion in the Forest Areas 7. Presence of Informal Settlers 8. Lack of Irrigation Canals on Silted Rivers 9. Unavailability of Technical Personnel to Support Farmers 10. High Illegal Logging Incidence
Opportunities	**Threats**
1. Increasing Investors' Interest in Solar-Powered Irrigation Systems 2. Presence of Business Opportunities and Tourism Growth 3. Availability of funds from the national government to implement projects 4. Provision of other material, technical, and financial support from different NGAs 5. Increasing Job Opportunities in the Mining Industry	1. Existence of Mining Activities in the neighboring cities/municipalities 2. Rapid Population Growth 3. Shortage of Irrigation and Potable Water Supply 4. Frequent Occurrence of Disasters and Calamities 5. High Tendencies of Uncontrolled Flooding

After conducting an analysis of the interlocking issues surrounding the Cantilan Irrigation System, it has been determined that the system is facing a pressing concern related to continuous flooding and degraded natural resources.

This issue poses a significant threat to the long-term environmental, social, and economic values of the Irrigation System and must be addressed in the long run.

5.2 Identified Issues, Problems, and Opportunities

A multi-stakeholder consultation and workshop that involves active participation from stakeholders of Cantilan Irrigation System was conducted last December 13, 2022. This workshop served as a platform that allows for collaborative problem-solving and decision-making, leading to empowerment of the community and integration of local knowledge.

A range of interrelated causes and consequences have been identified, with flooding, forest degradation, river degradation, and a lack of livelihood and opportunities being the four major problems encountered by CANTIS. Additionally, the conversion of public lands into other uses, inhibition of informal settlers, furtive illegal logging activities, shortage of water supply, and extreme climatic events are the other problems occurring in the area. Consequently, the stakeholders also identified corresponding opportunities in which might be an avenue to address these issues.

5.2.1 Flooding

During the planning workshop, flooding was identified as one of the hazards faced by the participants.

Flooding is a natural event that occurs when the absorptive capacity of soil and the flow capacity of rivers and streams are exceeded by heavy or continuous rainfall, resulting in the overflowing of water on land areas. The areas that are most susceptible to floods are flood plains, which are located near rivers and streams.

Flooding in forest communities within the watershed poses significant challenges and impacts on both human populations and the surrounding ecosystems. The watershed could experience various types of floods, such as riverine floods and flash floods, each with distinct characteristics and causes.

Riverine floods occur when rivers and their tributaries overflow due to excessive rainfall, and the damage can be widespread, affecting smaller rivers downstream, causing dams and dikes to break, and flooding nearby areas (Zurich, 2020).

Forested areas play a crucial role in regulating water flow and preventing floods by acting as natural sponges, absorbing and slowly releasing water. However, deforestation and land conversion have reduced the forest cover, leading to increased surface runoff and higher river discharge during heavy rainfall events. This exacerbates the risk of riverine floods in downstream communities. Flash floods, on the other hand, are characterized by their sudden and rapid onset and are often caused by intense rainfall within a short period. Forest communities situated in hilly or mountainous regions are particularly vulnerable to flash floods due to the steep terrain and the reduced ability of deforested areas to absorb and retain water. The loss of forest cover increases the speed of water flow and sediment transport, resulting in destructive and fast-moving floodwaters.

Pluvial floods occur when an extreme rainfall event creates a flood independent of an overflowing water body. Contrary to popular belief, pluvial flooding can occur in any location, urban or rural, even in areas with no nearby bodies of water.

To mitigate the impacts of flooding in forest communities, it is essential to involve scientific experts who can provide valuable insights and guidance. These experts can contribute to the development and implementation of effective strategies such as reforestation and afforestation initiatives, improved land use planning, and the construction of nature-based infrastructure. Reforestation efforts aim to restore forest cover, enhancing the capacity of ecosystems to absorb and retain water, and reducing the risk of riverine and flash floods.

Nature-based infrastructure, including the restoration and protection of mangrove forests, can help mitigate coastal flooding by acting as a buffer against storm surges. Furthermore, improved land use planning ensures that communities are located in safe zones, away from flood-prone areas. Collaboration between scientific experts, government agencies, local communities, and stakeholders is crucial for implementing these mitigation measures effectively. By combining scientific knowledge with community participation, sustainable solutions can be developed to reduce the vulnerability of forest communities to flooding and promote long-term resilience in the face of climate change.

5.2.2 Forest Degradation

Based on consultations and surveys conducted, it has been discovered that human activities are the main causes of deforestation in the area. These activities include illegal cutting of trees, kaingin, poaching, conversion of forest lands, and the extensive use of chemical fertilizers and charcoal-making.

The Philippine Clearing House Mechanism reported that the total national forest cover is around 7.14 million hectares or 23. 8% of the country's total land area of around 30 million hectares. However, this is significantly lower than the 1934 data of 17 million hectares.

The loss of forest cover has a negative impact on the production of goods and ecosystem services, as well as contributing to greenhouse gas emissions. The Philippines is committed to participating in the adjustment of its forest policy to the necessities of climate protection by establishing the Philippine National REDD-Plus Strategy (PRNRPS), which has become an integral part of the Philippine Development Plan 2011-2016 and the National Climate Change Action Plan 2011-2028.

The loss of forest cover results in a reduction in structural complexity, growth, and biodiversity, as well as diminished protection functions such as soil loss and production functions. To manage and conserve the forests in CANTIS, inclusive and holistic approaches are necessary. The workshop revealed essential aspects of forest resources management in the watershed. Some of the recommended forest management plans are environmental and social safeguards, strict adherence to the land use plan, culturally-sensitive programs, clear institutional and financial statements, community involvement such as CBFM, reforestation similar to the NGP, and the need for proper enforcement and implementation of existing forest laws aside from passing additional ones.

5.2.3 River Degradation

River degradation is a term used to describe the decline in the health and quality of rivers within a watershed. This deterioration has been caused by deforestation and unregulated mining practices, which have led to soil erosion, sedimentation, and siltation in rivers. The sediment load has significantly reduced water quality, clogged river channels, and altered the natural flow patterns, thus affecting aquatic habitats and biodiversity. Additionally, overfishing, destructive fishing methods, and the introduction of invasive species have further exacerbated river degradation by disrupting the natural food chain and reducing fish populations.

The consequences of river degradation are widespread, including the availability of clean water for drinking, irrigation, and other purposes. Moreover, degraded rivers can no longer provide suitable habitats for aquatic organisms, thus affecting biodiversity and ecosystem functions. The loss of biodiversity and disruption of ecosystem services have detrimental effects on the livelihoods of communities that rely on rivers for fishing, agriculture, and tourism.

Addressing river degradation requires a comprehensive approach that includes effective wastewater treatment, sustainable land use practices, reforestation efforts, and the enforcement of regulations on mining and fishing activities. Trees play a crucial role in river ecosystems, stabilizing the soil, preventing erosion, and providing suitable habitat for aquatic organisms.

As such, reforestation efforts and sustainable land management practices are crucial in restoring the health of river ecosystems.

To address river degradation in the watersheds a combination of measures is necessary. This includes stricter enforcement of environmental regulations, implementation of sustainable land management practices, reforestation efforts, promotion of eco-friendly agriculture, and community-based initiatives for waste management and pollution control. Integrated watershed management plans, involving collaboration between all stakeholders, are essential for restoring and preserving the health of these vital river ecosystems. Furthermore, promoting awareness and education among interest groups, encouraging community participation, and fostering partnerships between government agencies, local communities, and environmental organizations are crucial for the conservation and restoration of rivers in the watershed.

5.2.4 Livelihood Opportunities

Forest communities in watersheds face several challenges in sustaining their livelihood opportunities. The unsustainable exploitation of forest resources is a significant challenge that can lead to deforestation, habitat loss, and depletion of valuable flora and fauna. This situation affects the ecological balance and disrupts the traditional livelihood practices of these communities, which often rely on forest products for subsistence and income generation.

Limited access to markets, inadequate infrastructure, and lack of technical knowledge and financial resources poses obstacles to diversifying livelihood options and engaging in sustainable economic activities. Climate change impacts, such as

increased frequency and intensity of natural disasters, further exacerbate the challenges faced by forest communities.

To address these challenges, integrated and community-based approaches are crucial. Encouraging sustainable forest management practices is essential to ensure the long-term availability of forest resources.

This includes promoting agroforestry, which combines agricultural practices with tree planting, to provide alternative sources of income while preserving the forest ecosystem. Strengthening community organizations and providing capacity-building support, technical training, and access to credit can empower forest communities to develop sustainable livelihood initiatives and engage in value-added activities such as processing forest products or ecotourism. Establishing market linkages and improving infrastructure, such as roads and transportation systems, can enhance the connectivity of forest communities to markets and increase their economic opportunities.

Collaborative efforts between government agencies, non-governmental organizations, and local communities are essential for implementing and monitoring these initiatives. Moreover, incorporating climate change adaptation and resilience measures into livelihood programs can help forest communities better cope with the impacts of climate change, ensuring the sustainability of their livelihoods in the face of changing environmental condition.

6. PROPOSED NIA AREA OF MANAGEMENT

6.1 Delineated area for NIA management and other key stakeholders

The Presidential Decree 705 or the Revised Forestry Code of 1975A defined watershed as a land area drained by a stream or fixed body of water and its tributaries having a common outlet for surface run-off while a critical watershed is defined as a drainage area of a river system supporting existing and proposed hydro-electric power and irrigation works needing immediate rehabilitation as it is being subjected to a fast denudation causing accelerated erosion and destructive floods. It is closed from logging until it is fully rehabilitated. The CANTIS has an irrigation water source area of 23,763.69 ha. Carac-an River is the main source of irrigation water for the CANTIS. It drains to a single outlet (dam) for channeling to irrigation canals to the service area (**Figure 6.1**).

The management area is a defined geographic area that serves as the focus of the planning process. It is an area where land use issues, opportunities, and constraints are analyzed, and where planning goals and strategies are developed. The planning area can vary in size depending on the scope of the planning effort and the level of detail required. A management area is typically determined by a combination of factors including the natural and built environment, economic activities, social and cultural characteristics, and political boundaries. It is critical to consider the area's physical and socioeconomic characteristics in order to identify the key issues and challenges that must be addressed during the planning process.

It provides a framework for understanding land use patterns and trends, as well as developing a vision and future development strategies. The planning area is also used for mapping, analyzing, and evaluating land use options and scenarios.

The proposed NIA Area of Management (7,907.83 hectares) is based on the overlayed layers of vulnerability maps and culling out in the equation are the areas like densely vegetated area, protected area, key biodiversity area, and areas with existing land tenurial instrument. A weighted overlay of different maps was used to delineate the proposed management area of NIA. The summary table (**Table 6.1**) of maps used can be found below:

Table 6-1 Weighted Overlay Maps

Overlayed Maps	Culled-out Area
Soil Susceptibility Map	Land with existing tenurial instruments (Mining Tenements, NGP Sites, Ancestral Lands/CADT, CBFM)
Landslide Hazard Map	
Flood Hazard Map	
Fire Hazard Map	

Overlayed Maps	Culled-out Area
Forestland (open and secondary forest)	Forestland (Closed Canopy)
Land Use Map (agricultural area, barren land, and alienable and disposable land)	Residential, built-up area, water bodies
Slope Map (1% - 17.99%)	
Elevation Map	

In formulating a management plan for the proposed watershed, the incorporation of hazard maps, slope maps, elevation maps, and land use maps is justified based on their distinct analytical contributions. Hazard maps provide critical insights into the spatial distribution of potential natural hazards, allowing for targeted interventions and risk reduction measures in susceptible regions. Slope maps offer essential information on terrain steepness, aiding in the identification of areas prone to erosion, landslides, or slope instability, and informing land management strategies for erosion control and slope stabilization. Elevation maps provide valuable topographic data, facilitating the delineation of hydrological patterns, watershed boundaries, and the identification of areas with potential water retention or recharge capabilities. Land use maps offer a comprehensive view of existing human activities, enabling the identification of areas where land use practices may conflict with conservation objectives and guiding land use planning and management decisions. By integrating and overlaying these maps, a holistic understanding of the watershed dynamics emerges, facilitating the identification and prioritization of key management areas for efficient resource allocation and effective conservation measures.

To maximize the effectiveness of the watershed management plan that is being developed, it is essential to strategically remove residential areas, closed canopy forests, and lands that already have existing tenurial instruments from the map. This will allow for a greater focus on areas that require more attention and intervention. By doing this, it will prevent duplication of efforts with both government and private institutions, guaranteeing that resources are used efficiently, and interventions are directed towards the areas that need it the most. By excluding these areas, the watershed management plan can prioritize addressing critical issues and achieving the best possible outcomes.

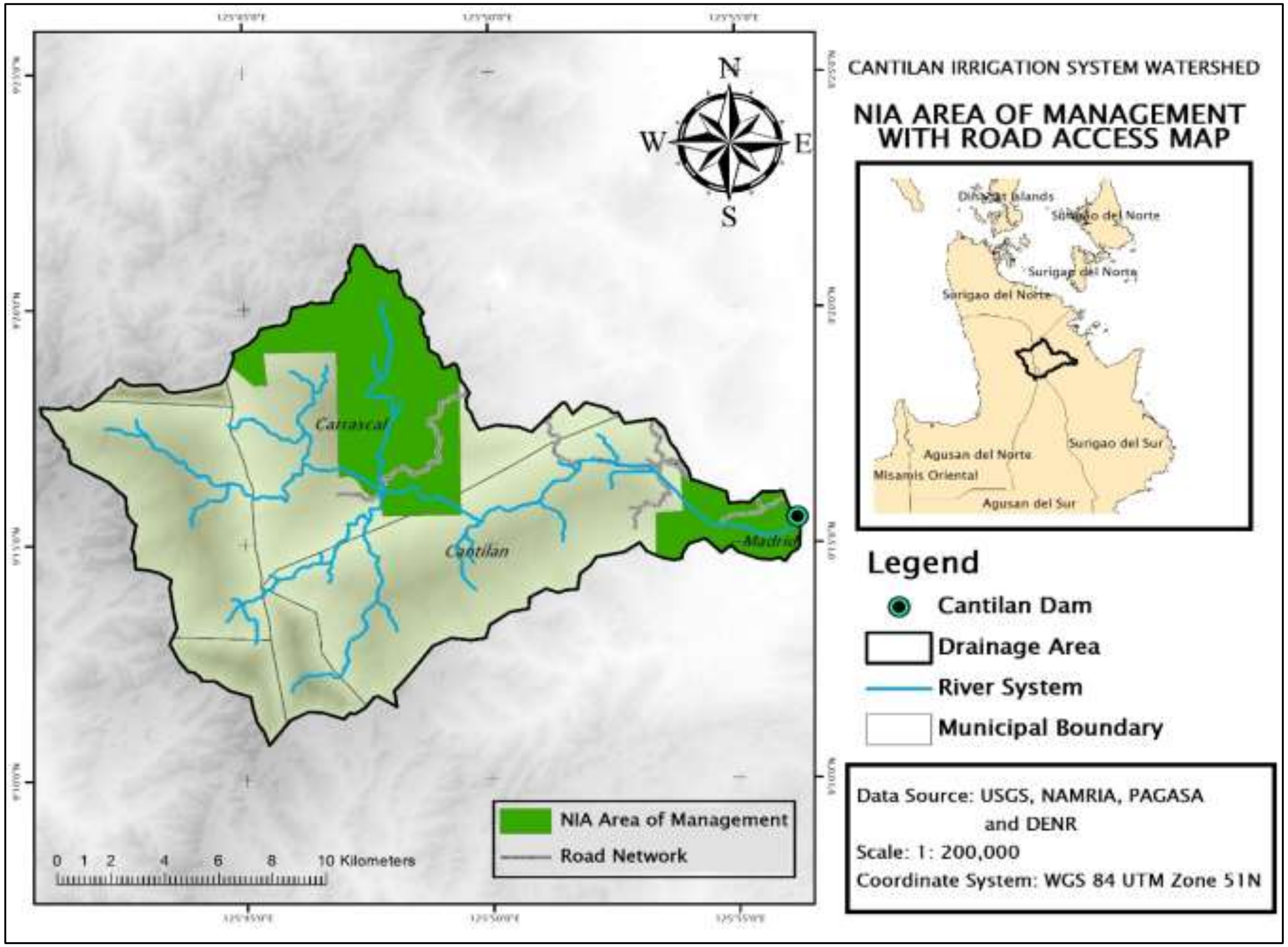


Figure 6-1 Proposed NIA Area of Management Showing Access Within the Site

Table 6-2. NIA Management Area

NIA Area of Management	Area (ha)	Percent Share
	7,907.83	33.28%
Total	**7,907.83**	**33.28%**

6.2 Areas of Constraints

To determine the NIA area for management, it must first determine what are the areas of constraints. Proposed areas for NIA interventions within CANTIS are constrained by the following:

1. Land Classification
2. National Greening Program sites
3. Tenurial Agreements / Permits
4. Existing Built-Up Area

6.3 Land Classification

The land classification system provides information regarding the location and size of forest / public lands and alienable and disposable lands. Forest land refers to the lands belonging to the public domain that have been officially designated as such through the land classification program of the Department of Environment and Natural Resources (DENR), as well as any public domain lands that have not yet been classified. Conversely, alienable and disposable lands are public domain lands that have undergone classification and have been declared suitable for allocation. The responsibility for managing forest land lies with both the DENR and local government units (LGUs), whereas the administration of alienable and disposable lands falls under the jurisdiction of LGUs and other government agencies such as the National Irrigation Administration (NIA). Approximately 7,000 ha of CANTIS are classified as A & D, while 116,856.10 were forested land (**Table 6-3**)

Table 6-3. Legal Land Classification of Cantilan Irrigation System

Land Classification	Area (ha)	Percent to Total
Alienable/Disposable	6,907.59	29.07%
Forest Land	16,856.10	70.93%
Total	**23,763.69**	**100.00%**

6.3.1 National Greening Program (NGP)

The National Greening Program (NGP) is a large-scale forest rehabilitation program initiated by the government through Executive Order No. 26, signed by President Benigno S. Aquino III on February 24, 2011. Its primary objective is to cultivate 1.5 billion trees over 1.5 million hectares across the country within a six-year period spanning from 2011 to 2016.

Beyond its reforestation goals, the NGP is regarded as a strategy to address climate change by bolstering the nation's forest reserves to absorb carbon dioxide, a major contributor to global warming. Additionally, the program aims to alleviate poverty by offering alternative livelihood opportunities to marginalized upland and lowland households, focusing on activities related to seedling production and the care and maintenance of newly-planted trees.

As a collaborative effort among the Department of Agriculture (DA), Department of Agrarian Reform (DAR), and Department of Environment and Natural Resources (DENR), half of the targeted trees for planting in the NGP consist of forest tree species intended for both timber production and ecological protection. The remaining 50 percent comprises agroforestry species.

The program encompasses various eligible areas for rehabilitation, including public domain lands such as forestlands, mangrove and protected areas, ancestral domains, civil and military reservations, urban greening areas, inactive and abandoned mine sites, as well as other suitable lands.

6.3.2 Tenurial Agreements / Permits

Lands classified as public forest may be granted tenure for:

- Industrial Forest Management Agreements (IFMA)
- Pasture Lease Agreements
- Community Based Forest Management Agreement (CBFMA) - 25-year term
- Certificate of Stewardship Contract (CSC) - 25-year term
- Certificate of Ancestral Domain Claim-Community Based Forest Management Agreement (CADC-CBFMA) and
- Certificate of Ancestral Land Claim-Community Based Forest Management Agreement (CALC-CBFMA)
- Mining Tenements

In CANTIS, there were tenurial instruments issued in the area. The tabulated list of tenurial instruments can be found in the table below:

Table 6-4 Land Tenurial Instruments Issued

Land Tenure	Area (ha.)	Percent Share
Ancestral Domain / CADT	5,379.02	22.64%
CBFM Area	1,073.86	4.52%
Carac-an NGP Area 2011-2021	355.19	1.49%
IFMA Area	69.06	0.29%
Rattan Cutting Contract R13-ICC-089	9,896.39	41.65%
Grand Total	**16,773.52**	**69.09%**

Table 6-5 Mining Tenements

Mining Firm	Area (ha.)	Percent Share
Marcventures Mining and Development Corporation	2,585.34	10.88%
Bright Green Development Corporation	4,500.41	18.94%
First Highlander Indigenous Resources Development Corporation	2,122.48	8.93%
Total	**9,208.23**	**38.75%**

6.3.3 Existing Built-Up Area

A built-up area refers to a coherent cluster of ten or more structures that are categorized as residential, commercial, industrial, or institutional land uses. In the case of CANTIS, the overall built-up area encompasses 14.94 hectares, representing 0.06% of the entire drainage area (**Table 6.6**).

Table 6-6. Built-Up Areas in CANTIS

Built-up Area	Area (ha)	Percent Share
	14.94	0.06%
Total	**14.94**	**0.06%**

6.4 PROPOSED SUB INTERVENTIONS/PROJECTS AND COVERAGE

6.4.1 Rationale

Soil erosion and sedimentation of river systems pose significant problems, issues, and challenges across various regions in the country. These issues are exacerbated by factors such as forest degradation, land conversion, and natural disasters, which contribute to the increasing visibility of these problems.

The severity of soil erosion potential (SEP) was assessed using the InVEST erosion modeling technique, revealing the municipalities with the highest levels of soil erosion. Among the municipalities evaluated, Cantilan emerged as the most affected, with a considerable area of 13,903.09 hectares and an estimated sedimentation of 2,879,292.05 tons. Followed by Carrascal, covering 9,494.40 hectares with an estimated sedimentation of 1,903,212.33 tons. Lastly, Madrid exhibits a relatively smaller impact, with a coverage of 366.2 hectares and an estimated sedimentation of 2,522.65 tons (**Table 6-7)**

Table 6-7: Soil Erosion Potential (SEP) Using InVEST

SEP	Area (ha)	SEP (tons)
Cantilan	13,903.09	2,879,292.05
Carrascal	9,494.40	1,903,212.33
Madrid	366.2	2522.65
Total	**23,763.69**	**4,785,027.02**

The proposed area of management for NIA interventions are confined within the CANTIS water resource area following the results of Ecological Profiling and Vulnerability Assessment of as well as initial consultation with DENR-PENRO in Caraga and different LGUs at the municipal and barangay levels covering the CANTIS.

The selection of the proposed area of management interventions were based on the vulnerability of the water resources to soil erosion vis-à-vis land cover and in consideration of land classification, existing tenurial instruments, and projects/ programs with financial support from the private sectors and other government instrumentalities. This was included in the analysis in order to prevent double counting and/ or reporting of the same project site.

The total area under consideration totaled to about **7,907.83** hectares for the implementation of proposed streambank stabilization and establishment of agroforestry and tree farming projects within these areas, subject to further negotiation/ coordination/ legal arrangement with the LGUs and appropriate landowners (for the alienable and disposable lands) and the DENR for forestland or public land.

The proposed initiative aims to implement streambank stabilization measures, covering an approximate area of 5,585.65 hectares, with a specific focus on agroforestry practices encompassing 1,595.07 hectares. Furthermore, the strategic installation of engineering structures is planned for areas identified as high-priority sites requiring these interventions.

With the implementation of the proposed subprojects, beneficiaries will have an opportunity to shift from conventional/ traditional agricultural farming systems to a more sustainable farming technologies geared towards soil and water conservation.

6.4.2 Objectives of the Management Plan

The general objective of this management plan is to implement the proposed subproject interventions primarily to reduce soil loss affecting the quality and quantity of water and further improve the NIA irrigation system's serviceability.

Enumerated below are the specific objectives of the proposed management interventions:

1. Ensure streambanks stabilization along the main channel and tributaries by planting native riparian species;
2. Implement agroforestry systems and establish tree plantations in pre-identified soil erosion susceptible areas;
3. Ensure quality and quantity of water of irrigation; and
4. Provide livelihood opportunities to the subproject beneficiaries.

6.5 Strategies in the Implementation of Proposed Projects

The proposed NIA area of management was identified based on the goal of the IWRMP for the CANTIS which is to reduce the problem of soil erosion and sedimentation in the watershed's river system. Four management interventions are being proposed for the CANTIS.

These include streambank stabilization, establishment of agroforestry systems (including model/demo sites), implementation of tree farms and plantations, and construction of engineering and engineering structures in highly erodible areas (**Table 6.8**).

Table 6-8: Proposed NIA area of management for CANTIS

Subprojects/ Interventions	Location	Land Classification	Area (ha)
1. Streambank stabilization (10-20 meters width from the bank of the river)	Cantilan, Carrascal and Madrid	Legal Easement*	5,585.65
2. Agroforestry Systems	Cantilan, Carrascal and Madrid	A&D	1,595.07
3. Establishment of Tree Farms and Plantations	Cantilan, Carrascal and Madrid	A&D	727.11
		Total	**7,907.83**

Note: ***DENR AO 2021-07 Guidelines on the establishment of legal easements along the seas, rivers, lakes, esteros, and creeks***

A. Streambank Stabilization

Many waterfront developments such as irrigation systems constructed along areas that are particularly susceptible to erosion over time, such as rivers and streams. The pace of the natural erosion is often accelerated by human activities that increase stormwater runoff and remove essential riparian vegetation from the banks. Due to the potential loss of property and structures bordering waterways, stabilization and/or protective measures are often necessary for the long-term preservation of these areas (**Figure 6.2**).

Figure 6-2: Stream Bank Before and After Stabilization with Vegetation, Neogreen 2020

- If suitable, existing soils are used. If soil must be added, suitable material must be used, and appropriate soil erosion control practices must be in place during construction to avoid sedimentation of the stream. The soil is generally held in place by biodegradable material, often coir fabric, wire mesh and/or stakes.

- The re-establishment of vegetation can be accomplished by seeding, either by manual or mechanical application or by installing plant cuttings, rootwads, bareroot or containerized specimens. Hardy, fast-growing native species should be selected and planted close together for dense coverage once mature. The entire exposed area of the bank should be planted to promote the spreading and interweaving of fibrous root systems to hold the soil in place. The most important consideration is the ability of the plants to withstand flood conditions all or most of the time.

- It is important to avoid the introduction of non-native species. These species can become invasive and out-compete existing vegetation. In addition, invasive plants are not familiar nesting or feeding habitat for fish and wildlife using these areas. In addition, the species in the natural system could be used and attempt to duplicate the native vegetation. The following plants can be used along banks (**Table 6-9**):

Table 6-9: List of suitable species for streambank stabilization seen during the fieldwork

Common Name	Scientific Name
Antipolo	*Artocarpus blancoi*
Bangkal	*Nauclea orientalis*
Balobo	*Diplodiscus paniculatus*
Coconut	*Cocos nucifera*
Dao	*Dracontomelon dao*
Dita	*Alstonia scholaris*
Ipil-ipil	*Leucaena leucocephala*
Tibig	*Ficus nota*
Narra	*Pterocarpus indicus*
Lumbang	*Aleurites molucanna*
Buho	*Schizostachyum lumampao*
Kawayang Kiling	*Bambusa vulgaris*
Santol	*Sandoricum koetjape*

Scouring of unstable riverbanks usually happens during heavy rains and peak river flows. Thus, there is a need to stabilize the streambanks in order to prevent or control this from happening. It is proposed that around 5,585.65 hectares along the stretch of the main river channel and tributaries will be stabilized by planting riparian species (**Table 6-9**).

B. Establishment of Agroforestry System

- **Definition**

Agroforestry is the practice of combining agriculture and forestry by intentionally using trees and shrubs alongside crops and livestock in a coordinated manner. This land-use system involves ecological and economic interactions between the different components. It is a dynamic approach to natural resource management that aims to diversify and sustain production, providing social, economic, and environmental benefits for land users. Agroforestry plays a crucial role for smallholder farmers, improving food supply, income, and health. It is a multifunctional system that offers various economic, sociocultural, and environmental advantages.

In the Philippines, agroforestry is defined as the integration of agriculture and forestry to ensure the production of food and wood without harming ecosystems. It has been recognized as an effective strategy for promoting sustainability, especially in upland areas.

The country's Community Based Forest Management (CBFM) has actively promoted agroforestry to address issues such as watershed and forest degradation, as well as climate change.

- **Benefits**

Agroforestry is a globally practiced approach that combines trees and shrubs with crops and animals, generating environmental, economic, and social benefits. It has been implemented for centuries in the United States and other parts of the world. The goal is to achieve a more diverse and productive output from the land compared to conventional agriculture. Agroforestry contributes to integrated land management, which aims to reduce human impacts on land, and it supports a green economy by promoting sustainable and renewable forest management, particularly for small-scale producers. The concept of agroforestry has ancient roots, with evidence of woody perennials being used in agricultural systems dating back to Roman times.

- **Application**

Agroforestry can be applied at different scales and in various ecosystems and cultures. When properly implemented, it improves livelihoods by enhancing health, nutrition, economic growth, environmental resilience, and ecosystem sustainability. It also supports social sustainability by meeting human needs while maintaining environmental health. Agroforestry is particularly promising for farm diversification in temperate regions, offering sustainable production of specialty crops, medicinals, livestock, and biofuel biomass. It also contributes to carbon sequestration, soil enrichment, biodiversity conservation, and improvements in air and water quality, benefiting landowners and society as a whole.

However, only two (2) out of the many agroforestry systems are believed to be most appropriate in CANTIS. These are SALT and multi-storey agroforestry systems. SALT is best to be applied in areas where 60% of the crops to be cultivated are annual cash crops and 40% is for trees. While multi-storey agroforestry is more appropriate in existing farms and plantations of coconut, banana, coffee and others.

Some of the crops and edible fruit-bearing trees which will be cultivated in the agroforestry farms include non-food and industrial crops, abaca (dried raw fiber) posted the highest growth at 24.4 percent, followed by sugarcane at 20.0 percent and coffee (dried berries) at 11.3 percent. All other seleced major non-food and industrial crops had an increase in production except for rubber (cup lump) which had a reduction in its production at 5.4 percent.

In terms of volume, sugarcane posted the biggest gain in production at 642,205 metric tons, followed by coconut (with husk) at 6,124 metric tons.

Sugarcane accounted for 67.1 percent of the total regional production for selected non-food and industrial crops, while coconut (with husk) ranked second, accounting for 32.5 percent share.

C. Establishment of Tree Farms and Plantations

Caraga is known as the timber capital of the country. It is where timber plantations are established primarily for veneer, plywood, pulp and paper production. Tree plantations of Falcata cover a significant percent of the total land area of industrial tree plantations (ITP) in Region 13. Industrial tree plantations (ITP), as defined by the Department of Environment and Natural Resources, are lands planted mainly for timber producing species, primarily to supply the raw materials requirements of existing or proposed wood processing plants and related industries. The Philippine wood industry had its "golden era" during the 1980s, but extraction of wood from natural forests has been regulated and eventually banned which stifled the development of the industry. Currently, Mindanao, especially the Caraga Region or famously known as the "Timber Corridor", has been developing their ITP industry. DENR reported that the Philippines produces 1 million cubic meters of lumber annually, but the demand is 5 million cubic meters. This leads to the importation of lumber. Wood processors, farmers, seedlings providers, traders, furniture makers, and other end-users are the various stakeholders benefiting from wood processing. Falcata (*Falcataria moluccana* [Miq.]) is of the most widely planted species in ITP. Falcata timber is primarily used for veneer and plywood manufacturing, poles, pulp, paper, furniture, wood crafts, and wood-based kitchen utensils. It is also used as a substitute for premium tree species.

The main tree crops which are proposed to be grown in the site are: Falcata, Kaatoan bangkal, and Batino. These are believed to have high demand in the market and will ultimately provide livelihood to the beneficiaries of the subproject. Apart from these ITP species, several fast-growing native plants will also be grown and retained while harvesting of desired tree crops is being done to ensure that the soil is still protected. **Table 6-10** provides the list of ITP species to be grown in CANTIS and their corresponding silvicultural requirements.

Table 6-10: List of tree species for CANTIS and their corresponding silvicultural requirements

Tree Species	Silvicultural Requirements
Falcata	A common spacing for a pulpwood rotation of 6 to 8 years is 3 x 3 in (APFN 1987). If sawtimber is desired, stands can be thinned to 6 x 6 in at 6 to 8 years and harvested at 15 years. In fertile sites a 4 x 4 in spacing for pulp is common (Tagudar 1974). In an investigation of closer spacings, Domingo (1967) found that growth at a 2 x 2 in spacing was significantly faster than 1 x 1 in. Under ideal conditions, *falcataria* can reach 7 m in height in 1 year, 15 m in height in 3 years and 30 m in 10 years. Growth averages 39 m 3/ha/yr on 10-year rotations and can reach up to 50 m 3/ha/yr on better soils (NAS 1983). Liming the soil from pH 6.5 to 7.0 did not improve growth or modulation (Ordinario 1986). Providing both nitrogen and phosphorus produced a marked increase in early growth in a red-yellow podzolic soil deficient in each nutrient (Moloney et al. 1986).
Kaatoan bangkal	*Anthocephalus cadamba* is a typical pioneer species that grows best on deep, moist, alluvial sites, and open in secondary forests along riverbanks and in the transitional zone between swampy, permanently flooded and periodically flooded areas. It grows on a variety of soils but is more abundant and dominant on well-accelerated fertile soils. It does not grow well on leached and poorly aerated soils, even when their physical conditions are good (Soerianegara and Lemmens 1993). Light is the most important condition for *A. cadamba*'s growth. In its natural habitat, the maximum temperature varies from 32 to 42 °C and the minimum temperature varies from 3 to 15.5 °C. The mean annual rainfall for growing ranges from 1500 to 5000 mm. However, some *A. cadamba* may also grow locally on much drier sites with as little as 200 mm

Tree Species	Silvicultural Requirements
	annual rainfall. The range of the altitude for growing is between 300 and 800 m above sea level. In the equator region it is found from just above sea level up to an elevation of 1000 m (Martawijaya et al. 1989).
Batino	It is a medium-sized (30–40 m tall) tree that grows quickly and is widely planted in south Asia. The wood is used as a multipurpose building material for transmission poles, packing cases and chests, paneling, doors, window frames, and plywood production. It is also used to make matchsticks and plywood. When planting, pick a soil that has good aeration and drainage. It's important to choose a planting location with well-drained soil that has good air circulation to avoid waterlogging. The ideal climate is tropical, with temperatures between 25 and 35 °C. Although Batino trees can tolerate some shade, planting them with a spacing of 8 to 10 meters will promote healthy growth and the development of their canopy. Regular watering is crucial, especially during dry spells, and mulching can help to retain soil moisture. Also, occasional pruning can enhance structural integrity.

These proposed management interventions for the CANTIS aim to address erosion and land degradation challenges. By implementing streambank stabilization, agroforestry systems, tree farms and plantations, and engineering structures, the overall integrity and functionality of the ecosystem can be restored and sustained. These interventions will not only contribute to soil conservation and reduced sedimentation but also provide economic and environmental benefits, fostering sustainable land management practices in the region.

6.6 Prioritization of NIA Management Area

Priority decision areas were identified based on the rate of erosion and slope of the area. Prioritization involves finding the intensity of risks formed by the product of the scores from the erosion, slope, and flood:

$$\textit{Priority score} = \textit{erosion} * \textit{slope} * \textit{flood}$$

The associated risk mapping should be able to depict/indicate high risk areas as the basis for identifying decision areas and prioritization.

Table 6-11. Prioritization - Determination Matrix

Parameters	Landslide	Flood	Fire	Slope	Total Score
River Buffer	3.5	5	2.5	3.5	14.5
Strict Protection Zone	3.5	3.5	3.5	3.5	14
Agroforestry Production Zone	3.5	3.5	2.5	3.5	13
Limited Production Zone	2	3.5	3.5	3.5	12.5
Unlimited Production Zone	3	2	3	3.5	11.5

Table 6-12 Scoring System of Prioritization

Scoring System	1	**No Occurrence**
	2	**Low**
	3	**Moderate**
	4	**High**
	5	**Very High**

6.7 Proposed Area for NIA Management per Development Year

The categorization of prioritization was utilized to establish the hierarchical order of NIA management areas based on their development year. Subsequent sections will delve into the suitable measures to be executed, accompanied by the necessary budgetary considerations (**Table 6.13** & **Figure 6.3-6.7**).

Table 6-13: NIA Management Area per Development Year

NIA Management Area	Implementation Year (ha)				
	Year 1	Year 2	Year 3	Year 4	Year 5
Protection Zone (River Buffer)	1,441.33	-	-	-	-
Strict Protection Buffer Zone	-	361.19	-	-	-
Unlimited Production Zone	-	-		-	412.91
Agroforestry Production Zone	-	-	3,506.64	-	-
Limited Production Zone	-	-	-	2,661.99	-

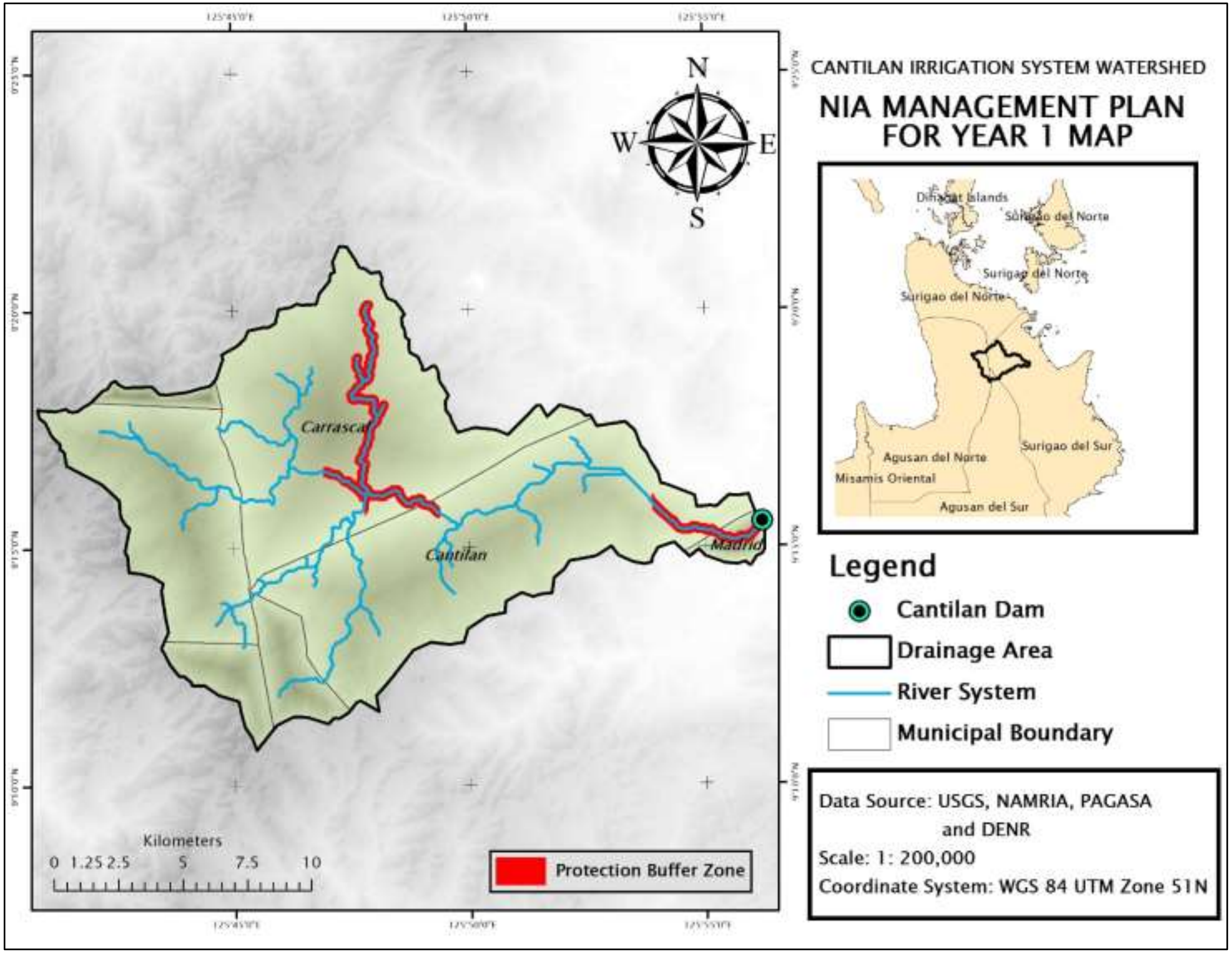


Figure 6-3: NIA Area Management Map, Year 1

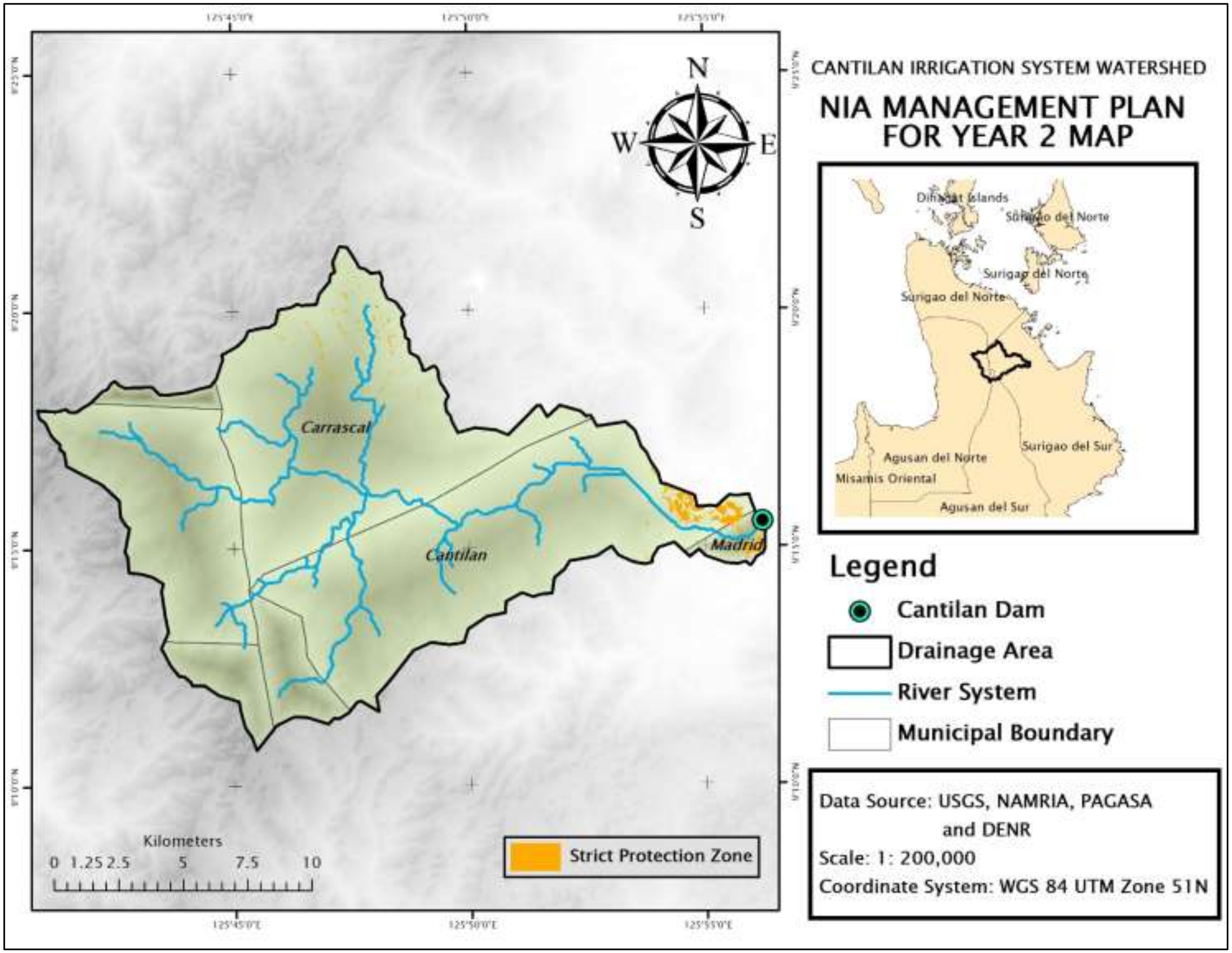


Figure 6-4: NIA Area of Management Map, Year 2

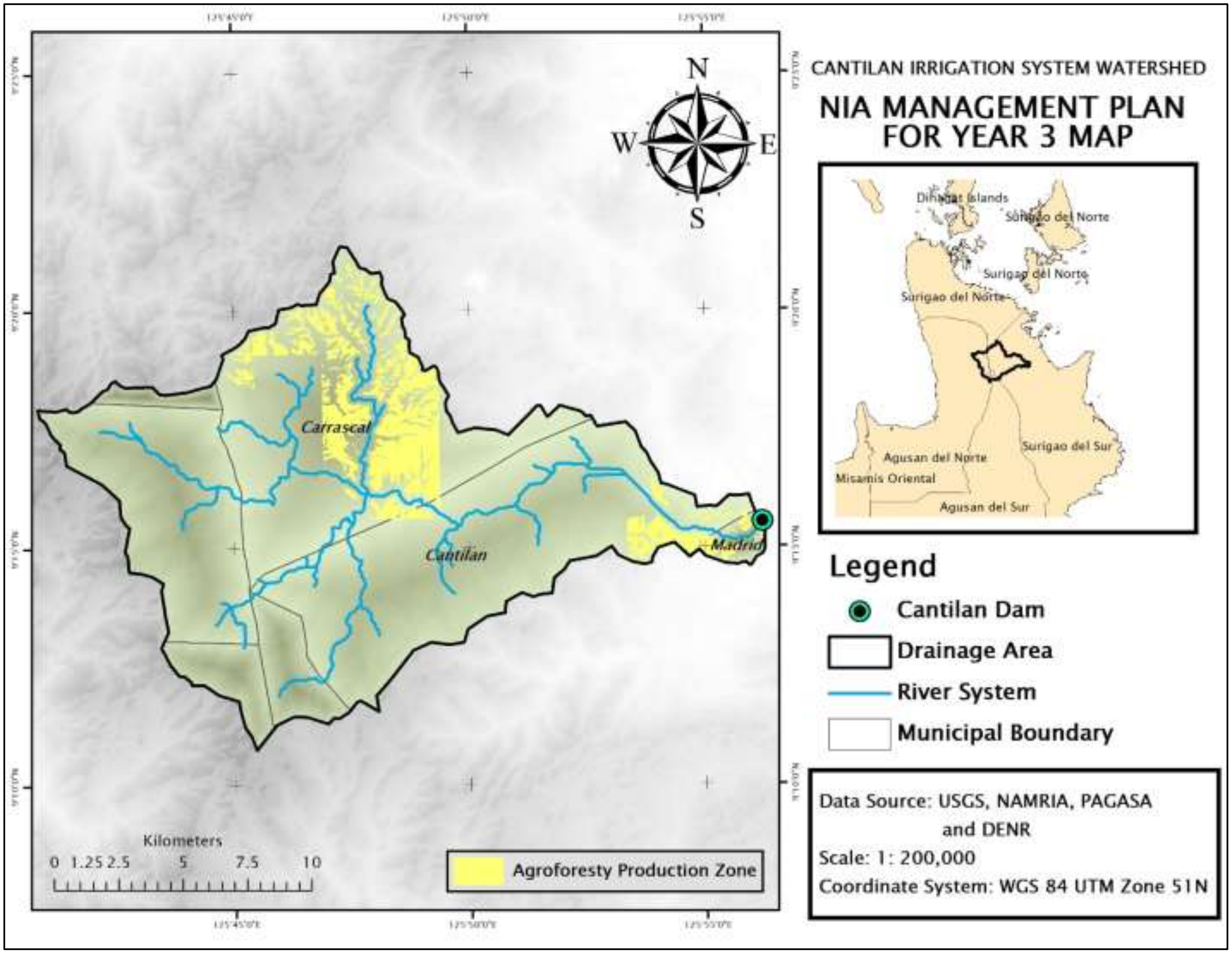


Figure 6-5: NIA Area of Management Map, Year 3

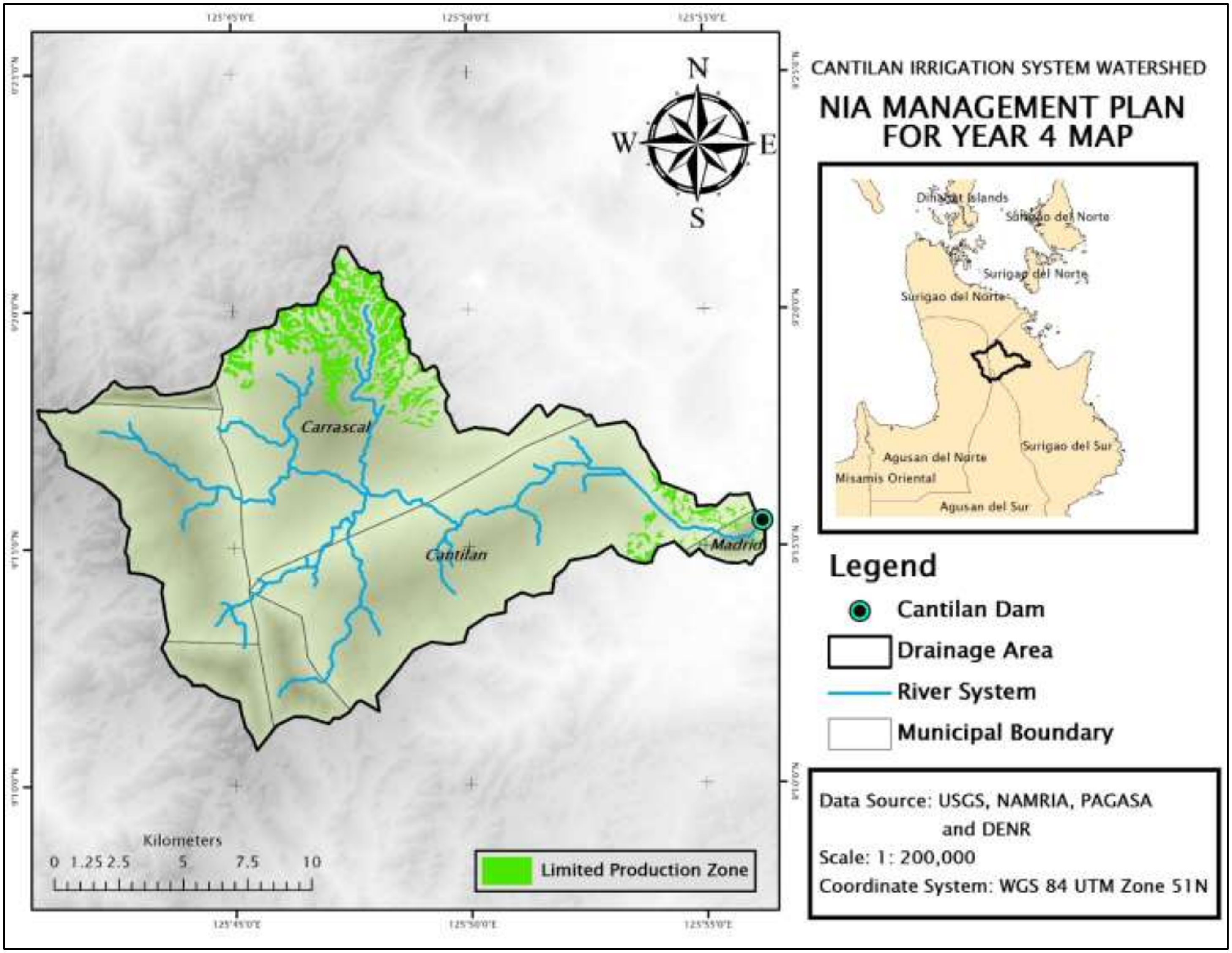


Figure 6-6: NIA Area of Management Map, Year 4

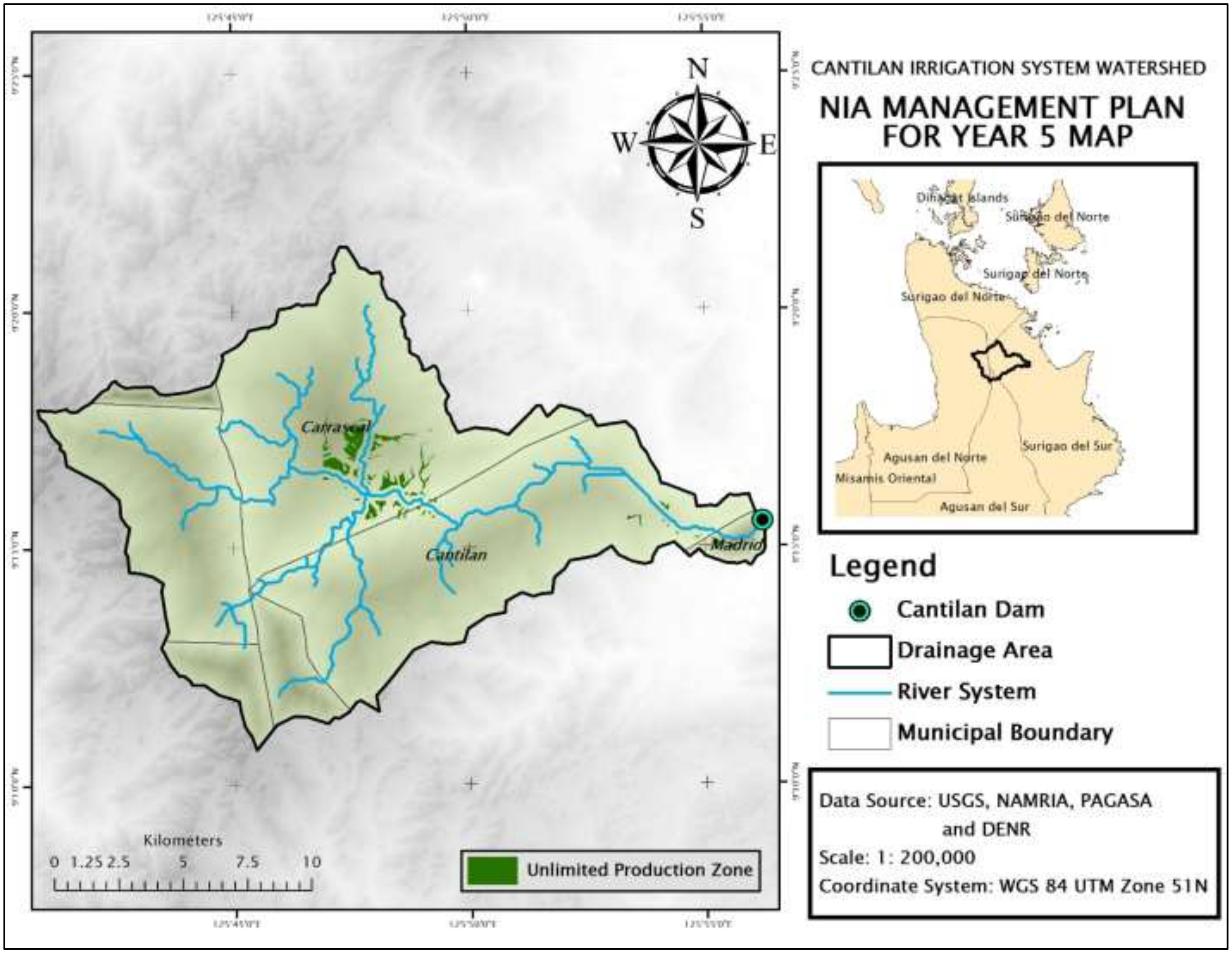


Figure 6-7: NIA Area of Management Map, Year 5

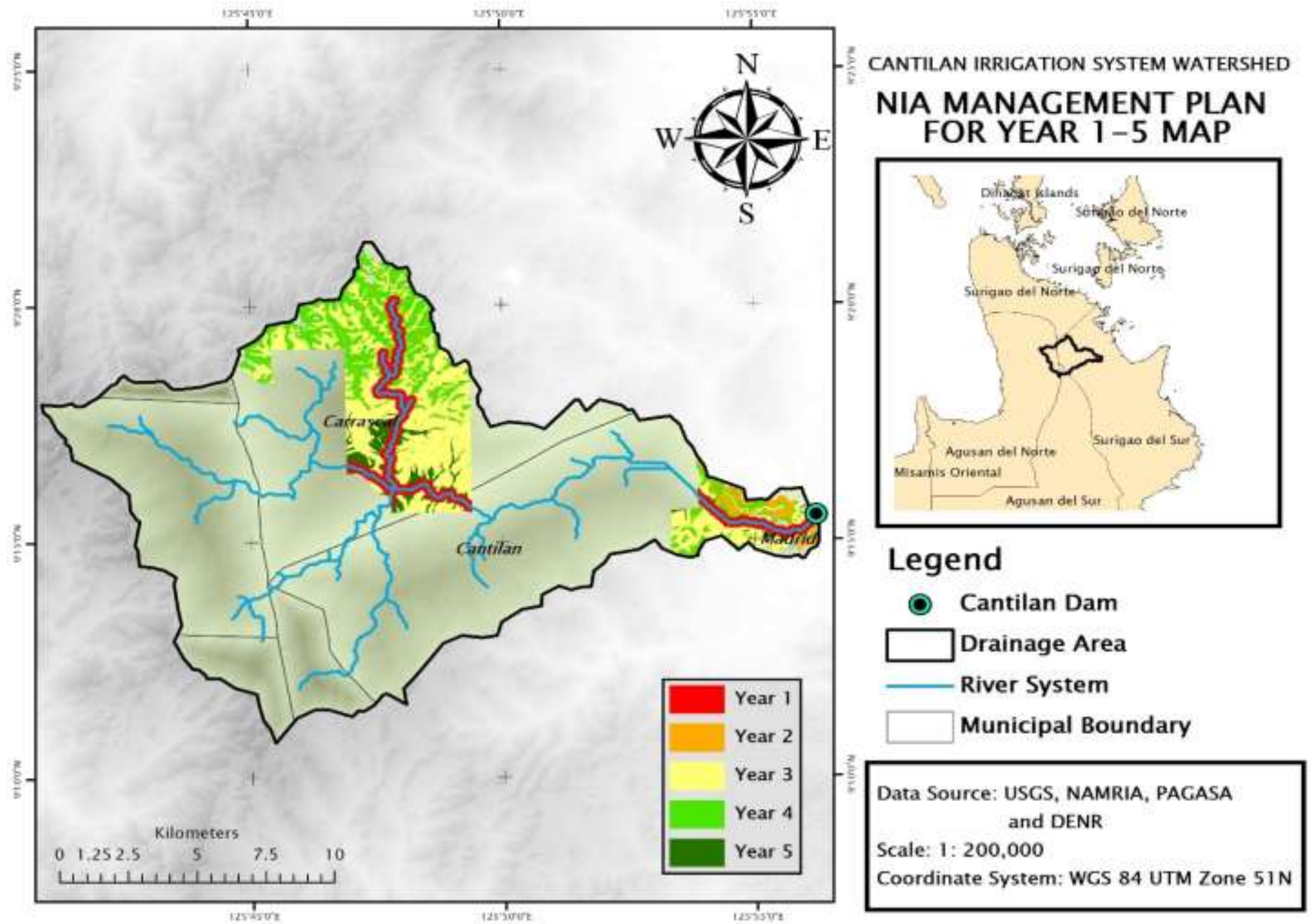


Figure 6-8 NIA Area of Management Map, Year 1 - 5

7. RECOMMENDED MANAGEMENT PLANS AND PROGRAMS

The proposed activities and programs in this section hold relevance within the project's context as they can be strategically positioned as recommendations. These recommendations should be directed towards relevant agencies possessing the necessary jurisdiction and capacity to effectively address those aspects.

By establishing effective collaboration and coordination mechanisms, the findings from multi-stakeholder consultations and series of workshops and its review process can be shared, accompanied by clear justifications for the recommended activities. This approach ensures a harmonized and synchronized approach to addressing the comprehensive needs of the Cantilan Irrigation System watershed, promoting a unified front in addressing its multifaceted challenges.

As a culmination of these efforts, the management plan provides intricate detail on the roles and responsibilities of each agency involved, with a particular emphasis on NIA's core mandate and expertise. Simultaneously, the plan duly acknowledges the valuable contributions of other agencies in tackling broader watershed concerns. The management plan crystallizes a cohesive and synergistic strategy, harnessing the strengths of multiple agencies to achieve the project's overarching objectives.

7.1.1 Development Framework

The successful implementation of the Irrigation Water Resources Management Plan (IWRMP) for the Cantilan Irrigation System relies on a development framework that encompasses key planning considerations identified through a series of workshops. This development framework comprises three fundamental components: a vision statement, goals and objectives, and programs and projects.

The vision statement represents a unifying perspective that delineates the future direction and desired outcomes for the management of water resources within the Cantilan Irrigation System. It serves as a guiding principle, providing a sense of purpose and direction for all stakeholders involved in the implementation of the IWRMP.

The vision statement is developed collaboratively and embodies the collective aspirations and long-term goals of the stakeholders, ensuring a shared commitment towards sustainable water resource management.

Goals and objectives constitute an integral part of the development framework, as they articulate the specific targets and milestones that must be accomplished within a defined timeframe. These goals and objectives are derived from the insights and priorities identified during the workshops, ensuring their alignment with the overall vision statement. By setting measurable and time-bound targets, the goals and objectives provide a framework for decision-making, resource allocation, and performance evaluation. They serve as benchmarks against which the progress and effectiveness of the IWRMP can be assessed.

The programs and projects component of the development framework encompasses the tangible initiatives and actions that will be undertaken to achieve the established goals and objectives. It involves the identification, design, and implementation of various programs and projects, ranging from infrastructure development and technological advancements to policy reforms and community engagement initiatives. These programs and projects are tailored to address the challenges and opportunities identified through the workshop process, ensuring a comprehensive and integrated approach to water resource management. By employing a diverse range of interventions, the programs and projects contribute to the sustainable utilization, conservation, and equitable distribution of water resources in the Cantilan Irrigation System.

The development framework of the Irrigation Water Resources Management Plan (IWRMP) for the Cantilan Irrigation System encompasses a vision statement, goals and objectives, and programs and projects, which collectively establish a structured and synchronized approach to guide decision-making, optimize resource allocation, and evaluate performance. This framework integrates a shared vision that is collectively endorsed, as well as specific and measurable targets and strategic initiatives. Through this integration, the development framework facilitates a comprehensive and sustainable management of water resources within the Cantilan Irrigation System. Consequently, the systematic implementation of this approach generates favorable ecological outcomes, preserving the integrity of the ecosystem, while also fostering positive socio-economic impacts for the various stakeholders involved.

7.1.2 Carac-an River Protection and Development Programs

The holistic development of Cantilan Irrigation System (CANTIS) should not solely center around economic progress. It is imperative to prioritize the improvement and sustainable management of the environment and natural resources (ENR) to achieve inclusive growth in the area. By preserving the ecological services that enhance CANTIS, we can effectively support key sectors of growth and safeguard the well-being of resource-dependent communities, especially in the face of climate change and the vulnerabilities posed by natural disasters.

Aligned with the identified major challenges of CANTIS, a set of four key programs have been delineated to appropriately harness and steward the river irrigation environment and natural resources. These programs encompass the following objectives:

7.1.3 Vision Statement

The stakeholders of CANTILAN (CANTIS) envision itself as:

"***To establish a well-managed Cantilan Irrigation System that promotes environmental sustainability and resilience, ensuring a harmonious coexistence between water resource utilization and ecosystem preservation."***

The vision for the Cantilan Irrigation System (RIS) acknowledges its substantial functional role. This vision statement was formulated through an inclusive and participatory multi-sectoral workshop, where representatives from NIA, DENR, LGU departments, Irrigators' Associations (IAs), and various stakeholders actively engaged in the process of its development.

7.1.4 Goals, Objectives and Strategies

In order to realize the overarching vision, a set of eight (8) goals have been formulated within the identified subsectors of management, climate change and natural hazards, abundant irrigation water, and environmental awareness.

Goal 1: Ensure Sustainable Water Resource Management

-

- Implement efficient water management practices to sustainably meet the irrigation needs of local communities.
- Enhance water conservation measures to optimize water utilization within the Cantilan Irrigation System.

Goal 2: Forest Land Protection and Rehabilitation

- Develop and implement strategies for the protection and rehabilitation of forest lands within the Cantilan Irrigation System.
- Promote reforestation efforts to enhance the ecosystem services provided by the forested areas.

Goal 3: Climate Change Adaptation and Mitigation

- Implement climate change adaptation measures to reduce vulnerability and enhance resilience within the Cantilan Irrigation System.
- Mitigate the negative impacts of climate change by integrating climate-resilient practices and infrastructure within the irrigation system.

Goal 4: Environmental Awareness and Education

- Promote environmental awareness and education programs to increase understanding and appreciation of the Cantilan Irrigation System among local communities and stakeholders.
- Foster a sense of responsibility and stewardship towards the conservation of the river system's natural resources.

Goal 5: Responsible Resource Utilization and Economic Development

- Promote responsible utilization of extractive resources within the Cantilan Irrigation System, considering environmental sustainability and long-term economic benefits.
- Support economic development initiatives that are compatible with the protection and conservation of the river system.

Goal 6: Sustainable Economic Development

- Facilitate sustainable economic development activities that leverage the potential of the Cantilan Irrigation System, while ensuring the preservation of its ecological integrity.
- Encourage the adoption of sustainable practices and technologies among businesses and industries operating within the river system.

Goal 7: Capacity Building and Collaboration

- Strengthen the capacity of the National Irrigation Administration (NIA) Region XIII and other relevant government agencies in effectively managing and coordinating the Cantilan Irrigation System.
- Foster collaboration and partnerships among stakeholders to enhance knowledge exchange, technical expertise, and resources for sustainable river system management.

Goal 8: Community Empowerment and Engagement

- Empower local communities by involving them in the decision-making processes and development initiatives of the Cantilan Irrigation System.
- Promote active participation and engagement of community members in sustainable practices, resource conservation, and management activities.

7.1.5 Sifting of Programs and Projects

To ensure seamless alignment between the National Irrigation Administration's (NIA) specific mandate and the primary project objective, a comprehensive review of the proposed activities within the Rehabilitation and Protection of Watershed Resources of the Cantilan Irrigation System (R&P WRSIS) is systematically carried out.

The process of sifting programs and projects involves meticulous evaluation and selection from a pool of proposed interventions, determining the eligibility of each as a program or project. During this phase, participants in the planning workshop refer to established guidelines to assess the feasibility and pertinence of individual interventions. Factors such as alignment with overall objectives, potential impacts, resource requisites, and timelines are thoroughly scrutinized.

Through this meticulous review, the workshop participants identify programs and projects that exhibit well-defined scopes, objectives, and expected outcomes.

A project, which is often used interchangeably with "program," signifies an intricately interlinked collection of activities. It represents a specific endeavor involving diverse functional units and specialists, featuring a clearly defined objective, a predetermined timeline, and an allocated budget. Typically, projects span durations ranging from 1 to 3 years.

Contrastingly, the term "non-projects" encompasses the routine functions executed within specific offices. These activities are performed by regular staff members using existing facilities and allocated budget resources.

7.1.6 Determination of "Ownership"

The determination of "ownership" involves the process of identifying which programs and projects among the identified interventions would be funded and supported by specific entities such as the NIA, LGU, DENR, DPWH, and other key stakeholders. It is crucial to distinguish and allocate ownership to ensure effective coordination and resource allocation for the implementation of the programs and projects.

During the workshop, participants were tasked with identifying the source or sources of funds for each of the proposed programs and projects. This assessment helped determine whether the funding would come from the national government, local government, or private sector/non-government organizations.

By identifying the ownership and funding sources, the planning workshop participants could ascertain the responsibilities and roles of each stakeholder in the implementation and sustainability of the programs and projects. This information aids in establishing clear lines of accountability, coordination, and resource mobilization among the involved entities, contributing to the successful execution of the initiatives.

7.1.7 Evaluation and Prioritization

After the identification of the sources of fund for each program/project, each group was asked to evaluate and rank the programs and projects using the set of criteria below (**Table 7.1-7.4**):

Table 7-1: Degree of Relevance

CRITERIA	DESCRIPTION	WEIGHT
Essential	Projects that directly support the achievement of the GOTS (Goals, Objectives, Target and Strategies)	3
	Project needed to maintain critically needed program	
	Projects that are critical/prerequisites to other downstream projects	
Very Relevant	Projects that directly support the achievement of the GOTS (Goals, Objectives, Target and Strategies) but not critical to the completion of making usable major improvement program	2
	Projects are required to maintain minimum standards as part of an ongoing program	
Relevant	Projects that indirectly support the achievement of the GOTS (Goals, Objectives, Target and Strategies) but directly support the other GOTS (Goals, Objectives, Target and Strategies).	1
	Projects that are to replace obsolete or unsatisfactory facilities or repair/maintain projects to prolong life of existing facilities	
Deferrable	Projects that indirectly support the achievement of the GOTS (Goals, Objectives, Target and Strategies) but the implementation can be deferred Projects that are needed for expansion of current programs	0
	Projects that are designed to initiate new programs	

Table 7-2: Degree of Urgency

CRITERIA	DESCRIPTION	WEIGHT
Urgent	Projects that cannot be reasonably postponed	2
	Projects that would remedy conditions dangerous to welfare of the people	
Necessary	Projects that are needed to meet emergency situations	1
	Projects that should be carried out to meet clearly identified and anticipated needs.	
Deferrable	Projects that can be postponed without detriment to present operations if budget cut is necessary.	0
	Projects that are questionable in terms of overall needs, adequate planning or overall timing.	

Table 7-3: Degree of Financial Implementability

CRITERIA	DESCRIPTION	WEIGHT
Desirable	Projects that have firm budget allocation	3
	Projects that are self-liquidating	
Implementabl e	Projects that have firm budget allocation from other national line agencies	2
	Projects for which external funding is already available or has been firmly committed	
Acceptable	Projects with potential donor or loan	1
	Projects that can be jointly funded by NIA, LGUs and other agencies.	
Deferrable	Projects with no identified funding	0

Table 7-4: Degree of Technical Implementability

CRITERIA	DESCRIPTION	WEIGHT
Urgent	Projects with available equipped staff and support logistics	2
Necessary	Projects with available support logistics but unequipped staff or vice versa	1
Deficient	Projects with no available staff and support logistics	0

7.1.8 Community-Based Forest Resource Management Program

The Forest Resource Management Program aims to protect, rehabilitate, and sustainably manage the forest lands and resources within Cantilan Irrigation System (RIS) to achieve an ecologically balanced and resilient watershed. The program emphasizes the involvement and empowerment of local communities in the management and conservation efforts, ensuring their active participation and benefits.

7.1.8.1 Key Components:

Forest Inventory, Mapping, and Land Use Planning:

- Conduct comprehensive forest inventory and mapping to assess the current state of forest resources within CANTIS.
- Develop a land use plan that optimizes the allocation of resources for both protection and sustainable production, taking into consideration the needs of resource-dependent communities in relevant LGUs and barangays.

Forest Land Use Plan (FLUP) Formulation:

- Formulate a detailed Forest Land Use Plan based on the identified priorities and objectives, incorporating sustainable management practices and conservation strategies.
- Ensure stakeholder participation and consultation during the formulation process to gather local knowledge and perspectives.

Reforestation of Denuded Forestlands and Upland Areas:

- Implement reforestation initiatives to restore denuded forestlands and promote the recovery of biodiversity.
- Adopt appropriate tree species selection and planting techniques, considering ecological suitability and community needs.
- Encourage community participation in tree planting activities, fostering a sense of ownership and responsibility.

Regular Water and Air Quality Monitoring:

- Establish a monitoring system to regularly assess water and air quality within CANTIS.
- Collect and analyze data to identify potential threats and prioritize mitigation measures.
- Collaborate with relevant agencies and stakeholders to ensure comprehensive monitoring efforts.

Information, Education, and Communication (IEC) Campaign:

- Conduct IEC campaigns to raise awareness and promote proper environmental management practices among local communities.
- Emphasize the importance of biodiversity conservation, sustainable resource utilization, and the benefits of an ecologically balanced watershed.

- Utilize various communication channels, such as workshops, seminars, community meetings, and media platforms, to disseminate information effectively.

Capacity Building:

- Provide training and education programs for Municipal Environment and Natural Resources Office (MENRO) staff and local forest managers.
- Enhance their knowledge and skills in forest resource management, conservation techniques, monitoring, and community engagement.
- Foster collaboration and knowledge sharing among stakeholders to strengthen the program's effectiveness.

Implementation Approach:

- Foster community-based management by involving local communities as primary stakeholders in decision-making processes.
-

- Establish collaborative partnerships with relevant government agencies, non-governmental organizations, and academic institutions to leverage expertise and resources.
- Conduct regular consultations and dialogue sessions with local communities to ensure their active participation and inclusivity.
- Develop mechanisms for community monitoring and enforcement to deter illegal activities and promote responsible forest resource use.

- Regularly evaluate the program's progress and adapt strategies based on feedback and changing environmental conditions.

By implementing this Community-Based Forest Resource Management Program, CANTIS will work towards achieving a sustainable and resilient watershed that supports ecosystem services while benefiting local communities.

7.1.9 Integrated Disaster Risk Reduction and Climate Change Adaptation Program

The Disaster Risk Reduction and Climate Change Adaptation Program aims to enhance the resilience of CANTIS by implementing measures that conserve soil resources, protect prime agricultural lands, and establish effective disaster preparedness and early warning systems.

The program seeks to improve the livelihoods of marginalized upland farmers while ensuring food self-sufficiency and the safety of communities vulnerable to erosion and other climate-related hazards.

7.1.9.1 Key Components:

Soil Conservation and Sustainable Agriculture:

- Educate farmers, especially marginalized upland farmers and kaingin farmers, on appropriate soil and water conservation technologies.
- Promote sustainable agricultural practices that enhance soil productivity and provide alternative sources of income for farmers.
- Introduce agroforestry systems and crop diversification to reduce soil erosion and increase resilience to climate change impacts.
-

- Provide training and technical assistance on sustainable farming practices and the adoption of climate-smart agricultural techniques.

Protection of Prime Agricultural Lands:

- Identify and designate prime agricultural lands within CANTIS for protection and conservation.
- Implement land use planning measures that prioritize agricultural productivity and prevent encroachment or conversion of these lands.
- Strengthen land tenure security and support mechanisms for farmers to ensure their access and control over agricultural resources.

Disaster Preparedness and Early Warning Systems:

- Establish an institutionalized early warning system for communities residing in erosion-prone areas.
- Install flood monitoring equipment and weather monitoring stations to provide timely and accurate information on potential hazards.
- Develop and implement community-based disaster preparedness measures, including evacuation plans and drills, to ensure the safety of vulnerable populations.
- Conduct capacity building programs to enhance the knowledge and skills of community members in disaster response and emergency management.

Information Dissemination and Community Engagement:

- Strengthen communication channels and information dissemination networks to ensure timely and accurate transmission of disaster-related information.
- Conduct community workshops, trainings, and awareness campaigns on disaster risk reduction, climate change adaptation, and soil conservation.

- Encourage active community participation in decision-making processes related to disaster preparedness and climate resilience.
- Foster partnerships with local organizations, civil society groups, and relevant government agencies to coordinate efforts and leverage resources.

Temporary Settlement and Livelihood Support:

- Develop plans and protocols for temporary settlements to accommodate communities displaced by disasters.
- Provide support for temporary shelter, basic needs, and livelihood recovery to affected individuals and families.
- Facilitate access to livelihood opportunities and income-generating activities to promote long-term resilience and recovery.

Implementation Approach:

- Establish a multi-stakeholder task force to oversee the implementation of the program, involving relevant government agencies, local communities, and non-governmental organizations.
- Conduct regular monitoring and evaluation to assess the effectiveness of implemented measures and make necessary adjustments.
-
- Foster collaboration with academic institutions and research organizations to generate knowledge and best practices for disaster risk reduction and climate change adaptation.
- Seek funding opportunities and partnerships with development agencies and organizations to ensure the sustainability of the program.

By implementing this Integrated Disaster Risk Reduction and Climate Change Adaptation Program, CANTIS will enhance its resilience to climate-related hazards, safeguard soil resources, and protect vulnerable communities.

The program aims to build a sustainable and climate-resilient ecosystem while promoting the well-being and livelihoods of local farmers and residents.

7.1.10 Riparian Erosion and Sedimentation Control Measures for River Rehabilitation Program

The River Rehabilitation Program aims to mitigate erosion, landslides, and sedimentation along riparian areas within CANTIS. By adopting effective erosion and sediment control measures, the program seeks to improve water yield, minimize surface water run-off, and mitigate the risk of flash floods downstream.

The program's implementation will safeguard and support the residents of the LGUs, particularly those living near environmentally critical areas identified as hazard-prone by DENR-Mines and Geosciences Bureau (MGB).

7.1.10.1 Key Components:

Riparian Erosion and Sedimentation Control Measures:

- Conduct a comprehensive assessment of riparian areas to identify erosion-prone zones and areas susceptible to landslides.
- Implement appropriate erosion control measures, such as the construction of gabion walls, vegetative buffer strips, and bioengineering techniques.
- Promote the use of erosion-resistant vegetation and bioengineering materials to stabilize riverbanks and minimize sedimentation.
- Monitor and maintain the implemented measures to ensure their long-term effectiveness.

Watershed Management and Reforestation:

- Implement watershed management initiatives to restore and protect the ecological functions of the river system.
- Conduct reforestation activities in critical areas to enhance soil stability, improve water infiltration, and reduce erosion.
- Prioritize the planting of native tree species that are well-suited to the riparian ecosystem and provide ecosystem services.
- Collaborate with local communities and relevant stakeholders to ensure their participation and ownership in the reforestation efforts.

Flood Control and Management:

- Develop and implement flood control measures that integrate natural and engineered solutions.
- Conduct hydrological assessments to determine the optimal design and location of flood control structures, such as retention ponds and floodplain restoration.
- Implement proper water flow management strategies to reduce the risk of flash floods downstream.
- Enhance community awareness and preparedness for flood events through training, drills, and the development of early warning systems.

Capacity Building and Knowledge Sharing:

- Provide training programs and workshops to local government units (LGUs), community members, and relevant stakeholders on riparian erosion and sedimentation control measures.
- Foster knowledge sharing and exchange of best practices among LGUs, government agencies, academic institutions, and community-based organizations.
- Encourage the integration of sustainable river rehabilitation practices into local development plans and policies.

Monitoring, Evaluation, and Reporting:

- Establish a monitoring and evaluation system to assess the effectiveness of implemented riparian erosion control measures and rehabilitation efforts.
- Regularly monitor water quality, sedimentation levels, and riverbank stability to track progress and identify areas for improvement.
- Prepare comprehensive reports on the program's outcomes and share them with stakeholders, LGUs, and DENR-MGB for transparency and accountability.

Implementation Approach:

- Foster collaboration among LGUs, DENR-MGB, academic institutions, non-governmental organizations, and local communities to ensure a coordinated approach to river rehabilitation.

- Conduct stakeholder consultations and engagement to gather local knowledge, perspectives, and support for the program.
- Secure funding from various sources, including government allocations, grants, and private sector partnerships, to sustain the program's implementation.
- Regularly review and update the program based on scientific research, technological advancements, and changing environmental conditions.

Through the implementation of the River Rehabilitation Program, CANTIS will witness reduced erosion, improved water yield, and decreased surface water run-off, thus minimizing the risk of flash floods downstream. The program will effectively protect and support the residents living near environmentally critical areas, ensuring a safer and more sustainable ecosystem for both the local government and the community.

7.1.11 Sustainable Livelihood Development Program

The Sustainable Livelihood Development Program aims to enhance the economic well-being and resilience of communities within CANTIS. By leveraging the natural resources and environmental improvements achieved through river rehabilitation efforts, the program seeks to create diverse and sustainable livelihood opportunities for local residents.

The program will empower community members, particularly those living near riparian areas, to improve their livelihoods while promoting the sustainable use of natural resources.

7.1.11.1 Key Components:

Livelihood Diversification and Entrepreneurship:

- Conduct a comprehensive livelihood assessment to identify potential income-generating activities suitable for the local context.
- Provide capacity-building training on entrepreneurship, business management, and financial literacy to equip community members with the necessary skills to establish and manage their livelihood ventures.
- Promote the diversification of livelihood activities to reduce dependency on a single income source and enhance community resilience.
- Support the establishment of cooperatives or community-based enterprises to foster collaboration, resource pooling, and collective marketing efforts.

Sustainable Agriculture and Agroforestry:

- Promote sustainable agricultural practices, such as organic farming, agroecology, and agroforestry systems, to enhance productivity while conserving the environment.
- Provide training and technical assistance on sustainable farming techniques, crop diversification, and value-added processing.
- Encourage the cultivation of high-value crops and the establishment of market linkages to increase income opportunities for farmers.
- Integrate agroforestry practices, including tree planting and intercropping, to improve soil fertility, watershed management, and biodiversity conservation.

Skills Development and Employment Opportunities:

- Offer skills training programs aligned with the needs of local industries, such as agri-business, sustainable resource management, eco-construction, and natural resource conservation.
- Facilitate linkages with potential employers, including local businesses, government agencies, and private sector partners, to create employment opportunities for community members.

- Foster partnerships with technical vocational institutions and training centers to provide accredited training programs and certifications.
- Encourage the inclusion of marginalized groups, such as women, youth, and indigenous communities, in skills development initiatives.

Access to Financing and Market Support:

- Facilitate access to microfinance programs, grants, and financial services to support the start-up and expansion of livelihood initiatives.
- Establish market linkages and facilitate value chain development to connect community-based enterprises with potential buyers, local markets, and tourism networks.
- Provide mentoring and business advisory services to help entrepreneurs develop business plans, improve product quality, and enhance market competitiveness.

Implementation Approach:

- Foster community participation and ownership in the program through active engagement, consultation, and involvement in decision-making processes.
- Establish partnerships with government agencies, non-governmental organizations, and private sector entities to leverage resources, expertise, and networks.

- Monitor and evaluate the impact of the program on livelihood development, income generation, and natural resource sustainability.
- Conduct regular capacity-building workshops, networking events, and knowledge-sharing platforms to foster learning and collaboration among stakeholders.

Through the Sustainable Livelihood Development Program, CANTIS will witness improved economic opportunities, increased income, and enhanced community.

7.2 Projects

The proposed projects presented here offer a comprehensive and integrated set of interventions to effectively tackle the interconnected drivers of forest degradation, biodiversity loss, land degradation, and water pollution within the CANTIS.

These components are designed to rehabilitate degraded forest areas, safeguard remaining natural forests, and mitigate pollution originating from sediments and toxic substances in rivers. Successful implementation of these sub-project components will directly contribute to the enhancement of water resources and biodiversity in the watersheds.

The projects encompass both policy and institutional development interventions, as well as ground development interventions. The policy and institutional interventions are envisioned to encompass the entire watershed area. Meanwhile, the identification of specific areas for ground development interventions is based on rigorous criteria such as land cover, slope, elevation, and land classification.

Through extensive stakeholder engagement and workshops, a range of potential strategies in the form of policies, programs, and projects (PPAs) have been identified as valuable contributions toward achieving the overall vision of the plan. These strategies have been collaboratively developed with stakeholders and aim to effectively address the identified challenges and goals pertinent to the CANTIS context (**Table 7.5**).

Table 7.5. Programs, and Projects

PROJECTS	DESCRIPTION
Community-Based Forest Resources Management Program	
Forest Landscape Restoration	Implement a comprehensive forest landscape restoration project to rehabilitate degraded areas, restore forest ecosystems, and improve biodiversity conservation within CANTIS.
Community-Based Agroforestry Cooperatives	Establish agroforestry cooperatives that promote sustainable farming practices, tree planting, and value-added processing of agroforestry products to enhance income generation and forest conservation.
Community Seed Bank and Plant Propagation	Set up a community seed bank and plant propagation center to preserve and propagate native tree species, providing a sustainable supply of seedlings for reforestation and agroforestry activities.
Community-Based Forest Protection Brigades	Form community-based forest protection brigades equipped with necessary skills and tools to combat illegal logging, encroachments, and other forest-related threats, ensuring the effective conservation and management of forest resources.
Sustainable Forest-Based Ecotourism	Develop sustainable forest-based ecotourism initiatives, including nature trails, camping facilities, and guided tours, to promote environmental education, cultural exchange, and generate income for local communities.
Participatory Forest Monitoring	Engage local communities in participatory forest monitoring programs, involving them in the collection of data on forest resources, biodiversity, and environmental indicators to support evidence-based decision-making.
Forest Education and Awareness Campaigns	Conduct forest education and awareness campaigns in schools and communities, raising awareness about the importance of forests, biodiversity conservation, and sustainable forest management practices.
Non-Timber Forest Product Development	Explore the sustainable harvesting, processing, and marketing of non-timber forest products (NTFPs) such as medicinal plants, wild fruits, and handicraft materials, creating income opportunities while promoting forest conservation.

PROJECTS	DESCRIPTION
Forest-based Carbon Sequestration Projects	Collaborate with carbon offset initiatives and develop forest-based carbon sequestration projects, allowing local communities to benefit from carbon credits and incentivizing the protection and restoration of forest ecosystems.
Forest Nursery	Establish community-run nurseries to produce tree seedlings for reforestation and restoration efforts, organizing tree planting campaigns involving schools, local organizations, and volunteers.
Sustainable Wood-Based Enterprises	Support the development of sustainable wood-based enterprises, such as eco-friendly furniture production and timber processing using certified sustainable timber sources, promoting responsible forest management practices.
Forest Education Centers and Interpretive Trails	Establish forest education centers and interpretive trails within CANTIS, providing visitors with educational resources, interactive exhibits, and guided tours to raise awareness about forest conservation and biodiversity.
Forest-Based Sustainable Energy Initiatives	Promote the use of sustainable forest-based energy sources, such as biomass energy and biochar production, reducing reliance on fossil fuels and promoting renewable energy alternatives.
Forest Research and Monitoring Program	Support research initiatives on forest ecology, biodiversity, and sustainable forest management practices, fostering scientific knowledge and innovation for the long-term conservation and sustainable use of forest resources.
Integrated Disaster Risk Reduction and Climate Change Adaptation Program	
Disaster Preparedness Training	Conduct an Information, Education, and Communication (IEC) campaign on disaster preparedness, focusing specifically on landslide and flooding risks. Provide training sessions to the community members, raising awareness about early warning signs, evacuation procedures, and response strategies.
Flood Monitoring and Early Warning System	Install flood monitoring equipment, such as river level sensors and rainfall gauges, to enhance the early warning capabilities of the community. Integrate these systems with local disaster management agencies and establish protocols for timely dissemination of flood alerts and evacuation advisories.
Riverway and Creek Dredging	Implement slope stabilization measures in landslide-prone areas, such as the construction of retaining walls, terracing, and bioengineering techniques. These measures will help reduce the risk of slope failures and mitigate the impact of landslides on the community.

PROJECTS	DESCRIPTION
Slope Stabilization and Landslide Mitigation	Implement slope stabilization measures in landslide-prone areas, such as the construction of retaining walls, terracing, and bioengineering techniques. These measures will help reduce the risk of slope failures and mitigate the impact of landslides on the community.
Flood Response Training	Provide training to community members on flood response and rescue techniques. Equip them with basic skills and knowledge on first aid, search and rescue, and emergency response protocols to enhance their ability to assist during flooding incidents.
Riparian Erosion and Sedimentation Control Measures for River Rehabilitation Program	
Riparian Vegetation Restoration	Implement a riparian development project focused on stream bank stabilization and restoration. This includes the planting of native vegetation along riverbanks, installation of erosion control structures, and implementation of sustainable land management practices to enhance the stability of stream banks and improve the overall health of the riparian ecosystem.
Integrated Soil and Water Conservation Program	Undertake the construction of flood control structures and drainage improvements to mitigate the risk of flooding in vulnerable areas. This may include the construction of retaining walls, levees, and flood channels to redirect and manage water flow during heavy rainfall events. Ensure that these infrastructure projects are designed to withstand climate change impacts and consider the natural hydrological processes of the area.
Flood Control Infrastructure Construction	Undertake the construction of flood control structures and drainage improvements to mitigate the risk of flooding in vulnerable areas. This may include the construction of retaining walls, levees, and flood channels to redirect and manage water flow during heavy rainfall events. Ensure that these infrastructure projects are designed to withstand climate change impacts and consider the natural hydrological processes of the area.
Sustainable Drainage System Implementation	Promote the implementation of sustainable drainage systems (SuDS) to manage stormwater runoff and reduce the risk of flooding. This includes the construction of bio-retention ponds, permeable pavement, and green roofs to capture and infiltrate rainwater, reducing the burden on conventional drainage systems. Raise awareness among local authorities and developers about the benefits and best practices of SuDS, encouraging their incorporation into new infrastructure projects.
Sustainable Livelihood Development Program	

PROJECTS	DESCRIPTION
Sustainable Agroforestry Livelihood	Implement a sustainable agroforestry livelihood program that promotes the cultivation of high-value crops, agroforestry systems, and value-added processing of forest products. Provide training and support to local communities in agroforestry techniques, sustainable farming practices, and market linkages to enhance income generation while promoting forest conservation.
Eco-Tourism and Community-Based Homestays	Develop an eco-tourism and community-based homestay program that leverages the natural resources and cultural heritage of the area. Encourage local community members to participate in tourism-related activities, such as guided nature tours, handicraft production, and cultural performances, providing them with additional sources of income while showcasing the region's biodiversity and cultural richness.
Forest-Based Livelihood Cooperatives	Facilitate the formation of forest-based livelihood cooperatives, where community members can collectively engage in sustainable forest management activities and value-chain development. This may involve the establishment of cooperatives focused on forest product processing, eco-friendly timber production, or non-timber forest product collection and marketing. Provide training, capacity building, and access to markets to strengthen the cooperatives' sustainability and economic viability.

7.2.1 Work and Financial Schedule

The total cost for the implementation of the Irrigation Water Resources Management Plan for the Cantilan Irrigation System is estimated at **PhP 5,336,588,636.13**. The budget includes costs for the implementation of various projects, services and legislation needed to realize the goals and objectives of the said plan. Based on the table below, it shows the different government agencies tasked to lead in the implementation of projects. As this will be discussed further in the succeeding chapters, the implementation of the plan will be managed by the Project Management Unit. The plan covers the period from 2024 to 2027 (**Table 7.6**).

Table 7.6. CANTIS Work and Financial Schedule

PROJECT	TYPE OF PROJECT			IMPLEMENTING AGENCY	PERIOD OF IMPLEMENTATION	COST ESTIMATE (PHP)
	PROJECT	SERVICES	LEGISLATION			
Forest Landscape Restoration	/			DENR	2024-2027	34,065,443
Community-Based Agroforestry Cooperatives		/		LGUs and DENR	2024-2027	1,000,000
Community Seed Bank and Plant Propagation	/			DENR	2024-2027	1,760,989
Community-Based Forest Protection Brigades	/			DENR	2024-2027	1,500,000
Sustainable Forest-Based Ecotourism	/			DENR	2024-2027	1,500,000
Participatory Forest Monitoring		/		DENR and BLGUs	2024-2027	5,000,000
Forest Education and Awareness Campaigns		/		DENR	2024-2027	1,000,000
Non-Timber Forest Product Development	/			DENR	2024-2027	1,500,000

PROJECT	TYPE OF PROJECT			IMPLEMENTING AGENCY	PERIOD OF IMPLEMENTATION	COST ESTIMATE (PHP)
	PROJECT	SERVICES	LEGISLATION			
Forest-based Carbon Sequestration Projects	/			DENR and NIA	2024-2027	10,000,000
Forest Nursery	/			NIA	2024-2027	20,000,000
Sustainable Wood-Based Enterprises	/			DENR	2024-2025	2,000,000
Forest Education Centers and Interpretive Trails	/			DENR	2024-2025	5,000,000
Forest-Based Sustainable Energy Initiatives	/			DENR	2024-2034	2,000,000
Forest Research and Monitoring Program		/		DENR	2024-2034	2,000,000
Disaster Preparedness Training		/		LGUs	2024-2034	1,500,000
Flood Monitoring and Early Warning System	/			DOST-PAGASA and LGUs	2024-2025	5,000,000
Riverway and Creek Dredging	/			DPWH	2024-2025	10,000,000

PROJECT	TYPE OF PROJECT			IMPLEMENTING AGENCY	PERIOD OF IMPLEMENTATION	COST ESTIMATE (PHP)
	PROJECT	SERVICES	LEGISLATION			
Slope Stabilization and Landslide Mitigation	/			DPWH	2024-2025	5,206,250,547.56
Flood Response Training		/		LGUs	2024-2034	5,000,000
Riparian Vegetation Restoration	/			NIA	2024-2027	10,000,000
Integrated Soil and Water Conservation Program	/			NIA	2024-2027	8,000,000
Flood Control Infrastructure Construction	/			DPWH	2024-2025	5,206,250,547.56
Sustainable Drainage System Implementation	/			DPWH and LGUs	2024-2027	2,000,000
Sustainable Agroforestry Livelihood	/			NIA	2024-2027	1,000,000
Eco-Tourism and Community-Based Homestays	/			DENR	2024-2025	50,000,000
Forest-Based Livelihood Cooperatives		/		DENR	2024-2025	2,000,000

7.3 NIA-Led Programs and Projects

The formulation of an Irrigation Water Resources Management Plan is a critical endeavor that involves multiple stakeholders, including national government agencies, local government units, and irrigator's associations, in the context of CANTIS. This plan aims to address the various issues and concerns surrounding irrigation and water resources management while identifying appropriate interventions and allocating sufficient funds for implementation.

This comprehensive plan consists of two main parts. The first part focuses on engaging and involving all stakeholders through consultation workshops, ensuring that their perspectives and proposals are taken into account. This inclusive approach ensures a collaborative effort in developing effective strategies for irrigation water resources management specific to CANTIS. The second part of the plan is dedicated to the projects and activities to be undertaken by the National Irrigation Administration, specifically tailored to CANTIS. This part aims to identify suitable interventions and allocate necessary resources to improve the irrigation water supply in the area.

The proposed sub-project components are developed based on a thorough analysis of key informant interviews, reviews of watershed management plans, local government land use and development plans, field assessments, and GIS-assisted analysis of the physical and biological conditions of the CANTIS drainage area. These components are designed to address the pressing issues of soil erosion and sedimentation, with the ultimate goal of enhancing the quality and availability of irrigation water sources in CANTIS.

To ensure effective management and mitigate potential risks, areas prone to erosion and landslides, as identified in the geo-hazard map, have been classified under appropriate management interventions. Highly susceptible areas are recommended for a combined vegetative and engineering approach, while moderately susceptible areas are targeted for vegetative measures. Additionally, streambank stabilization measures are proposed for areas surrounding streams flowing through erosion and landslide-prone areas within CANTIS.

By implementing these sub-project components, the Irrigation Water Resources Management Plan aims to enhance the sustainability and efficiency of the CANTIS system, leading to improved irrigation water supply for agricultural activities in the area.

This introductory part sets the stage for the subsequent sections of the plan, which will delve into the specific projects, activities, and strategies to be implemented to achieve the desired outcomes.

7.3.1 Forest Nursery

Tropical forest nurseries run by communities are an empowering and sustainable approach to forest restoration and conservation. These nurseries are typically managed and operated by local communities who have a deep connection with and vested interest in the forests and landscapes surrounding them. By actively engaging communities in the establishment and management of these nurseries, multiple benefits can be realized, including increased ownership, livelihood opportunities, and ecological restoration.

When communities take charge of tropical forest nurseries, it fosters a sense of stewardship and responsibility towards their local environment. They become actively involved in the entire process, from seed collection and propagation to nurturing the seedlings until they are ready for planting. This hands-on involvement not only enhances their knowledge and skills but also instills a sense of pride and commitment to the restoration efforts. With this, selected community members can be sourced for man-power and labor.

One of the significant advantages of community-run tropical forest nurseries is the socio-economic benefits they bring. By cultivating and selling tree seedlings, communities can generate income and improve their livelihoods. This income diversification can be particularly valuable for communities residing in or near forested areas, as it reduces their dependency on unsustainable practices such as logging or slash-and-burn agriculture. The revenue generated from the sale of seedlings can be reinvested in community development initiatives, education, healthcare, and other essential needs.

Furthermore, community-run nurseries contribute to the conservation of local biodiversity and the restoration of degraded ecosystems. Communities have an intimate knowledge of their surrounding forests and can prioritize the propagation of indigenous and endemic tree species that are ecologically important and well-suited to the local environment. By focusing on native species, these nurseries help maintain the integrity of the local ecosystem and promote biodiversity conservation.

Community involvement in tropical forest nurseries also fosters social cohesion and collective action. It encourages collaboration, knowledge sharing, and mutual support among community members. As communities work together towards a common goal of restoring and conserving their forests, it strengthens social bonds and empowers individuals to actively participate in environmental decision-making processes.

In conclusion, community-run tropical forest nurseries represent a sustainable and inclusive approach to forest restoration and conservation. They empower local communities, provide livelihood opportunities, promote biodiversity conservation, and strengthen community resilience. By recognizing and supporting the vital role of communities in nurturing and restoring tropical forests, we can achieve long-term ecological and socio-economic benefits for both present and future generations.

7.3.2 Riparian Vegetation Restoration

Riparian ecosystem restoration focuses on revitalizing and enhancing the health and functionality of riparian zones, which are the areas of land adjacent to rivers, streams, and other water bodies. These ecosystems are critically important as they provide a wide range of ecological benefits, including water filtration, flood mitigation, erosion control, habitat provision, and nutrient cycling.

The restoration of riparian ecosystems involves a combination of ecological, hydrological, and land management strategies aimed at improving their structure, function, and resilience.

The figure below shows the proposed planting design for 200-meter riparian buffer zone river systems in CANTIS (**Figure 7.1**).

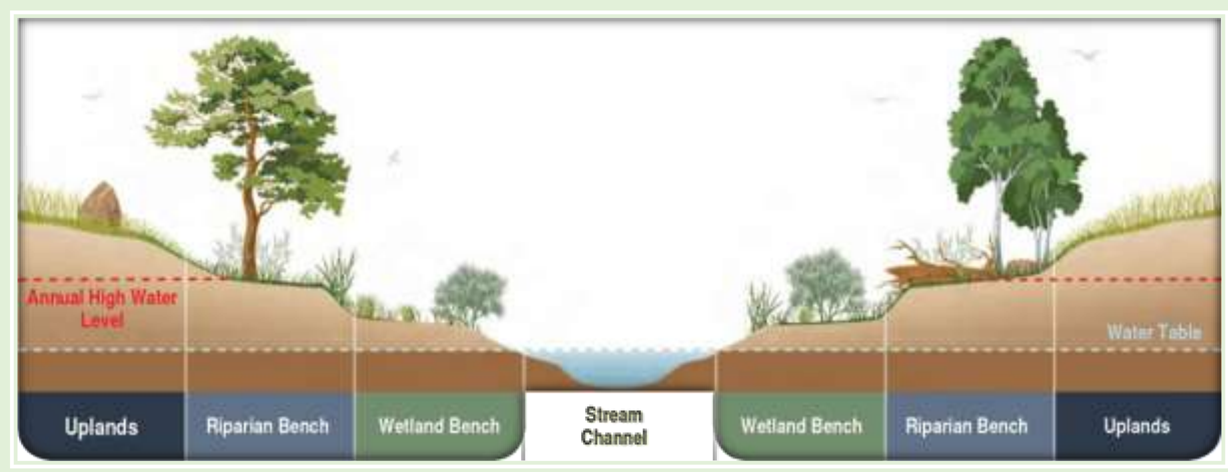


Figure 7-1: Suggested Planting Design for Streambank Stabilization

Wetland Bench

Species Selection:

- Main Plant Species: Talisay (*Terminalia catappa*)
- Supporting Plant Species: Bamboo (*Bambusa* spp.)

Spacing and Arrangement:

- Talisay: Plant the Talisay trees at a spacing of 1.5 meters x 1.5 meters to 2 meters x 2 meters. This means each Talisay tree will be planted 1.5-2 meters apart from the adjacent trees both in rows and columns. Close planting spacing is advised as it may promote leaf production and soil erosion control for streambank stabilization. This also induces maximizing foliage cover and root network, and boosting ecological benefits in the wetland portions.
- Bamboo: Include a single line of bamboo with a spacing of 5 to 7 meters between each bamboo plant. This line of bamboo should run parallel to the streambank. Close bamboo spacing along the streambanks is recommended to help to stabilize soil, prevent erosion, filter surface runoff, improve wildlife habitat, and foster biodiversity.

Planting Layout:

- Start by marking the boundary of the 5-meter riparian buffer strip along the streambank.

- Begin planting the Talisay trees within the buffer strip, maintaining the 1.5 to 2-meter spacing between each tree. Plant them in rows, ensuring that the distance between the rows is also 1.5 to 2 meters.
- Along the same side as the Talisay trees, establish a single line of bamboo with a spacing of 5 meters between each bamboo plant. This line should be perpendicular to the rows of Talisay trees.

Planting Process:

- Dig holes that are large enough to accommodate the root systems of the Talisay trees.
- Plant each Talisay tree in its designated spot, ensuring that the spacing is consistent throughout.
- Plant the bamboo plants in a straight line, using a measuring tape or similar tool to ensure a 5 to 7-meter interval between each plant.

Maintenance and Care:

- Provide regular watering and maintenance during the establishment phase to promote healthy growth and survival of the plants.
- Monitor for any signs of stress, pests, or diseases and take appropriate measures to address them.
- Implement mulching to conserve moisture, suppress weed growth, and enhance soil health within the riparian buffer strip.
- Conduct periodic pruning and thinning to maintain the desired spacing and promote optimal growth of the Talisay trees and bamboo.

Riparian Bench

Species Selection:

- Main Plant Species: Native Riparian Trees (Malabayabas (*Tristianopsis decorticata*), Malabulak (*Bombax ceiba*), and Banaba (*Lagerstroemia speciosa*))
- Supporting Plant Species:
  - Suitable Ground Covers:

    a. Lemongrass (*Cymbopogon citratus*) - Provides ecological benefits through streambank stablization by avoiding soil erosion and deterring pests. It also provides potential economic advantages by generating income by being used in the food, medicine, and cosmetics.

b. Vetiver grass (*Chrysopogon zizanioides*) - Offers environmental benefits via soil erosion prevention, water purification, provision of habitat to wildlife. Also provides economic benefits from handicrafts and perfume production and potential use in sustainable farming practices (e.g., as fodder).

Spacing and Arrangement:

- Native Riparian Trees: Plant the trees at a spacing of 5 meters apart. This spacing will allow them to grow and develop a healthy canopy while providing shade and stability to the riparian area.
- Ground Covers: Plant these species densely within the buffer strip to provide ground cover and prevent soil erosion. The spacing between shrubs and ground covers can be around 0.5-1 meter, depending on the specific species' growth habits.

Planting Layout:

- Mark the boundary of the 15-meter riparian bench buffer strip along the streambank.
- Begin planting the Native Riparian Trees along the outer edge of the buffer strip, leaving enough space for them to grow and spread their branches. Maintain the recommended spacing between each tree.
- Fill the remaining area of the buffer strip with Ground Covers, planting them closer together to achieve a dense coverage.

Planting Process:

- Dig holes that are large enough to accommodate the root systems of the trees and shrubs.
- Plant each tree and shrub in its designated spot, ensuring that they are properly aligned with the spacing requirements.
- Water the newly planted vegetation thoroughly to support their establishment.

Maintenance and Care:

- Regularly monitor the growth and health of the planted trees, shrubs, and ground covers.
- Provide sufficient water during dry periods to promote their survival.
- Conduct periodic pruning to maintain the desired shape and prevent overcrowding.

- Implement weed control measures to minimize competition for nutrients and resources.
- Monitor and address any pest or disease issues promptly using appropriate organic methods.
- Ensure the buffer strip remains free from encroachment or disturbance.

Upland Bench

Species Selection:

- Main Crop Species: Fruit Trees (e.g., Rambutan and Mangoosteen)
- Supporting Agroforestry Species: Timber Tree (Falcata),
- Annual Crops: Vegetables (Monggo Beans)

Spacing and Arrangement:

- Fruit Trees: Plant the fruit trees at a spacing of 6-8 meters apart to provide ample space for their growth and canopy development.
- Supporting Agroforestry Species: Plant the timber trees, medicinal plants, and nitrogen-fixing trees at varying spacing within the buffer strip based on their specific growth requirements. Aim for a spacing of 3-4 meters between each tree to allow for optimal growth and interactions.
- Annual Crops: Allocate specific areas within the buffer strip for annual crop cultivation, using raised beds or rows with appropriate spacing depending on the crop's requirements.

Planting Layout:

- Mark the boundary of the 180-meter riparian bench buffer strip along the streambank.
- Begin planting the Fruit Trees along the outer edge of the buffer strip, maintaining the recommended spacing between each tree.
- Fill the remaining area of the buffer strip with the Supporting Agroforestry Species, distributing them in a way that maximizes their beneficial interactions and utilization of available resources.
- Designate separate areas within the buffer strip for the cultivation of annual crops, ensuring proper spacing and organization.

Planting Process:

- Prepare the planting holes for the fruit trees and supporting agroforestry species, considering their root systems' size and depth.
-

- Plant each tree in its designated spot, ensuring the spacing is consistent with the recommended distances.
- Prepare the soil in the designated areas for annual crop cultivation, incorporating organic matter and ensuring proper drainage.
- Plant the annual crops according to their specific spacing requirements and preferred planting method (e.g., direct seeding or transplanting).
- Water all newly planted vegetation thoroughly to support their establishment.

Maintenance and Care:

- Regularly monitor the growth and health of the planted trees and annual crops, providing appropriate water, nutrients, and pest control measures.
- Prune the fruit trees to maintain their shape, promote airflow, and enhance fruit production.
- Implement organic mulching to conserve moisture, suppress weed growth, and enrich the soil.
- Practice intercropping and companion planting techniques to maximize space utilization and enhance pest management.
- Harvest the annual crops when they reach maturity, ensuring proper timing and handling to optimize yield.
- Rotate annual crops in subsequent planting seasons to promote soil health and reduce disease and pest buildup.

7.3.3 Integrated Soil and Water Conservation Program

The Integrated Soil and Water Conservation program adopts a comprehensive and synergistic approach to address the intricate challenges associated with soil erosion, land degradation, and water resource management. Its overarching goal is to conserve and sustainably manage soil and water resources through the implementation of diverse strategies and measures. The deployment of this program has the potential to be situated within the Agroforestry Production Zone, Limited Production Zone, and Unlimited Production Zone. In these zones, the program appears to be well-suited with respect to land utilization, land tenure, hazard, and various other pertinent considerations.

Recognizing that soil erosion, driven by factors such as improper land use practices, deforestation, and inadequate water management, poses significant threats to environmental integrity, agricultural productivity, and water quality, the program strives to combat these issues holistically. It emphasizes the importance of integrated approaches that consider the interrelationships between soil and water.

By targeting various stages and processes involved in soil erosion and water resource management, the program aims to achieve comprehensive and long-lasting solutions.

Central to the program's approach is the implementation of soil conservation practices. These practices encompass a range of techniques, including terracing, contour plowing, strip cropping, and cover cropping. By employing these methods, the program effectively minimizes soil erosion, enhances soil structure, and promotes efficient water infiltration. Additionally, the program advocates for the use of vegetative measures, such as vegetation strips, buffer zones along water bodies, and reforestation, which play a pivotal role in stabilizing slopes, reducing runoff, and preventing sedimentation.

Furthermore, the program places a strong emphasis on the establishment of sound water management systems. This entails the adoption of efficient irrigation techniques, water harvesting methods, and irrigation scheduling practices to optimize water utilization and minimize wastage resulting from runoff or evaporation. Through these measures, the program aims to ensure the sustainable utilization of water resources and maintain adequate water supply for agricultural production.

To ensure the program's efficacy, regular monitoring and evaluation mechanisms are implemented. These mechanisms enable systematic assessment of the implemented measures, facilitating evidence-based decision-making and adaptive management.

By closely monitoring the program's impact, effectiveness, and efficiency, necessary adjustments and refinements can be made to enhance its outcomes.

Furthermore, the program places great emphasis on capacity building and knowledge sharing among stakeholders, fostering a culture of sustainable practices and enabling the replication and scaling-up of successful initiatives across different contexts.

Terracing (18 to 30% Slope): Constructing terraces on sloping lands helps to reduce soil erosion by creating flat areas that prevent water runoff and allow water to infiltrate into the soil. Terraces can be implemented using stone walls, contour bunds, or vegetative barriers (**Figure 7.2**).

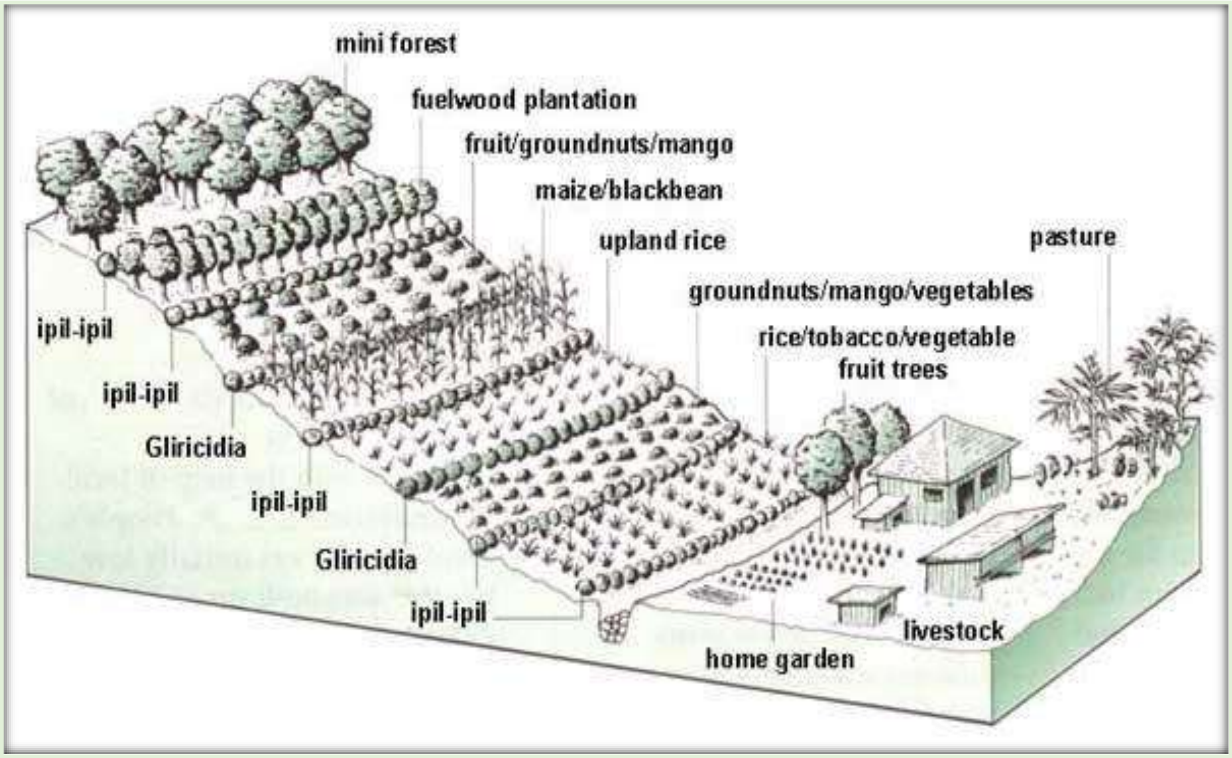


Figure 7-2: Terraces on Sloping Lands

Contour Plowing (30 to 50% Slope): Plowing along the contour lines instead of up and down the slope helps to slow down water runoff and minimize soil erosion. This technique reduces the formation of channels that can carry away fertile topsoil (**Figure 7.3**).

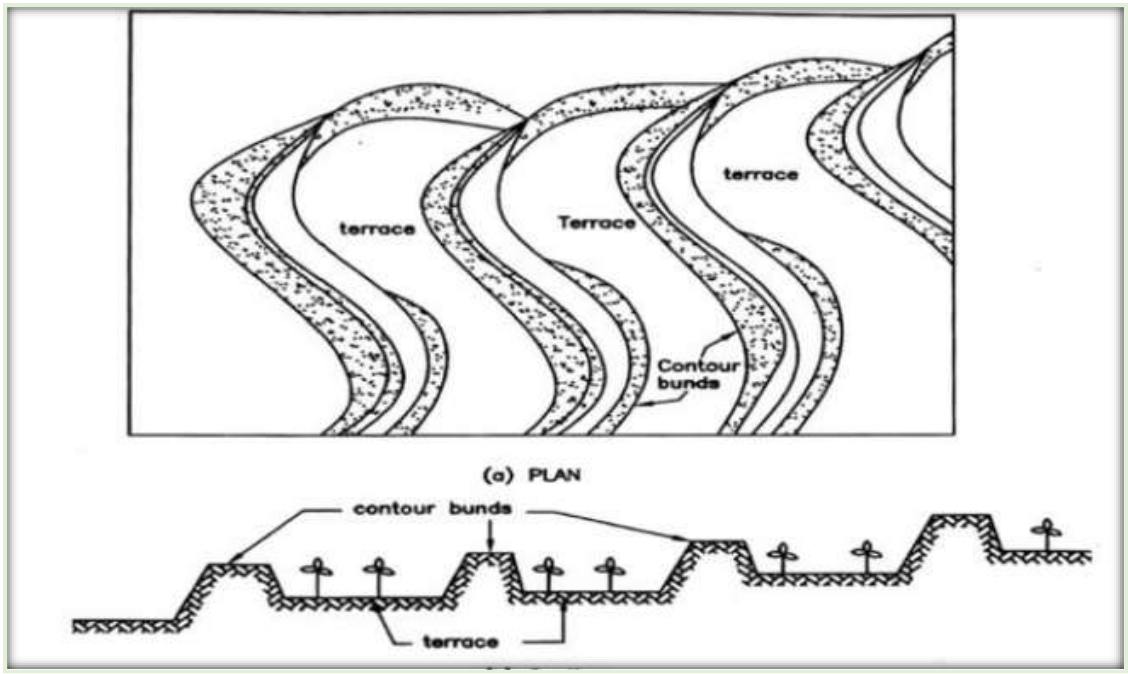


Figure 7-3: Contour Plowing

Mulching: Applying organic mulch, such as straw or wood chips, on the soil surface helps to prevent soil erosion by reducing the impact of raindrops, maintaining soil moisture, and suppressing weed growth. Mulching also improves soil structure and fertility.

Conservation Tillage: Adopting conservation tillage practices, such as minimum tillage or no-till farming, helps to reduce soil disturbance and maintain soil structure. By leaving crop residues on the soil surface, conservation tillage minimizes erosion, increases organic matter content, and improves water infiltration.

Crop Rotation: Implementing crop rotation systems helps to break the cycle of pests and diseases, improves soil nutrient availability, and reduces the risk of soil erosion. Rotating crops with deep-rooted plants can also enhance soil stability and water absorption.

Cover Crops: Planting cover crops, such as legumes or grasses, during fallow periods or between cash crops, provides ground cover and helps to protect the soil from erosion. Cover crops also enhance soil fertility by fixing nitrogen, improving soil structure, and reducing nutrient leaching.

Water Conservation Structures: Constructing water conservation structures, such as check dams, retention ponds, or contour bunds, helps to slow down water flow, reduce erosion, and retain water on agricultural lands. These structures promote infiltration, recharge groundwater, and minimize sedimentation in downstream areas.

7.3.4 Sustainable Agroforestry Livelihood

Livelihood Assessment and Planning

Objective: Conduct a comprehensive livelihood assessment to identify potential income-generating activities suitable for the local context.

Activities:

- Engage with the community to gather information on existing livelihood practices, available resources, and market opportunities.
- Conduct surveys, interviews, and focus group discussions to assess community skills, interests, and aspirations.
- Analyze the data collected to identify potential livelihood options that align with the community's capabilities and market demand.
- Facilitate participatory planning sessions with community members to prioritize and select the most viable livelihood activities.

Capacity-Building and Training

Objective: Provide capacity-building training on entrepreneurship, business management, and financial literacy to equip community members with the necessary skills to establish and manage their livelihood ventures.

Activities:

- Develop training modules and materials on entrepreneurship, business planning, financial management, marketing, and value chain development.
- Conduct training sessions and workshops for community members, focusing on building entrepreneurial skills and enhancing business acumen.
- Provide mentorship and coaching to individuals or groups interested in starting their own livelihood enterprises.
- Organize exposure visits to successful livelihood projects or enterprises to inspire and learn from best practices.

Livelihood Diversification

Objective: Promote the diversification of livelihood activities to reduce dependency on a single income source and enhance community resilience.

Activities:

- Conduct awareness campaigns to educate the community about the benefits and importance of livelihood diversification.
- Facilitate training sessions on alternative livelihood options, such as agroforestry, sustainable agriculture, handicraft production, or ecotourism.
- Provide technical assistance and support in establishing new livelihood activities, including access to inputs, equipment, and market linkages.
- Encourage collaboration and knowledge sharing among community members engaged in different livelihood activities.

Cooperative and Enterprise Development

Objective: Support the establishment of cooperatives or community-based enterprises to foster collaboration, resource pooling, and collective marketing efforts.

Activities:

- Conduct capacity-building workshops on cooperative formation, governance, management, and leadership.
- Facilitate the establishment of cooperative structures and support the development of business plans and operational frameworks.
- Assist in accessing financial services, grants, or microcredit facilities to strengthen the cooperatives' financial capabilities.
- Facilitate networking opportunities and linkages with potential buyers, markets, and value chain partners.

7.3.5 Budgetary Requirement

To implement the above-mentioned projects, the National Irrigation Administration would need to allocated funds amounting to **PhP 652,910,605.29** for the whole 5-year implementation (**Table 7.5-7.7**).

Forest Nursery

Table 7-5: Forest Nursery Budgetary Requirement

Component/Activity	Unit	Target	Unit Cost (PhP)	Cost Per Unit (PhP)	Total		Implementation Schedule									
					Target	Cost (PhP)	Year 1		Year 2		Year 3		Year 4		Year 5	
							Target	Budget	Target	Budget	Target	Budget	Target	Budget	Target	Budget
1. Forest Nursery																
Site Selection and Preparation																
a. Identification of a suitable location with adequate access to water, sunlight, and proper soil conditions for nursery beds.	ha.	0.50	500.00	500.00	0.50	250.00	0.50	250.00								
b. Clearing of the selected site of any vegetation, rocks, or debris.	ha.	0.50	10,000.00	5,000.00	0.50	2,500.00	0.50	2,500.00								
c. Installation of drainage and irrigation systems.	sq.m	1,350.00	200.00	270,000.00	0.50	135,000.00	0.50	135,000.00								
Infrastructure Development																
a. Constructing of nursery structures such as shade houses, polyhouses, and greenhouses.	sq.m	2,250.00	900.00	2,025,000.00	0.50	1,012,500.00	0.50	1,012,500.00								
b. Constructing an office space for administrative work and record-keeping.	sq.m	90.00	2,000.00	180,000.00	0.50	90,000.00	0.50	90,000.00								
c. Installation of fencing around the nursery area.	m	600.00	300.00	180,000.00	0.50	90,000.00	0.50	90,000.00								
Seed Collection and Storage																
a. Identification and collection of seeds from suitable tree species (2m X 2m)	sdlgs.	2,250.00	5.00	11,250.00	0.50	5,625.00	0.50	5,625.00	0.50	5,625.00	0.50	5,625.00	0.50	5,625.00	0.50	5,625.00
b. Construction of seed storage conditions, including	sq.m	37.50	7,000.00	262,500.00	0.50	131,250.00	0.50	131,250.00								

Component/Activity	Unit	Target	Unit Cost (PhP)	Cost Per Unit (PhP)	Total		Implementation Schedule									
							Year 1		Year 2		Year 3		Year 4		Year 5	
					Target	Cost (PhP)	Target	Budget	Target	Budget	Target	Budget	Target	Budget	Target	Budget
temperature and humidity control, to maintain seed viability.																
Physical Project Cost				**2,934,250.00**		**1,467,125.00**		**1,467,125.00**		**5,625.00**		**5,625.00**		**5,625.00**		**5,625.00**
Operating and Maintenance Cost			0.30	880,275.00		440,137.50		440,137.50		1,687.50		1,687.50		750.00		750.00
Sub-Total Cost				**3,814,525.00**		**1,907,262.50**		**1,907,262.50**		**7,312.50**		**7,312.50**		**6,375.00**		**6,375.00**

Riparian Vegetation Restoration

Table 7-6: Riparian Vegetation Restoration Budgetary Requirements

Component/Activity	Unit	Target	Unit Cost (PhP)	Cost Per Unit (PhP)	Total		Implementation Schedule									
							Year 1		Year 2		Year 3		Year 4		Year 5	
					Target	Cost (PhP)	Target	Budget	Target	Budget	Target	Budget	Target	Budget	Target	Budget
1. Riparian Vegetation Restoration																
Wetland Bench (5m to 5m)																
Site identification/survey, mapping & planning	ha	0.50	1,500.00	750.00	0.50	1,500.00	1.58	1,185.00								
Production/Procurement of Planting Materials (w/ 10% mortality allowance)																
a. Talisai seedlings	sdlgs	315.50	28.00	8,834.00	0.50	4,417.00	0.50	4,417.00								
b. Bamboo culm (Kawayan tinik, bayog, giant bamboo/bontong)	sdlgs	315.50	45.00	14,197.50	0.50	7,098.75	0.50	7,098.75								
Site preparation																
a. Underbrushing	ha.	0.50	3,000.00	1,500.00	0.50	750.00	1.58	2,370.00								
b. Baseline establishment/staking	stake	631.00	1.00	631.00	0.50	315.50	1.58	996.98								
c. Hole digging	hills	631.00	1.50	946.50	0.50	473.25	1.58	1,495.47								
Seedlings transport	sdlgs.	631.00	5.00	3,155.00	0.50	1,577.50	1.58	4,984.90								
Planting	sdlgs.	631.00	5.00	3,155.00	0.50	1,577.50	1.58	4,984.90								
Maintenance and Protection	ha.	0.50	4,603.00	2,301.50	0.50	1,150.75	1.58	3,636.37	1.58	14,545.48	1.58	14,545.48	1.58	14,545.48	1.58	7,937.92
Physical Project Cost				**35,470.50**		**18,860.25**		**31,169.37**		**14,545.48**		**14,545.48**		**14,545.48**		**7,937.92**
Monitoring and Evaluation			0.10	3,547.05		1,886.03		3,116.94		9,097.33		9,097.33		9,097.33		9,097.33
Sub-Total Project Cost				**39,017.55**		**20,746.28**		**34,286.31**		**38,188.29**		**38,188.29**		**38,188.29**		**24,973.17**
Riparian Bench (15m to 15m)																
Site identification/survey, mapping & planning	ha	0.50	1,500.00	750.00	0.50	1,500.00	13.65	10,237.50								
Production/Procurement of Planting Materials (w/ 10% mortality allowance)																

Component/Activity	Unit	Target	Unit Cost (PhP)	Cost Per Unit (PhP)	Total		Implementation Schedule									
							Year 1		Year 2		Year 3		Year 4		Year 5	
					Target	Cost (PhP)	Target	Budget	Target	Budget	Target	Budget	Target	Budget	Target	Budget
a. Malabayabas	sdlgs	2,723.00	30.00	81,690.00	0.50	40,845.00	0.50	40,845.00								
a.1 Thinning	tree	0.50	10,000.00	5,000.00	0.50	2,500.00					136.15	340,375.00			340.38	850,937.50
b. Banaba	sdlgs	2,723.00	40.00	108,920.00	0.50	54,460.00	0.50	54,460.00								
b.1 Thinning	tree	0.50	10,000.00	5,000.00	0.50	2,500.00					272.30	680,750.00			340.38	850,937.50
Site preparation																
a. Underbrushing	ha.	0.50	3,000.00	3,000.00	0.50	3,000.00	13.65	40,950.00								
b. Baseline establishment/staking	stake	631.00	8.00	10,096.00	0.50	10,096.00	13.65	137,810.40								
c. Hole digging	hills	631.00	3.00	3,786.00	0.50	3,786.00	13.65	51,678.90								
Seedlings transport	sdlgs.	631.00	5.00	6,310.00	0.50	6,310.00	13.65	86,131.50								
Planting	sdlgs.	631.00	5.00	6,310.00	0.50	6,310.00	13.65	86,131.50								
Maintenance and Protection	ha.	0.50	4,603.00	4,603.00	0.50	4,603.00	13.65	62,830.95	13.65	68,577.60	13.65	68,577.60	13.65	68,577.60	13.65	68,577.60
Physical Project Cost				**235,465.00**		**135,910.00**		**571,075.75**		**68,577.60**		**1,021,125.00**				**1,701,875.00**
Monitoring and Evaluation			0.10	23,546.50		13,591.00		57,107.58		62,223.84		62,223.84		62,223.84		62,223.84
Sub-Total Project Cost				**259,011.50**		**149,501.00**		**628,183.33**		**130,801.44**		**1,083,348.84**		**62,223.84**		**1,764,098.84**
Upland Bench (180m to 180m)																
Site identification/survey, mapping & planning	ha	0.50	1,500.00	750.00	0.50	1,500.00	1,958.09	1,468,567.50								
Production/Procurement of Planting Materials (w/ 10% mortality allowance)																
a. Mangoosteen	sdlgs	17,405.00	20.00	348,100.00	0.50	174,050.00	0.50	174,050.00								
b. Rambutan	sdlgs	17,405.00	10.00	174,050.00	0.50	87,025.00	0.50	87,025.00								
c. Gmelina	sdlgs	17,405.00	20.00	348,100.00	0.50	174,050.00	0.50	174,050.00								
c.1 Thinning	tree	0.50	10,000.00	5,000.00	0.50	2,500.00					870.25	2,175,625.00			2,175.63	5,439,062.50
d. Falcata	sdlgs	17,405.00	20.00	348,100.00	0.50	174,050.00	0.50	174,050.00								
d.1 Thinning	tree	0.50	10,000.00	5,000.00	0.50	2,500.00					870.25	2,175,625.00			2,175.63	5,439,062.50

Component/Activity	Unit	Target	Unit Cost (PhP)	Cost Per Unit (PhP)	Total		Implementation Schedule									
					Target	Cost (PhP)	Year 1		Year 2		Year 3		Year 4		Year 5	
							Target	Budget	Target	Budget	Target	Budget	Target	Budget	Target	Budget
Site preparation																
a. Underbrushing	ha.	0.50	3,000.00	3,000.00	0.50	3,000.00	1,958.09	5,874,270.00								
b. Baseline establishment/staking	stake	631.00	2.00	1,262.00	0.50	1,262.00	1,958.09	2,471,109.58								
c. Hole digging	hills	631.00	1.00	1,893.00	0.50	1,893.00	3,916.18	7,413,328.74								
Seedlings transport	sdlgs.	631.00	3.00	3,786.00	0.50	3,786.00	1,958.09	7,413,328.74								
Planting	sdlgs.	631.00	3.00	3,155.00	0.50	3,155.00	1,958.09	6,177,773.95								
Maintenance and Protection	ha.	0.50	4,603.00	2,512.00	0.50	2,512.00	1,958.09	4,918,722.08	1,958.09	4,918,722.08	1,958.09	9,837,444.16	1,958.09	9,837,444.16	1,958.09	9,837,444.16
Physical Project Cost				**1,244,708.00**		**631,283.00**		**36,346,275.59**		**9,837,444.16**		**14,188,694.16**		**9,837,444.16**		**20,715,569.16**
Monitoring and Evaluation			0.10	124,470.80		63,128.30		3,634,627.56		983,744.42		1,418,869.42		983,744.42		2,071,556.92
Sub-Total Project Cost				**1,369,178.80**		**694,411.30**		**39,980,903.15**		**10,821,188.58**		**15,607,563.58**		**10,821,188.58**		**22,787,126.08**

Integrated Soil and Water Conservation (Unlimited Production, Limited Production, and Agroforestry Production Zone)

Agroforestry Production Zone and Limited Production Zone

Table 7-7: Agroforestry Production Zone and Limited Production Zone Budgetary Requirements

Component/Activity	Unit	Target	Unit Cost (PhP)	Cost Per Unit (PhP)	Total		Implementation Schedule									
							Year 1		Year 2		Year 3		Year 4		Year 5	
					Target	Cost (PhP)	Target	Budget	Target	Budget	Target	Budget	Target	Budget	Target	Budget
3. Integrated Soil and Water Conservation (Agro and Limited)																
Site identification/survey, mapping & planning	ha	0.50	1,500.00	750.00	0.50	1,500.00					797.54	1,196,302.50				
Production/Procurement of Planting Materials (w/ 10% mortality allowance)																
a. Mangoosteen	sdlgs	31,153.71	20.00	623,074.20	0.50	311,537.10					0.50	155,768.55				
b. Rambutan	sdlgs	31,153.71	10.00	311,537.10	0.50	155,768.55					0.50	77,884.28				
c. Gmelina	sdlgs	31,153.71	20.00	623,074.20	0.50	311,537.10					0.50	155,768.55				
c.1 Thinning	tree	0.50	5,000.00	2,500.00	0.50	1,250.00					1,557.68	1,947,100.00			3,894.22	4,867,768.75
d. Falcata	sdlgs	31,153.71	20.00	623,074.20	0.50	311,537.10					0.50	155,768.55				
d.1 Thinning	tree	0.50	5,000.00	2,500.00	0.50	1,250.00					1,557.68	3,894,200.00			3,894.22	4,867,768.75
Site preparation																
a. Underbrushing	ha.	0.50	3,000.00	3,000.00	0.50	3,000.00					797.54	2,392,605.00				

Component/Activity	Unit	Target	Unit Cost (PhP)	Cost Per Unit (PhP)	Total		Implementation Schedule									
							Year 1		Year 2		Year 3		Year 4		Year 5	
					Target	Cost (PhP)	Target	Budget	Target	Budget	Target	Budget	Target	Budget	Target	Budget
b. Baseline establishment/staking	stake	631.00	2.00	1,262.00	0.50	1,262.00					797.54	1,006,489.17				
c. Hole digging	hills	631.00	1.00	1,893.00	0.50	1,893.00					797.54	1,509,733.76				
Seedlings transport	sdlgs.	631.00	3.00	3,786.00	0.50	3,786.00					797.54	3,019,467.51				
Planting	sdlgs.	631.00	3.00	3,155.00	0.50	3,155.00					797.54	2,516,222.93				
Maintenance and Protection	ha.	0.50	4,603.00	2,512.00	0.50	2,512.00					797.54	2,003,407.92	797.54	2,003,407.92	797.54	2,003,407.92
Physical Project Cost				**2,202,117.70**		**1,109,987.85**						**20,030,718.71**		**2,003,407.92**		**11,738,945.42**
Monitoring and Evaluation			0.10	220,211.77		110,998.79						2,003,071.87		200,340.79		1,173,894.54
Sub-Total Project Cost				**2,422,329.47**		**1,220,986.64**						**22,033,790.58**		**2,203,748.71**		**12,912,839.96**

Unlimited Production Zone (Falcata Plantation)

Component/Activity	Unit	Target	Unit Cost (PhP)	Cost Per Unit (PhP)	Total		Implementation Schedule									
							Year 1		Year 2		Year 3		Year 4		Year 5	
					Target	Cost (PhP)	Target	Budget	Target	Budget	Target	Budget	Target	Budget	Target	Budget
3. Integrated Soil and Water Conservation (Unlimited)																
3.1. Falcata Plantation Establishment (Spacing 5m x 5m)																
Site identification/survey, mapping & planning	ha	0.50	1,200.00	600.00	0.50	300.00									52.30	31,377.00
Production/Procurement of Planting Materials (w/ 10% mortality allowance)																
a. Falcata	sdlgs	20,918.00	20.00	418,360.00	0.50	209,180.00									52.30	21,878,136.20
a.1 Thinning	tree	0.50	5,000.00	2,500.00	0.50	1,250.00					1,045.90	1,307,375.00			2,614.75	3,268,437.50
Site preparation																
a. Underbrushing	ha	0.50	3,000.00	1,500.00	0.50	750.00									52.30	78,442.50
b. Baseline establishment/staking	stake	20,918.00	2.00	41,836.00	0.50	20,918.00									52.30	2,187,813.62
c. Hole digging			1.00													
Seedlings transport	sdlgs.	20,918.00	3.00	62,754.00	0.50	31,377.00									52.30	3,281,720.43
Planting	sdlgs.	20,918.00	3.00	62,754.00	0.50	31,377.00									52.30	3,281,720.43
1st Pass (3 months after planting)																
a. brushing	ha	0.50	2.00	1.00	0.50	0.50									52.30	52.30
b. ring weeding/cultivation	sdlg	20,918.00	3.00	62,754.00	0.50	31,377.00									52.30	3,281,720.43
c. fertilizer application	sacks	1.00	2,000.00	2,000.00	0.50	1,000.00									52.30	104,590.00
2nd Pass (4 months after 1st pass)																
a. brushing	ha	0.50	2.00	1.00	0.50	0.50									52.30	52.30
b. ring weeding/cultivation	sdlg	20,918.00	3.00	62,754.00	0.50	31,377.00									52.30	3,281,720.43

Component/Activity	Unit	Target	Unit Cost (PhP)	Cost Per Unit (PhP)	Total		Implementation Schedule									
							Year 1		Year 2		Year 3		Year 4		Year 5	
					Target	Cost (PhP)	Target	Budget	Target	Budget	Target	Budget	Target	Budget	Target	Budget
3rd Pass (4 months after 2nd pass)																
a. brushing	ha	0.50	2.00	1.00	0.50	0.50									52.30	52.30
b. ring weeding/cultivation	sdlg	20,918.00	3.00	62,754.00	0.50	31,377.00									52.30	3,281,720.43
Physical Project Cost				**780,569.00**		**390,284.50**						**1,307,375.00**				**22,048,042.66**
Monitoring and Evaluation			0.10	6,543,640.18		6,543,640.18										2,204,804.27
Sub-Total Project Cost				**7,324,209.18**		**6,933,924.68**										**24,252,846.92**

8. FINANCIAL COSTS AND BENEFITS

Financial evaluation is a crucial step in assessing public sector projects to ensure the availability of funds for their investment, construction, and operational phases. While positive economic returns are important for project success, they alone are insufficient. It has become evident that projects with high economic potential can still fail if there is inadequate funding to support their implementation and ongoing operations.

This chapter specifically examines the evaluation of financial viability, encompassing both commercial viability and economic feasibility, for various proposed initiatives such as forest nursery adoption, rehabilitation of riparian vegetation, implementation of soil and water conservation measures, development of agroforestry systems, and establishment of industrial tree plantations. The financial evaluation process involves assessing the viability of these projects by considering factors such as projected costs, potential revenues, cash flow analysis, profitability indicators, and funding sources. It aims to determine if the project can generate sufficient financial returns to cover its expenses and ensure long-term sustainability.

While positive economic returns are necessary, they are not the sole determinant of project success. The financial evaluation process plays a critical role in assessing the financial viability and commercial potential of public sector projects, including those related to forest nurseries, riparian vegetation rehabilitation, soil and water conservation, agroforestry development, and industrial tree plantations. By considering funding availability alongside economic returns, decision-makers can make informed choices and increase the likelihood of project success.

8.1 Methodology

Financial analysis employs discounted cash flow analysis (DCF) as a primary tool for evaluating projects from an investment perspective. The fundamental purpose of conducting a financial evaluation is to ensure that an investor can achieve an adequate rate of return that compensates for the risks associated with the project. Furthermore, the evaluation aims to determine whether the project can generate sufficient free cash flows (FCFs) to cover its capital repayment obligations.

The financial evaluation process involves developing financial projections and conducting sensitivity analyses, which are grounded in the investment and financing plan, project implementation data, and anticipated revenues, operating costs, and maintenance expenses.

To assess the financial viability of the projects, key metrics derived from the DCF model were utilized. These metrics provide insights into the project's ability to generate positive returns and meet the required financial objectives. They include metrics such as net present value (NPV), internal rate of return (IRR), payback period, and profitability index.

By employing these metrics and analyzing the projected cash flows, the financial evaluation offers a comprehensive assessment of the projects' potential for success and financial soundness. It enables decision-makers to determine whether the expected returns and cash flows align with the investment risks and provide an adequate basis for repayment of the project's capital.

- Financial Internal Rate of Return (FIRR)
- Project Net Present Value (NPV)
- Cost-Benefit Ratio

Of note, sensitivity analyses are expressed in current terms (i.e. with inflation escalation).

8.2 Financial Costs

8.2.1 Capital Costs

The estimated total capital cost is **PhP 652,910,605.29**which will be financed by the National Irrigation Administration. The funds will be used for the procurement of seedlings and other planting materials including labor. This incorporates cost of physical and price contingencies, as well as allowances for price increase due to inflation.

The estimated annual cash disbursement requirements of the Project consistent with the proposed implementation schedule and broken down by related expenditure components.

8.2.2 Operating and Maintenance Cost

The operating and maintenance cost is an annual expense which is primarily earmarked for ring weeding, re-planting, application of fertilizer, patrol work, and monitoring and evaluation. The O&M costs for the project amounts to **PhP 65,730,829.05.**

8.3 Project Revenue

The source of operating revenues will come from the sale of fruits/crops planted in the streambank, and agroforestry system. Using the assumptions enumerated below, the project will generate a total revenue of **PhP 2,100,883,190.00.**

8.3.1 Forest Nursery

In computing for the revenues from nursery production, the following assumptions were made:

- 2-meter x 2-meter spacing per seedling
- 1 hectare nursery can cater 2,500 seedlings
- The average cost of native tree species seedlings is 50 pesos

8.3.2 Bamboo

In computing for the revenues from bamboo production, the following assumptions were made:

- 5-meter x 10-meter spacing per plant
- 3 culms per cluster/year is produced
- The farmgate price per culm is 100 pesos
- Bamboo will be productive on its 5th year (Philippine Bamboo Industry Roadmap (2016)

8.3.3 Malabayabas

In computing for the revenues from Malabayabas production, the following assumptions were made:

- 5-meter x 5-meter arrangement
- 25,000 pesos/log/tree on its 25th to 30th year

8.3.4 Banaba

In computing for the revenues from Banaba production, the following assumptions were made:

- 5-meter x 5-meter spacing arrangement
- 300 pesos/kilo on its leaf part
- Productive on its 8th year

8.3.5 Mangosteen

- 8-meter x 8-meter spacing arrangement
- 200 pesos/kilo (fruit)
- Productive on its 8th year

8.3.6 Rambutan

- 8-meter x 8-meter spacing arrangement
- 200 pesos/kilo (fruit)
- Productive on its 8th year

8.3.7 Gmelina

- 4-meter x 4-meter spacing arrangement
- 12,000 pesos/log/tree
- Productive on its 10th year

8.3.8 Falcata

- 4-meter x 4-meter spacing arrangement (Upland Bench)
- 5-meter x 5-meter spacing arrangement (Industrial Tree Plantation)
- 8,000 pesos/log/tree
- Productive on its 10th year

Table 8-1: Annual Disbursement Schedule of Project Capital and O&M Cost (PhP)

Cost Item	TOTAL	NPV	Year 1	Year 2	Year 3	Year 4	Year 5
Capital Cost							
Forest Nursery	1,718,700.00	1,465,553.03	1,688,700.00	7,500.00	7,500.00	7,500.00	7,500.00
Riparian Vegetation Restoration							
Wetland Bench	122,724.96	96,797.17	90,973.28	7,937.92	7,937.92	7,937.92	7,937.92
Riparian Bench	6,136,816.00	4,015,779.51	622,238.40	68,577.60	5,446,000.00		13,615,000.00
Upland Bench	113,610,735.92	86,891,884.81	66,693,403.44	9,837,444.16	27,242,444.16	9,837,444.16	53,349,944.16
Integrated Soil and Water Conservation							
Agroforestry and Limited Production Zone	95,304,934.04	81,218,550.21			91,298,118.20	4,006,815.84	159,775,370.53
Unlimited Production Zone	209,276,379.69	156,382,845.54			20,918,000.00		188,358,379.69
Sub-total of Capital Cost	**652,910,605.29**	**₱357,620,973.93**	**69,095,315.12**	**9,921,459.68**	**144,920,000.28**	**13,859,697.92**	**415,114,132.29**
O&M Cost							
Forest Nursery	59,643.75	₱50,503.20	57,581.25	281.25	281.25	750.00	750.00
Riparian Vegetation Restoration	-	₱0.00					
Wetland Bench	45,486.64	₱29,347.99	9,097.33	9,097.33	9,097.33	9097.328	9,097.33
Riparian Bench	311,119.20	₱200,734.15	62,223.84	62223.84	62,223.84	62223.84	62,223.84
Upland Bench	46,919,381.86	₱29,349,447.70	8,553,349.64	5,902,466.50	10,821,188.58	10,821,188.58	10,821,188.58
Integrated Soil and Water Conservation							
Agroforestry and Limited Production Zone	5,407,818.99	₱4,587,326.20			5,007,137.41	400,681.58	400,681.58
Unlimited Production Zone	17,994,516.01	₱15,427,397.13					17,994,516.01
Sub-total of O&M Cost	**65,730,829.05**	**₱38,150,568.77**	**8,682,252.06**	**5,974,068.91**	**10,892,790.99**	**10,893,259.74**	**29,288,457.34**
Total Cost	**718,641,434.34**	**₱395,771,542.70**	**77,777,567.18**	**15,895,528.59**	**155,812,791.27**	**24,752,957.66**	**444,402,589.63**

Cost Item	TOTAL	NPV	Year 1	Year 2	Year 3	Year 4	Year 5
Capital Cost							
Forest Nursery	1,718,700.00	₱1,465,553.03	1,688,700.00	7,500.00	7,500.00	7,500.00	7,500.00

Cost Item	TOTAL	NPV	Year 1	Year 2	Year 3	Year 4	Year 5
Riparian Vegetation Restoration	-						
Wetland Bench	83,035.36	₱71,189.44	83,035.36				
Riparian Bench	553,660.80	₱474,674.90	553,660.80				
Upland Bench	56,855,959.28	₱48,744,821.06	56,855,959.28				
Integrated Soil and Water Conservation							
Agroforestry and Limited Production Zone	150,927,114.87	₱129,395,674.61			150,927,114.87		
Unlimited Production Zone	4,670,082,359.53	₱4,003,842,900.83					4,670,082,359.53
Sub-total of Capital Cost	**4,880,220,829.84**	**₱2,309,017,659.84**	**59,181,355.44**	**7,500.00**	**150,934,614.87**	**7,500.00**	**4,670,089,859.53**
			O&M Cost				
Forest Nursery	171,870.00	₱146,555.30	168,870.00	750.00	750.00	750.00	750.00
Riparian Vegetation Restoration	-	₱0.00					
Wetland Bench	85,176.24	₱54,955.72	17,035.25	17,035.25	17,035.25	17,035.25	17,035.25
Riparian Bench	654,007.20	₱421,965.53	130,801.44	130,801.44	130,801.44	130,801.44	130,801.44
Upland Bench	59,791,538.81	₱39,783,643.73	16,506,784.50	10,821,188.58	10,821,188.58	10,821,188.58	10,821,188.58
Integrated Soil and Water Conservation							
Agroforestry and Limited Production Zone	64,674,632.80	₱49,672,140.50			31,620,018.59	16,527,307.10	16,527,307.10
Unlimited Production Zone	7,721,476,040.11	₱6,619,921,159.21					7,721,476,040.11
Sub-total of O&M Cost	7,798,705,939.46	₱3,624,599,881.49	**16,823,491.19**	**10,969,775.26**	**10,969,775.26**	**10,969,775.26**	**7,748,973,122.47**
Total Cost	**12,678,926,769.30**	**₱5,933,617,541.33**	**76,004,846.63**	**10,977,275.26**	**161,904,390.13**	**10,977,275.26**	**12,419,062,982.01**

Table 8-2: Project Revenues

Trees/Crops/Facilities	TOTAL	NPV	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Forest Nursery	637,500.00	₱305,733.18	75,000.00	62,500.00	62,500.00	62,500.00	62,500.00	62,500.00	62,500.00	62,500.00	62,500.00	62,500.00
Bamboo	252,400.00	₱134,259.95			31,550.00	31,550.00	31,550.00	31,550.00	31,550.00	31,550.00	31,550.00	31,550.00
Malabayabas	-	₱0.00	-	-	-	-	-	-	-	-	-	
Banaba	3,267,600.00	₱1,912,262.44	-	-							1,633,800.00	1,633,800.00
Mangoosteen	72,837,750.00	₱53,961,563.02								24,279,250.00	24,279,250.00	24,279,250.00
Rambutan	31,077,440.00	₱12,150,869.22	-	-	3,884,680.00	3,884,680.00	3,884,680.00	3,884,680.00	3,884,680.00	3,884,680.00	3,884,680.00	3,884,680.00
Gmelina	1,195,686,300.00	₱878,865,125.08	-									1,195,686,300.00
Falcata	797,124,200.00	₱585,910,083.39	-									797,124,200.00
Total Revenue	**2,100,883,190.00**	**1,533,239,896.28**	**75,000.00**	**62,500.00**	**3,978,730.00**	**3,978,730.00**	**3,978,730.00**	**3,978,730.00**	**3,978,730.00**	**28,257,980.00**	**29,891,780.00**	**2,022,702,280.00**

8.3.9 Financial Viability Analysis

Financial analysis is a crucial aspect of project evaluation, aimed at assessing the project's financial viability and attractiveness to potential investors. It involves the utilization of financial indicators such as net present value (NPV), internal rate of return (IRR), and benefit-cost ratio (BCR) to determine the project's financial feasibility.

To evaluate a project's financial attractiveness, these indicators are employed to measure the profitability and potential return on investment. The projected costs and revenues are essential inputs for conducting a comprehensive financial analysis.

The cash flows attributed to equity owners represent the net financial cash flows generated by the project in relation to the total investment. Through financial analysis, it becomes possible to ascertain the minimum level of income required to incentivize funders to undertake the investment, essentially bringing the NPV from a negative value to zero.

8.3.10 Net Present Value

Net present value (NPV) is a financial metric used to assess the profitability of a project by comparing the present values of its anticipated benefits and costs. It represents the net monetary gain that can be achieved by undertaking the project after accounting for the discounted present worth of both the project's costs and benefits using an appropriate discount rate.

In essence, NPV quantifies the value added or subtracted by the project in today's terms, taking into account the time value of money. A positive NPV indicates that the project is expected to generate more value than the invested costs, while a negative NPV suggests that the project is likely to result in a net loss. Thus, NPV serves as a critical financial criterion for decision-making, helping to determine the economic attractiveness and feasibility of an investment opportunity. The general rule for the NPV criterion is:

- Accept a project with NPV greater than or equal to zero.
- Reject a project with NPV less than zero.

The computed NPV is **PhP ₱395,771,542.70**. Using NPV parameter, the project is financially viable.

8.3.11 Financial Internal Rate of Return

The financial internal rate of return (FIRR) of a project is the discount rate at which the net present value (NPV) of the project's costs and benefits becomes zero. It is the rate at which the present value of project costs matches the present value of project benefits.

In other words, the FIRR represents the discount rate at which the inflows and outflows of the project are balanced in present value terms. It is the rate at which the project's anticipated cash flows are discounted to their current value, such that the present value of costs is equal to the present value of benefits.

The FIRR is a crucial financial indicator used to assess the financial attractiveness and profitability of a project. If the FIRR exceeds the required rate of return or hurdle rate, it signifies that the project is expected to generate returns that exceed the cost of capital and is considered financially viable. Conversely, if the FIRR falls below the required rate of return, it suggests that the project may not generate sufficient returns to justify the investment. The general rule for the IRR criterion is:

- Accept a project if its FIRR is greater than or equal to the opportunity cost of capital.
- Reject a project if its FIRR is greater than or equal to the opportunity cost of capital.

The computation of the financial internal rate of return (FIRR) aims to determine the discount rate that equates the series of cash flows to zero. This equilibrium signifies that the FIRR is the discount rate that achieves balance between the present values of project revenues and costs. To deem a project acceptable, the FIRR should be equal to or higher than its weighted average cost of capital (WACC).

In the context of this analysis, the WACC is computed by considering the capital sources, specifically government equity. The cost of equity capital is determined by its opportunity cost, representing the foregone returns that could have been earned by investing the capital in another project or investment opportunity with similar risk. The estimated cost of equity is 6.07%, which serves as the WACC for this analysis.

The WACC acts as a hurdle rate against which the FIRR is compared to evaluate the project's investment viability. In the case of the project under consideration, the FIRR is computed as 16%. A higher FIRR than the WACC indicates that the project is financially viable, as it is anticipated to generate returns that surpass the cost of capital.

8.4 Benefit Cost Ratio

This is defined as the ratio of the discounted benefits to the discounted costs at the appropriately defined discount rate, which is the WACC. The general rule for the BCR criterion is:

- Accept a project with BCR greater than or equal to one.
- Reject a project with BCR less than one.

For this project, the computed BCR is **3.87** thus, the project is financially feasible.

Table 8-3: Financial Indicators

FINANCIAL VARIABLES	VALUES	REMARKS
Net Present Value	395,771,542.70	Should be greater than zero (0)
Financial IRR	20%	Should be greater than WACC
B/C ratio	3.87	Should be more than 1 to be financially viable

8.5 Sensitivity Analysis

A sensitivity analysis was performed to determine the effects of changes in some of the assumptions on the computation of the FIRR, NPV and BCR. The sensitivity analysis was done on all nominal prices (total investment and equity perspectives) under the following NEDA-prescribed scenarios:

- Case 1 - Decrease in benefits by 10% and 20%
- Case 2 - Increase in costs by 10% and 20%
- Case 3 - Combination of Cases 1 and 2

Using the worst-case scenario, i.e., actual costs exceeding budget by 20%, and actual revenues falling short of expected levels by 20%, FIRR fall to 8%, which is still more than the WACC. A summary of the results is shown in the table below:

Table 8.4. Results of Financial Sensitivity Analyses

Financial Variables			Project Cost				
			20% decrease	**10% decrease**	**Base Case**	**10% Increase**	**20% Increase**
Project Benefits	20% decrease	FIRR	15%	13%	11%	9%	8%
		B/C	3.17	2.82	2.53	2.30	2.11
		NPV	676,592,097.19	637,567,455.71	598,542,814.24	559,518,172.76	520,493,531.28
	10% decrease	FIRR	17%	15%	13%	11%	10%
		B/C	3.56	3.17	2.85	2.59	2.38
		NPV	800,190,750.82	761,166,109.34	722,141,467.86	683,116,826.39	644,092,184.91
	Base Case	FIRR	19%	17%	15%	13%	12%
		B/C	3.96	3.52	3.17	2.88	2.64
		NPV	923,789,404.44	884,764,762.97	845,740,121.49	806,715,480.01	767,690,838.53
	10% increase	FIRR	21%	19%	17%	15%	13%
		B/C	4.35	3.87	3.48	3.17	2.90
		NPV	1,047,388,058.07	1,008,363,416.59	969,338,775.11	930,314,133.64	891,289,492.16
	20% increase	FIRR	23%	21%	19%	17%	15%
		B/C	4.75	4.22	3.80	3.46	3.17
		NPV	1,170,986,711.69	1,131,962,070.22	1,092,937,428.74	1,053,912,787.26	1,014,888,145.79

9. ECONOMIC COSTS AND BENEFITS

The primary objective of conducting an economic analysis is to assess the macroeconomic implications of implementing and operating a project. This analysis involves evaluating the net economic benefits derived from the project in relation to the economic costs incurred during its implementation and operation.

The economic feasibility of a project serves as a basis for private sector participation in public sector projects. The economic evaluation aims to determine whether the expected economic benefits of the project surpass the anticipated economic costs, thereby yielding an economic internal rate of return (EIRR) of at least 10% in accordance with the NEDA-ICC requirements. This threshold ensures that the project is economically viable and contributes positively to the overall economy.

9.1 Methodology

The economic analysis undertaken for the proposed projects within the Cantilan Irrigation System involved conducting an incremental discounted cash-flow analysis. This analysis aimed to assess the economic viability of the projects. To facilitate the economic evaluation, all prices used in the analysis were expressed exclusive of customs duties and taxes.

The incremental discounted cash-flow analysis involved estimating and comparing the incremental cash flows associated with the implementation and operation of the projects. This analysis considered the time value of money by discounting the future cash flows to their present value. The net present value (NPV) of the projects was calculated by subtracting the present value of project costs from the present value of project benefits. The following economic indicators were calculated to determine the viability of the proposed project.

- Economic Internal Rates of Return (EIRR)
- Economic Net Present Value (ENPV)
- Benefit-Cost Ratio (BCR)

The Economic Internal Rate of Return (EIRR) represents the discount rate at which the Net Present Value (NPV) of the project becomes zero. It is a critical metric in assessing the economic feasibility of the project, and it must meet or surpass the economic threshold set by the National Economic and Development Authority (NEDA), typically at a minimum of 10%.

The Economic NPV captures the present value of the net benefits, which signifies the difference between the project's benefits and costs, expressed as a unified value in the same unit of measurement employed in accounting tables. The Benefit-Cost Ratio (BCR) measures the relationship between the project's costs and benefits.

The analysis primarily focused on examining the incremental impact of the project by comparing two scenarios: the "With the Project" scenario and the "Without the Project" scenario. This approach enables a comprehensive evaluation of the project's incremental effects by considering the disparities in outcomes between these scenarios. By quantifying the incremental benefits and costs, the analysis offers valuable insights into the project's economic viability and its potential contribution to overall economic development. The analysis was conducted based on the flowchart shown in **Figure 9.1**.

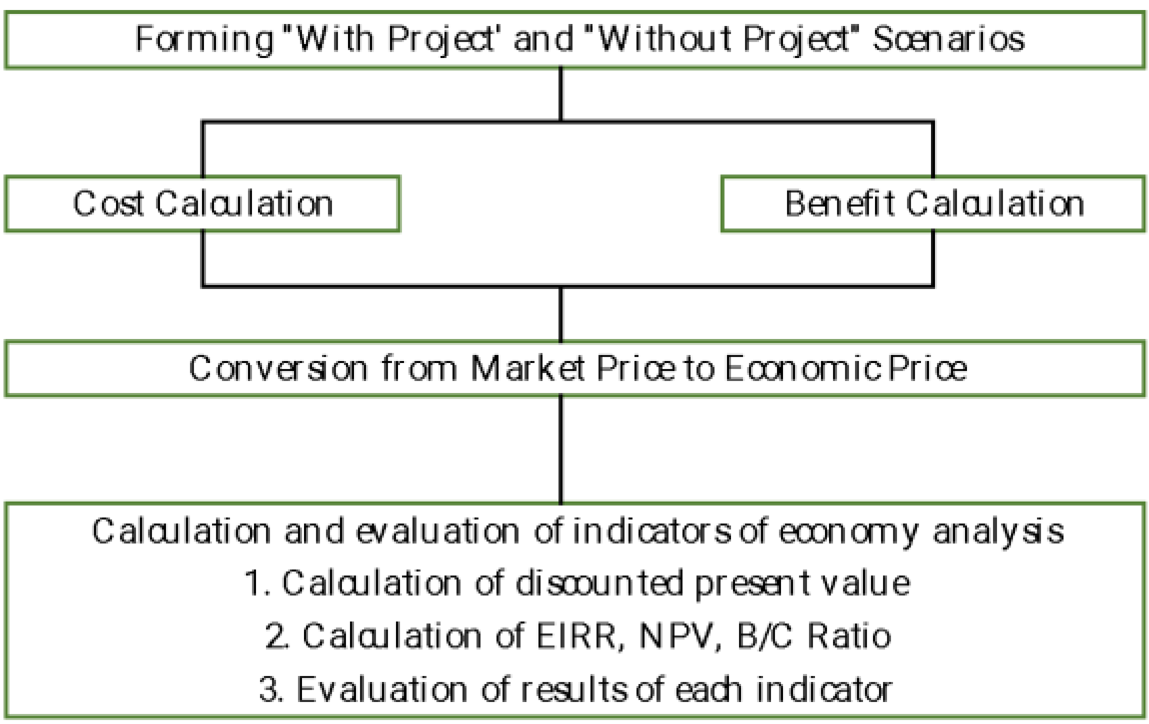


Figure 9-1: Process of Economic Analysis

A sensitivity analysis was also carried out to assess the responsiveness of the viability indicators to changes in critical variables such as Economic Costs and Benefits.

9.2 Social Discount Rate

The Social Discount Rate (SDR) represents the minimum rate that the Economic Internal Rate of Return (EIRR) of a proposed project must equal or surpass in order for it to be considered economically viable. This rate serves as a hurdle that determines the acceptability of the project from a social perspective. In accordance with the guidelines and procedures outlined by the National Economic and Development Authority (NEDA), specifically through a memorandum dated September 30, 2016 titled "Revisions on Investment Coordination Committee Guidelines and Procedures (updated SDR for the Philippines)", the prescribed SDR for this study is set at ten percent (10%).

The utilization of the SDR is essential in evaluating the economic feasibility of the project, as it ensures that the project's expected benefits are appropriately compared to the associated costs, accounting for the societal perspective. By employing the SDR as a benchmark, decision-makers can assess whether the project offers sufficient economic returns to justify the allocation of resources and contribute to the overall welfare and development of the society.

9.3 Economic Cost

The economic cost calculation involves the exclusion of capital costs and transfer payments, such as the Value Added Tax (VAT), from the analysis. Additionally, shadow pricing is applied to determine the value of commodities (goods or services) from the perspective of the overall economy. These shadow prices are utilized to capture the true economic value of the commodities being evaluated.

The shadow pricing assumptions used in this analysis adhere to the guidelines outlined in the ICC Project Evaluation Procedures and Guidelines developed by the National Economic and Development Authority (NEDA) (**Table 9.1**).

These guidelines provide a framework for determining appropriate shadow prices that reflect the economic significance and impact of the commodities under consideration.

Table 9-1: Shadow Pricing Assumptions

PARAMETERS	VALUES
Shadow Exchange Rate	1.2
Shadow Wage Rate	0.6
Import Duties	3%
Personal Income Tax	10%

**Based on ICC Project Evaluation Procedures and Guidelines prepared by NEDA, and assessment of the Study Team for this Project.*

The shadow wage rate of 0.60 for unskilled labor and personal income tax of 10% were applied for this analysis.

Following the application of the necessary shadow pricing for both Capital and O&M Costs, the Total Economic Cost of the project was calculated to be PhP **737,033,636.52 (₱509,186,756.49**in NPV**)**

9.4 Economic Benefits

Economic benefits accruing from the increase in income from fruit tree growing as part of the Agroforestry Livelihood.

Table 9-2: Project Economic Cost without VAT

Cost Item	TOTAL	NPV	Year 1	Year 2	Year 3	Year 4	Year 5
Capital Cost							
Forest Nursery	1,718,700.00	₱1,465,553.03	1,688,700.00	7,500.00	7,500.00	7,500.00	7,500.00
Riparian Vegetation Restoration							
Wetland Bench	122,724.96	₱96,797.17	90,973.28	7,937.92	7,937.92	7,937.92	7,937.92
Riparian Bench	6,136,816.00	₱4,015,779.51	622,238.40	68,577.60	5,446,000.00		13,615,000.00
Upland Bench	113,610,735.92	₱86,891,884.81	66,693,403.44	9,837,444.16	27,242,444.16	9,837,444.16	53,349,944.16
Integrated Soil and Water Conservation							
Agroforestry and Limited Production Zone	95,304,934.04	₱81,218,550.21			91,298,118.20	4,006,815.84	159,775,370.53
Unlimited Production Zone	209,276,379.69	₱156,382,845.54			20,918,000.00		188,358,379.69
Sub-total of Capital Cost	**652,910,605.29**	**₱447,113,593.86**	**69,095,315.12**	**9,921,459.68**	**144,920,000.28**	**13,859,697.92**	**415,114,132.29**
O&M Cost							
Forest Nursery	171,870.00	₱146,555.30	168,870.00	750.00	750.00	750.00	750.00
Riparian Vegetation Restoration	-	₱0.00					
Wetland Bench	45,486.64	₱29,347.99	9,097.33	9,097.33	9,097.33	9,097.33	9,097.33
Riparian Bench	311,119.20	₱200,734.15	62,223.84	62,223.84	62,223.84	62,223.84	62,223.84
Upland Bench	59,791,538.81	₱39,783,643.73	16,506,784.50	10,821,188.58	10,821,188.58	10,821,188.58	10,821,188.58
Integrated Soil and Water Conservation							
Agroforestry and Limited Production Zone	5,407,818.99	₱4,587,326.20			5,007,137.41	400,681.58	400,681.58
Unlimited Production Zone	17,994,516.01	₱15,427,397.13					17,994,516.01
Sub-total of O&M Cost	**84,123,031.23**	**₱60,175,004.50**	**16,746,975.67**	**10,893,259.74**	**15,900,397.15**	**11,293,941.33**	**29,288,457.34**
Total Economic Cost	**737,033,636.52**	**₱509,186,756.49**	**85,842,290.79**	**20,814,719.42**	**160,820,397.43**	**25,153,639.25**	**444,402,589.63**

Table 9-3: Project Economic Benefits without VAT

Trees/Crops/Facilities	TOTAL	NPV	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Forest Nursery	1,250,000.00	₱768,070.89	125,000.00	125,000.00	125,000.00	125,000.00	125,000.00	125,000.00	125,000.00	125,000.00	125,000.00	125,000.00
Bamboo	504,800.00	₱336,633.84			63,100.00	63,100.00	63,100.00	63,100.00	63,100.00	63,100.00	63,100.00	63,100.00
Malabayabas	-	₱0.00	-	-	-	-	-	-	-	-	-	
Banaba	3,267,600.00	₱2,343,405.51	-	-							1,633,800.00	1,633,800.00
Mangoosteen	58,270,200.00	₱48,303,120.96								19,423,400.00	19,423,400.00	19,423,400.00
Rambutan	46,616,160.00	₱25,691,505.50	-	-	5,827,020.00	5,827,020.00	5,827,020.00	5,827,020.00	5,827,020.00	5,827,020.00	5,827,020.00	5,827,020.00
Gmelina	956,549,040.00	₱790,536,396.69	-									956,549,040.00
Falcata	637,699,360.00	₱527,024,264.46	-									637,699,360.00
Total Revenue	**1,704,157,160.00**	**₱ 667,499,488.45**	**125,000.00**	**125,000.00**	**6,015,120.00**	**6,015,120.00**	**6,015,120.00**	**6,015,120.00**	**6,015,120.00**	**25,438,520.00**	**27,072,320.00**	**1,621,320,720.00**

9.5 Economic Viability

The projects were evaluated, and the results of the evaluation suggest that the whole project is practically economically feasible with an EIRR of **15%**, which exceeds the 10.00% hurdle rate. The project will have a net present value of **PhP 158,312,731.96** and a BCR of **1.31.**

Economic Indicators

ECONOMIC VARIABLES	VALUES	REMARKS
Net Present Value	158,312,731.96	Should be greater than zero (0)
Economic IRR	15%	Should be greater than the SDR
BCR	1.31	Should be more than 1 to be financially viable

9.6 Sensitivity Analysis

A combination of 20% increase in costs and 20% decrease in project benefits will result in 8%EIRR, NPV of PhP -77,024,517.03, and BCR of 10.58, all of which suggest that the project is not economically feasible.

Table 9.5. Results of Economic Sensitivity Analyses

Financial Variables			Project Cost				
			20% decrease	**10% decrease**	**Base Case**	**10% Increase**	**20% Increase**
Project Benefits	20% decrease	EIRR	15%	13%	11%	9%	8%
		B/C	1.31	1.17	1.05	0.95	0.87
		NPV	126,650,185.57	75,731,509.92	24,812,834.27	(26,105,841.38)	(77,024,517.03)
	10% decrease	EIRR	17%	15%	13%	11%	10%
		B/C	1.47	1.31	1.18	1.07	0.98
		NPV	193,400,134.41	142,481,458.76	91,562,783.12	40,644,107.47	(10,274,568.18)
	Base Case	EIRR	19%	17%	15%	13%	12%
		B/C	1.64	1.46	1.31	1.19	1.09
		NPV	260,150,083.26	209,231,407.61	158,312,731.96	107,394,056.31	56,475,380.66
	10% increase	EIRR	21%	19%	17%	15%	13%
		B/C	1.80	1.60	1.44	1.31	1.20
		NPV	326,900,032.10	275,981,356.46	225,062,680.81	174,144,005.16	123,225,329.51
		EIRR	23%	21%	19%	17%	15%

Financial Variables			**Project Cost**				
			20% decrease	**10% decrease**	**Base Case**	**10% Increase**	**20% Increase**
	20% increase	B/C	1.97	1.75	1.57	1.43	1.31
		NPV	393,649,980.95	342,731,305.30	291,812,629.65	240,893,954.00	189,975,278.35

9.7 Recommendation

The outcomes, as determined in the economic feasibility study of the proposed projects, shows a positive NPV of **PhP 209,231,407.61**, a greater than 1 BCR which is 1.46, and an EIRR of 15% which is way higher than the SDR of 10%.

Therefore, it can be concluded that the implementation of the projects is economically viable. Hence, the projects are worth undertaking.

10. INSTITUTIONAL MANAGEMENT STRUCTURE

The workshop held on December 13, 2022, to develop an institutional framework for CANTIS management received positive feedback, particularly due to the co-management principle. According to Section 3 (i) of the Local Government Code, local government units are required to share the responsibility of maintaining ecological balance within their territorial jurisdiction with the national government. Hence, both local and national governments are mandated by RA 7160 to act as co-managers of the national territory and patrimony.

The plan's implementation will be overseen by the local government unit level. The management of the river irrigation system will be handled at the municipality level. To ensure effective implementation and avoid complex institutional arrangements, simplification is the key strategy. In the event of its exigency, NIA may establish a committee comprising diverse agencies at a later point during the execution of the management strategy. This initiative aims to cultivate a more comprehensive methodology in the enactment of the watershed management plan.

Local Government RIS Unit

Office of the Mayor:

➢ Mayor: Provides overall leadership, policy direction, and decision-making for the LGU.

Department of Agriculture and Environmental Management:

- o Department Head: Oversees the implementation of agricultural and environmental programs.
- ● Farmers' Capacitation Unit:
- ✓ Agroforestry Specialist: Conducts training and capacity-building activities for farmers in agroforestry practices, sloping agricultural land technology, and land management.
- ● Tree Nursery and Farm Development Unit:
- ✓ Nursery Development Officer: Establishes and manages tree nurseries at the barangay level to produce seedlings for planting at the irrigation system and agroforestry farms.
- ● Regular Tree Planting Unit:
- ✓ Tree Planting Coordinator: Organizes and coordinates regular tree planting activities within the drainage area of the irrigation system.
- ● Farmer Assistance Program Unit:

- ✓ Agricultural Development Officer: Administers financial assistance programs to support agricultural production and provide assistance to farmers utilizing the irrigation system.

Department of Public Works and Infrastructure:

- o Department Head: Manages the development and maintenance of infrastructure projects.
- ● Irrigation System Construction Unit: Irrigation maintenance and development
- ✓ Engineer: Designs, constructs, and maintains the irrigation system, including canals, pumps, and water distribution infrastructure.
- ● Drainage and Sewerage System Unit:
- ✓ Engineer: Constructs and maintains drainage and sewerage systems associated with the irrigation system, ensuring proper water management and waste disposal.

Department of Social Welfare and Development:

- o Department Head: Oversees social welfare and community development programs.
- ● Informal Settler Relocation Unit:
- ✓ Relocation Coordinator: Plans and manages the relocation of informal settlers affected by the development of the irrigation system, ensuring their proper resettlement and integration into new communities.

Department of Environment and Natural Resources:

- o Department Head: Manages environmental protection and conservation efforts.
- ● Mining and Quarrying Monitoring Unit:
- ✓ Environmental Officer: Monitors and regulates mining and quarrying activities in the vicinity of the irrigation system to ensure compliance with environmental regulations.

Department of Solid Waste Management:

- o Department Head: Implements solid waste management programs and initiatives.
- ● Solid Waste Management Unit:
- ✓ Waste Management Officer: Ensures the proper implementation of the LGU's solid waste management plan in relation to the irrigation system, including waste collection, recycling initiatives, and public awareness campaigns.

Each unit within the departments may have staff members, technicians, and support personnel as required to carry out their specific tasks and responsibilities. This institutional management structure ensures effective coordination and implementation of the various activities outlined in the text, specifically focusing on the development, management, and sustainability of the irrigation system while addressing the needs of farmers, environmental protection, community development, and infrastructure improvements within the LGU.

11. MONITORING AND EVALUATION

Results-Based Management (RBM) is a managerial strategy advocated by UN-Habitat, aiming to enhance performance and achieve quantifiable outcomes in development initiatives. This approach emphasizes a continuous cycle of feedback, learning, and improvement to adapt and refine existing plans based on the lessons learned through monitoring and evaluation processes. By utilizing the knowledge acquired from past and ongoing activities, RBM allows for programmatic adjustments, reorientation, and informed future planning.

The significance of rigorous monitoring and evaluation within an RBM framework lies in its capacity to extract relevant information from both historical and ongoing endeavors. This information serves as a valuable basis for programmatic fine-tuning and decision-making, facilitating the achievement of desired development results. Monitoring and evaluation activities establish clear linkages between past, present, and future initiatives, enhancing the engagement of local stakeholders in the process. By effectively implementing monitoring and evaluation mechanisms, organizations can assess the direction and progress of their work, validate claims of success, and identify areas for improvement. This systematic approach fosters a culture of learning and accountability, providing insights for evidence-based decision-making and ultimately enhancing the effectiveness and impact of development efforts.

11.1 Monitoring

Monitoring serves as a fundamental process through which stakeholders regularly gather feedback on the progress made towards the attainment of their goals and objectives. It entails a comprehensive review of the advancement made in relation to the desired outcomes. Conversely, evaluation entails a rigorous and independent assessment of completed or ongoing activities to ascertain the degree to which they have achieved their stated objectives and contributed to decision-making processes. The combined implementation of monitoring and evaluation is instrumental in enhancing project success, as highlighted by Mahaney and Lederer (2003, 2010, 2011).

In the context of implementing a management plan, one valuable monitoring tool that can be utilized is the integration of remote sensing techniques and geographic information systems (GIS).

Remote sensing employs advanced technologies, such as satellite imagery and aerial photography, which are then combined with the analytical capabilities of GIS. This integrated approach facilitates the monitoring and analysis of various aspects within a watershed, including land cover changes, vegetation health, and erosion patterns. By utilizing remote sensing and GIS, comprehensive information can be obtained regarding the dynamics of the ecosystem as a whole, enabling the identification and assessment of any significant changes that may have occurred over time.

The application of remote sensing and GIS in monitoring contributes to an enhanced understanding of the intricate relationships and interdependencies within a given environment. It enables the identification of key indicators and the tracking of trends and patterns, facilitating evidence-based decision-making and the identification of necessary interventions. The timely and accurate information derived from remote sensing and GIS further supports adaptive management approaches by providing critical data to inform adjustments and refinements to the management plan. Ultimately, the integration of these monitoring tools contributes to the overall effectiveness and success of the project implementation process.

Table 11-1 Summary of Monitoring And Evaluation-Roles And Responsible Units

Management Roles and Responsibilities	Project implementation organizations
Establish Monitoring Objectives: Define the specific objectives and goals of the monitoring process. ➢ This includes identifying the key parameters to be monitored, such as land cover changes, vegetation health, and erosion patterns within the watershed.	Executing Agency CO
Select Remote Sensing Data: Choose appropriate remote sensing data sources, such as satellite imagery or aerial photography, that provide the necessary spatial and temporal resolution to capture the desired information. ➢ Consider factors such as data availability, frequency of updates, and suitability for the specific monitoring objectives.	IMO

Management Roles and Responsibilities	Project implementation organizations
Acquire and Process Data: Obtain the selected remote sensing data and process it using appropriate techniques. ➢ This may involve image preprocessing, such as atmospheric correction, geometric correction, and data fusion, to ensure accurate and consistent results.	IMO
Perform Image Analysis: Utilize GIS tools and techniques to analyze the processed remote sensing data. This involves extracting relevant information related to land cover changes, vegetation health, and erosion patterns. ➢ Apply classification algorithms, change detection methods, and spatial analysis tools to derive meaningful insights.	IMO
Interpret and Evaluate Results: Interpret the analyzed data and evaluate the results against predefined indicators and thresholds. ➢ Assess the extent to which the observed changes align with the management plan's goals and objectives. Identify any significant trends, anomalies, or potential issues that require further attention.	IMO
Communicate and Report Findings: Prepare clear and concise reports summarizing the monitoring findings. ➢ Communicate the results to relevant stakeholders, including decision-	RO, IMO

Management Roles and Responsibilities	Project implementation organizations
makers, project managers, and local communities. ➢ Present the information in a manner that facilitates understanding and informs subsequent decision-making processes.	
Feedback and Adaptation: Use the monitoring results as feedback to inform adaptive management approaches. ➢ Identify areas where adjustments, interventions, or refinements to the management plan are required based on the observed changes and trends. ➢ Continuously incorporate the lessons learned from monitoring into future planning and decision-making processes.	CO, RO, IMO
Regular and Ongoing Monitoring: Implement regular and ongoing monitoring to capture changes over time and ensure the sustained effectiveness of the management plan. ➢ Update the remote sensing data and repeat the monitoring process periodically	Either IMO or within the executing agency
** adjustment of frequency will be based on the specific needs and dynamics of the project.	

11.2 Evaluation

Evaluations and monitoring are applicable to various aspects, including activities, projects, programs, policies, and organizations. While monitoring involves ongoing tracking of progress towards predetermined goals, evaluations provide an independent and comprehensive assessment of whether activities are on track and meet their intended objectives. Evaluations employ more rigorous procedures and analysis, offering an objective and in-depth examination of performance.

Project evaluations, in particular, offer valuable opportunities for learning and improvement for all stakeholders involved in the project (Volden and Welde, 2022). The primary purpose of both monitoring and evaluation is to generate information that can enhance performance and achieve planned results.

In order to assess the effectiveness of a project in terms of its financial aspects and corresponding efficiency, a cost-benefit analysis can be employed. This analytical approach evaluates the economic feasibility and efficiency of a watershed project by considering the monetary costs and benefits associated with its implementation and maintenance. Additionally, it takes into account other factors such as improved water availability, reduced flood risk, enhanced ecosystem services, and potential economic gains.

Cost-benefit analysis provides a structured framework for decision-making by comparing the monetary value of project benefits against its costs. By systematically weighing the positive and negative financial impacts, the analysis helps determine the economic viability and efficiency of the project. It allows decision-makers to assess whether the benefits derived from the project outweigh the associated costs and whether the project aligns with economic objectives and priorities.

Moreover, the cost-benefit analysis provides a comprehensive understanding of the project's potential broader impacts, beyond financial considerations. By incorporating factors such as improved water availability and enhanced ecosystem services, the analysis captures the full range of benefits that extend beyond monetary values. This holistic perspective allows decision-makers to evaluate the project's overall value and contribute to informed decision-making.

Overall, the utilization of cost-benefit analysis within project evaluations enables a thorough assessment of financial feasibility, efficiency, and the broader impacts of watershed projects. This analytical approach enhances the understanding of project outcomes and supports evidence-based decision-making, facilitating effective resource allocation and maximizing the benefits derived from the project.

- Define Evaluation Objectives: Clearly define the objectives of the evaluation process. Determine the specific aspects to be assessed, such as the financial feasibility and efficiency of the watershed project, as well as the broader impacts it aims to achieve.
- Identify Evaluation Criteria: Identify the criteria that will be used to assess the project's financial side and corresponding efficiency. This may include factors such as costs, benefits, economic gains, improved water availability, reduced flood risk, and enhanced ecosystem services. Establish clear indicators and metrics to measure the project's performance against these criteria.
- Gather Data: Collect relevant data related to the project's costs and benefits. This may involve obtaining financial records, budget information, and data on the project's outcomes and impacts. Ensure the data collected is reliable, accurate, and representative of the project's financial and economic aspects.
- Conduct Cost-Benefit Analysis: Perform a comprehensive cost-benefit analysis to assess the project's financial feasibility and efficiency. Calculate the monetary costs associated with implementing and maintaining the watershed project, including construction, operation, and maintenance expenses. Evaluate the monetary benefits derived from the project, such as economic gains, improved water availability, reduced flood risk, and enhanced ecosystem services. Consider both tangible and intangible benefits, assigning appropriate monetary values or using other valuation techniques.
- Quantify and Compare Costs and Benefits: Quantify the costs and benefits identified in the cost-benefit analysis. Calculate the net present value (NPV) by subtracting the total costs from the total benefits over the project's lifetime. Determine the benefit-cost ratio (BCR) by dividing the total benefits by the total costs. Assess the sensitivity of the results to changes in assumptions or factors that may influence the project's financial feasibility and efficiency.
- Interpret and Analyze Results: Interpret the results of the cost-benefit analysis to assess the project's financial viability and efficiency. Analyze the NPV and BCR to determine whether the benefits outweigh the costs and whether the project aligns with economic objectives and priorities. Consider the broader impacts and non-monetary factors in the analysis, such as improved water availability and enhanced ecosystem services, to gain a comprehensive understanding of the project's value.
- Communicate and Report Findings: Prepare a clear and concise evaluation report summarizing the findings of the cost-benefit analysis. Present the results to relevant stakeholders, including decision-makers, project managers, and stakeholders affected by the project. Communicate the evaluation findings in a manner that facilitates understanding and informed decision-making.
-

- Apply Lessons Learned: Utilize the evaluation findings to derive lessons learned and recommendations for future projects and decision-making processes. Identify areas for improvement and adjustments based on the evaluation results, such as optimizing cost allocation, enhancing benefit realization, or refining project implementation strategies.

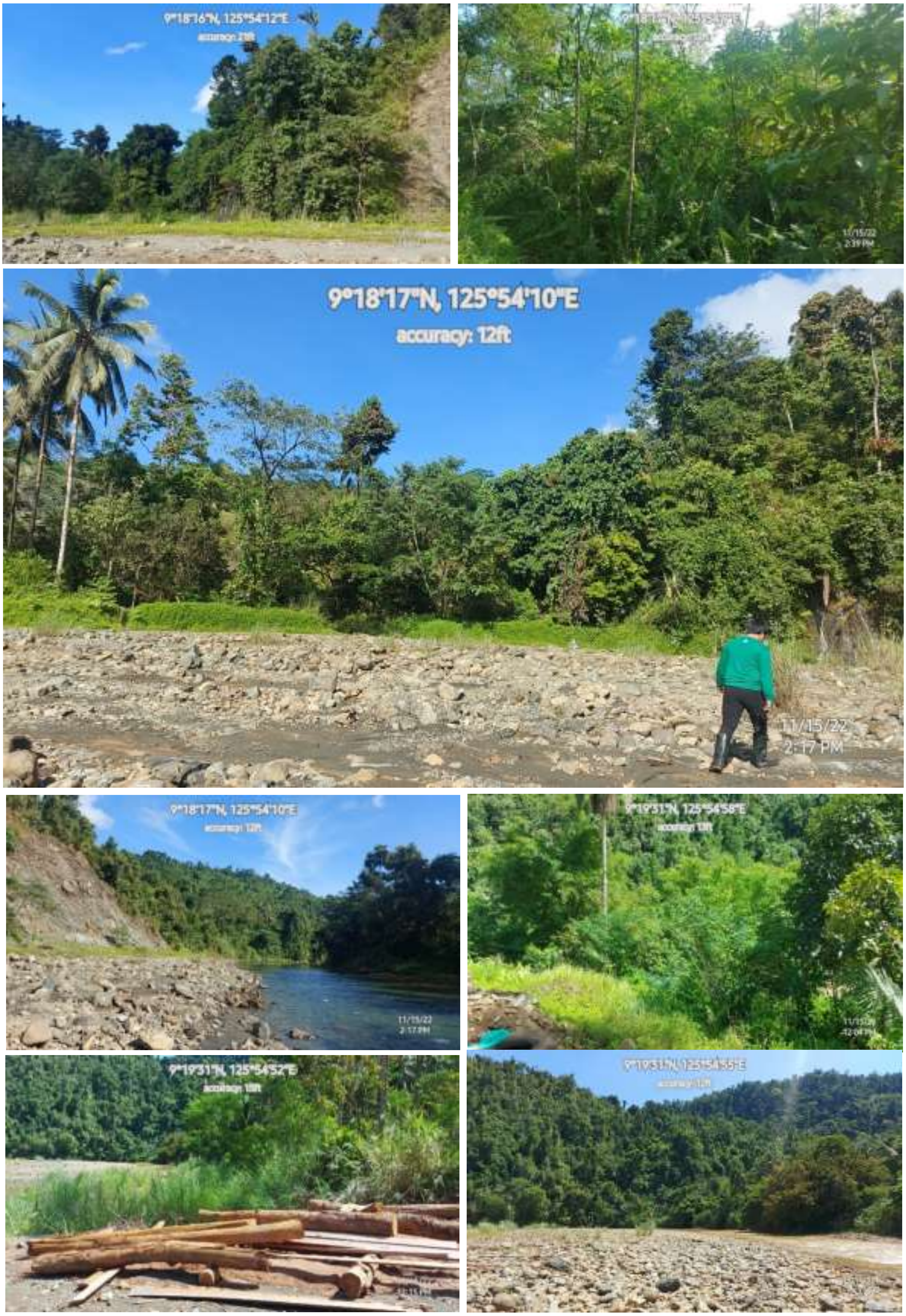
ANNEXES

Annex I - Field Photo Documentation

Annex Figure 1. Dam Site Visitation

Annex Figure 2. NIA Office Visitation

Annex Figure 3. Mining Site Visitation



Annex Figure 4. Floral Assessment

Annex Figure 5. Site Visitation and Floral Assessment

Annex Figure 6. Survey of Fauna

Annex Figure 7. Socio-economic Profiling Survey

Annex II - Notice to Proceed

REPUBLIC OF THE PHILIPPINES
NATIONAL IRRIGATION ADMINISTRATION
Caraga Regional Office
Barangay Bancasi, Butuan City

NOTICE TO PROCEED

October 19, 2022

ENGR. JOHN GILBERT GOPEZ, ENP.
President
SAGE ENVIRONMENTAL CONSULTANCY, INC.
Quezon City

Dear Sir;

The attached Contract Agreement having been approved, notice is hereby given to **SAGE ENVIRONMENTAL CONSULTANCY, INC.** that work may commence on the the **Preparatory Activity for Plan Formulation, Detailed Characterization/ Appraisal, Management Plan Formulation and Drafting/Finalization of Plan** under Contract No. **WATERSHED-2022-CANTILAN IS-01-SDS-RO-R** effective upon receipt of this notice.

Upon receipt of this notice, you are responsible for performing the services under the terms and conditions of the Agreement and in accordance with the Implementation Schedule.

Please acknowledge receipt and acceptance of this notice by signing both copies in the space provided below. Keep one copy and return the other to the National Irrigation Administration CARAGA Region.

Very truly yours,

JUNE NATHANIEL S. PLAZA
Regional Manager A

RBC - ____

I acknowledge receipt of this Notice on ______________________

Name of the Representative of the Bidder ______________________

Authorized Signature ______________________

Annex III - Terms of Reference

TERMS OF REFERENCE (TOR)

FOR

MANAGEMENT PLAN FOR IRRIGATION WATER RESOURCES
(MPIWR)

OF

CANTILAN IRRIGATION SYSTEM WATERSHED

REGION XIII

IN THE PREPARATION OF REHABILITATION AND PROTECTION OF WATER RESOURCES SUPPORTING IRRIGATION SYSTEMS (R&P WRSIS)

MANAGEMENT PLAN FOR IRRIGATION WATER RESOURCES (MPIWR)

TERMS OF REFERENCE

I. NIS Profile

Project Proponent and Region: **Surigao del Sur Irrigation Management Office**
Name of NIS : **Cantilan Irrigation System**
Type of structure (Intake, Diversion, Pump, Reservoir type): **Ogee**
Geographic coordinates (WGS 84): 9°28'52"N,125°93'75"E
Administrative location of Irrigation Water Source (municipality/ies and province and Region) : **Madrid, Surigao del Sur, Caraga Region 13**
Reservoir area (if applicable): N/A
Irrigation water source : Carac-an River
Service Area (Ha) : **2,209 has.**
Contract Duration : **180 calendar days**
(Other significant details)

I. RATIONALE

The need for rehabilitation and protection of Irrigation Water Resources (IWR) is becoming more critical, based on National Irrigation Master Plan (NIMP) 2020-2030, on **Protection and Proper Management of Irrigation water sources,** it states that "... *climate change has been impacting water resources watersheds and river basins that provide water to irrigation systems. These catchments and river basins have already undergone long periods of development, land use change, and degradation or depletion of environmental resources. Many watersheds are already at their critical state and their dependable water supply often proves to be inadequate to meet the irrigation water demand especially during dry season. The NIA must therefore be active in interagency collaboration to protect, develop and manage forests and other natural resources.*".

Henceforward, the DENR-NIA Memorandum of Agreement (MOA) was crafted and approved last August 2019 to support the development, protection, and management of critical irrigation water sources.

In line with this, NIA aims to assist in the formulation of management plans for the protection and rehabilitation of Irrigation Water Sources (IWS) in collaboration with DENR. This plan envisages assessing the irrigation river sources "health" in terms of land cover, land use, cropping patterns, soil erosion, conservation practices, and related concerns to come up with appropriate practices and corresponding strategies, work targets, and cost.

This Terms of Reference (TOR) has been prepared for the purpose of selecting a consulting firm to formulate and develop a Plan for the Rehabilitation, Protection, and Management of water resources supporting irrigation systems.

MANAGEMENT PLAN FOR IRRIGATION WATER RESOURCES (MPIWR)

TERMS OF REFERENCE

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This Terms of Reference (TOR) has been prepared for the purpose of selecting a consulting firm to formulate and develop a Plan for the Rehabilitation, Protection, and Management of water resources supporting irrigation systems.

6. Conduct assessment of the study area which includes ecological profiling of irrigation water sources, Socio-economic Survey (SES), Key Informant Interview (KII), Focus Group Discussion (FGD), Gender and Development (GAD), mapping of the study area.
7. Estimate soil erosions rate using acceptable methods as a reference in the development of management plan and future evaluation.
8. Identify proposed monitoring plots for flora, fauna, soil erosion, and water quality.
9. Conduct vulnerability assessment of the study area which includes but is not limited to anthropogenic activities, flooding, erosion, water pollution, and ecological degradation.
10. Prepare 5-year detailed management plans and programs.
11. Conduct Training/workshop prior to turn over of the approved plan
12. Present the formulated management plan to NIA management review and approval.

V. REQUIRED EXPERTS AND QUALIFICATIONS

In order to efficiently carry out the study, a multi-disciplinary team has to be organized to formulate the plan. The required qualifications, major duties, and responsibilities of the key experts are presented as follows:

1) Water Resources Management Specialist /Team Leader

He/she must at least have Environmental Science/ Management, Environmental Planning or other related degrees. Must have at least ten (10) years of professional experience and at least five (5) project work experiences relative to the development of water resources management planning to meet the objective of this program. He/she must be responsible in the following undertakings in the attainment of the following target output;

a. Provide overall direction in all aspects of the consultancy services including technical support and guidance to the team;
b. Work closely with the project proponent and other concern agencies/offices (DENR, NCIP, LGU, NGOs, etc.) for the acquisition of relevant information and necessary permit/s and clearance/s;
c. Conduct irrigation water resources assessment/baselining including but not limited to the physical, biological, socio-economic, land classification, land cover, and other significant information;
d. Conduct vulnerability assessment of the study area which includes but is not limited to anthropogenic activities, flooding, erosion, water pollution, and ecological degradation;

e. Review/evaluate the timely delivery and quality control of all required outputs of the team;
f. Prepare activity plan/s and program/s for the conduct of the study.
g. Collaborate with DENR and other stakeholders in the entire process of planning;
h. Prepare detailed management plan in consultation thru consultative planning with stakeholders to come up with a time-bound work plan;
i. Present formulated plan to the proponent and other stakeholders for acceptance and approval; and
j. Facilitate and conduct necessary trainings/workshop/s to NIA field personnel relative to the implementation of formulated management plan/s and program/s.

2) Sociologist/Anthropologist

He/she has at least a Bachelor's degree in Sociology and other related disciplines. Must have at least seven (7) years of professional experience and at least five (5) similar projects work experience in dealing with Indigenous People, the conduct of Free Prior Inform Consent (FPIC), and acquisition of necessary permit to National Commission on Indigenous People (NCIP), the conduct of socio-economic interview, Focus Group Discussion, Public Consultations, and other similar activities.

a. Coordinate/validate with the NCIP on the presence of Indigenous People (IPs)/Ancestral Domain;
b. Formulate and adopt Indigenous People Development Plan (IPDP), if applicable;
c. Capacitate the proponent in FPIC process whenever required for the acquisition of Certification Precondition (CP);
d. Establish baseline information of the socio-economic condition of the community within the project area including but not limited to the demography, livelihood, and existing development programs;
e. Conduct social surveys (KII, SES, FGD) and public consultation to community/ies within the project area;
f. Prepare IEC program and Social Development Management Program;
g. Prepare Gender and Development (GAD) Plan; and
h. Provide inputs and estimate costs in the formulation of a detailed management plan.

3) Agriculturist/ Agroforestry/ Forestry/ Specialist

a. He/she has at least a Bachelor's degree in Agriculture/Agroforestry/ Forestry and other related disciplines. Must have at least seven (7) years of professional experience and at least five (5) similar project work experiences in the field of land resources planning, agricultural biodiversity assessment, pedology, agroforestry, and other related projects.

b. Undertake reviews of current land utilization, crops, and types of farming technology use;
c. Identify major land utilization contributing to the degradation of soil;
d. Conduct survey on prevailing land cover and farm management within the irrigation water source;
e. Identify impacts of the current land cover, utilization, farming systems and recommend appropriate mitigating measures;
f. Determine appropriate agricultural crops and trees suitable for rehabilitation and reforestation programs; and
g. Provide inputs and estimate costs in the formulation of a detailed plan.
h. Provide nursery plan and establishment, if applicable.

4) Agricultural Economist/ Economist

He/she has at least a Bachelor's degree in Economics, Agricultural Economics, and other related courses. Must have at least five (5) years of professional experience and five (5) project work experiences in handling economic studies and assessment for water resources planning, irrigation development, and other related projects.

a. Review and update the financial and socio-economic parameters to be considered in the study;
b. Gather agro-economic data within the study area and supporting agricultural data from concerned Government agencies and private entities;
c. Use input from various specialists of the team to develop cost and benefit estimates; and
d. Present the derivation of cost and benefits with the implementation of the proposed plans and programs.

5) Agricultural and Biosystems Engineer (ABE) / Civil Engineer (CE)

He/she has at least a Bachelor's degree in Agricultural Biosystem/ Civil Engineering and other related courses. Must have at least five (5) years of professional experience and five (5) project work experiences in handling economic studies and assessment for water resources planning, irrigation development, and other related projects.

a. Recommend appropriate mitigating structures;
b. Present knowledge or information resulting in usable, economical and sustainable technologies to enhance utilization of agricultural and other biological products and sustainable management of related environmental resources;

c. Cost estimates in the proposed mitigating structures and other related subprojects.

6) Geographic Information System (GIS) Specialist

He/she has at least required education equivalent to a Bachelor's degree in Environmental Science, Geomatics, Geodetic, Geography, Engineering, Computer Science, or closely related field. Must have at least five (5) years of professional experience in the field of analyzing spatial data through mapping software, designing digital maps with geographic data and various data sets, and has experience with mapping tools such as QGIS or ArcGIS, etc.

a. Gather shapefiles, and other necessary data to prepare maps showing the delineated Service Area, Reservoir Area, Watershed/Drainage Area, NIA area of Management, etc.
b. Prepare maps and oversee the preparation of vulnerability assessment and other GIS analyses as part of the formulation of the management plan.
c. Prepare other maps and data needed in the management plan formulation.

VI. ECOLOGICAL PROFILING OF IRRIGATION WATER SOURCES AND VULNERABILITY ASSESSMENT

The Plan shall be carried out through ecological profiling on the physical, biological, and socio-economic settings of the irrigation water source as the results of the examination should describe in detail with the corresponding maps, tables, photo documentations, graphs, and other significant features of the concerned area. Furthermore, the result will be used as a supporting detail to the identified NIA area of management.

VII. FORMULATION OF DETAILED MANAGEMENT PLAN

RPWRSIS provides actions to:

1. Abate sedimentation of river channel leading to the irrigation system reservoir, intake, and drainage facilities;
2. Promote sustainable land use in sloping areas especially along channels to minimize the rate of erosion;
3. Identify climate-resilient structures to mitigate erosion and sedimentation in irrigation water sources;
4. Restore degraded land within the delineated NIA area of management;
5. Ensure quantity and quality of irrigation waters;
6. Provide other livelihood programs to minimize high dependency on natural resources extraction within irrigation water sources; and

7. Mainstreaming of gender and development.

The detailed management plan should cover immediate areas of the intake/pump site/ diversion intake/dam site, reservoirs, and rim banks. Interventions shall cover Alienable and Disposable (A & D) lands to avoid overlapping with DENR programs/ coverage. Hence, the area of coverage in formulating the detailed management plan should be delineated in coordination with DENR field office and other stakeholders.

In the formulation of the detailed management plan, shall adopt climate-resilient mitigating measures in response to the result of vulnerability assessment. Mitigating measures shall not be limited to vegetative but also include protection, the introduction of appropriate Sloping Agriculture Land Technology (SALT), appropriate land use planning to maximize production while minimizing impacts to soil and water degradation, Information Education and Communication (IEC) campaign plans, implementation of structural measures.

Stakeholders shall be identified and consulted during the ecological profiling and in the crafting of management plans and programs. The plan must be in collaboration with stakeholders in managing irrigation water sources.

Additionally, the plan outline should have the major components namely: 1) Executive Summary, 2) Ecological profiling of irrigation water source, 3) Vulnerability assessment, 4) Summary of Environmental Issues, Problems, and Challenges, 5) Proposed NIA area of management, 6) Recommended management plans and programs.

VIII. PROCUREMENT OF SERVICES

The National Irrigation Administration (NIA) shall select, by way of Quality-Cost Based Selection (QCBS) Procedure pursuant to the provisions of RA 9184, otherwise known as the "Government Procurement Reform Act (GPRA) and its revised Implementing Rules and Regulations (IRR) and based on the following criteria:

Technical Proposal: 80%
Financial Proposal: 20%

The Approved Budget for the Contract (ABC) is based on the estimated number of person-months for specific key staff, as specified below:

Key Staff	No. of Personnel	Man-Months
Water Resources Management Specialist /Team Leader	1	6
Sociologist/Anthropologist	1	3

Agriculture /Agroforestry/ Forestry Specialist	1	3
ABE/CE	1	2
Agricultural Economist/Economist	1	2
GIS Specialist	1	2

The ABC of the proposed study is **Two Million Eight Hundred Twelve Thousand Eighty-Five Pesos & 97/100. (Php 2,812,085.97)** inclusive of all applicable government taxes and charges, professional fees and other incidental and administrative cost. The contract amount shall be a **fixed-priced contract**. Any extension of contract time shall not involve any additional cost to the government.

(Note: Please attached copy of approved POW and details of ABC for ready reference for the review and approval of the TOR)

IX. TIMELINES, DELIVERABLES, AND SCHEDULE OF PAYMENTS

1. Timelines and Deliverables

The study shall be completed within a period of **180 calendar days** commencing from the date of receipt of the Notice to Proceed (NTP). Deliverables for the projects as enumerated in Table 1. Electronic/soft copies with the initial review of the RIOs of the reports and generated maps (vector and raster) shall be submitted to NIA (CO) to facilitate and expedite a complete review of all the submissions.

Table 1. Descriptions and Timeline of Deliverables

Deliverables		Description	Timeline submission
Draft Inception Report	3 hard copies: RIO & NIA-CO -1 soft copy -2 hard copies NIA-CO - -1 soft copy -1 hard copies	-Shall be submitted for review and approval. -Shall include the detailed work and financial program for the scope of work of the study. -Shall contain methodologies and a detailed schedule (Gantt Chart) of all activities proposed to meet the requirement set in this TOR. -Shall include list of key expert personnel based on the submitted bid docs. -Shall attach as an annex of the report the approved TOR and NTP.	15 calendar days upon receipt of NTP
Final Inception Report	3 hard copies: RIO & NIA-CO -1 soft copy -2 hard copies NIA-CO - -1 soft copy -1 hard copies		5 calendar days upon receipt of comments
Draft Ecological Profile of Irrigation Water source and Vulnerability Assessment	3 hard copies: RIO & NIA-CO -1 soft copy		60 Calendar days from the receipt of NTP

	-2 hard copies NIA-CO - -1 soft copy -1 hard copies	-Shall include photo documentation during survey assessment, attendance sheets during consultations, minutes of the meetings, and other significant documents.	
Final Ecological Profile of Irrigation Water source and Vulnerability Assessment	3 hard copies: RIO & NIA-CO -1 soft copy -2 hard copies NIA-CO - -1 soft copy -1 hard copies	-Shall include the delineated proposed NIA area of management that was discussed and approved by NIA.	30 calendar days upon receipt of comments
Draft Management Plan incorporating the Revised Ecological profile & Vulnerability Assessment reports and other attachments.	3 hard copies: RIO & NIA-CO -1 soft copy -2 hard copies NIA-CO - -1 soft copy -1 hard copies	Shall be submitted once the NIA area management has been approved and finalized. Shall focus the plan on the identified NIA area of management. Shall present the complete results of the study covering all activities, findings, and recommendations based on the scope of work outlined in the TOR.	145 calendar days from receipt of NTP
Final Management Plan incorporating the Final	15 hard copies	Shall incorporate all appropriate revisions & clarifications on the Draft Management Plan. All digital and electronic copies of excel files (costing,	20 calendar days after receipt of

Ecological profile & Vulnerability Assessment reports and other attachments.	RIO-1 soft copy -12 hard copies NIA-CO -3 hard copies -1soft copy	POW, ABC, coordinates, etc.), maps, shapefiles (vector/raster), KMZ/KML files, and other significant documents shall be submitted in compact disk or other related soft copy storage.	comments from NIA but not more than 165 calendar days from receipt of NTP
Conduct of trainings/workshops for the implementation of the plan		Shall be done by the consultant to orient and prepare the proponent in the approved management plan.	15 calendar days upon acceptance of the management plan but not more than 180 calendar days from receipt of NTP

2. Schedule of Payments

DESCRIPTION	PAYMENT (%)
Upon submission of Draft Inception report	10
Upon approval/acceptance of the Final Inception Report	5
Upon submission of Draft Ecological Profile of Irrigation Water Resource and Vulnerability Assessment Report	10
Upon approval/acceptance of Final Ecological Profile of Irrigation Water Resource and Vulnerability Assessment Report	15
Upon submission of the Draft Management Plan	25
Upon approval/acceptance of the Final Management Plan incorporating the Final Ecological profile report and Vulnerability Assessment Report and other attachments	20
Upon completion of the Conduct of trainings/workshops for the implementation of the plan	15

X. RESPONSIBILITIES OF THE CONSULTANTS

The consultant shall perform the works and act as coordinator to NIA and other concerned agencies pertaining to the formulation and preparation of **MPIWR**. The consultants shall not release, use or copy information concerning this works related to anyone without the consent of the proponent.
The consultant shall accommodate inquiries of the proponent, submit progress reports of activities to IMOs/RIOs whenever necessary.

The consultant shall attend leveling off meetings and all necessary Technical Discussions.

XI. RESPONSIBILITIES OF THE PROPONENT

The project proponent shall provide the Consultants with all the necessary project documents/information/data. Provide assistance during the conduct of stakeholder consultations, meetings, as well as the acquisition of necessary clearances for the conduct of the study, shall be provided.

Submitted by:

ENGR. JUNE NATHANIEL S. PLAZA
Regional Irrigation Manager

Recommending Approval:

ENGR. C'ZAR M. SULAIK
Deputy Administrator for Engineering and Operation

Approved by:

GEN. RICARDO R. VISAYA (Ret)
Administrator

Note: *Reimbursable costs (consultation meetings., workshop cost, laboratory cost etc., vehicle rental, laborer cost) be included in the POW-A*