CLIMATE CHANGE COMMISSION · PHILIPPINES ·

Global Green Growth Institute

GEOGRAPHIC INFORMATION SYSTEMS

GEOGRAPHIC INFORMATION SYSTEMS MODULE explains the different techniques of spatial analysis in relation to CORE approaches and demonstrates the use of GIS in land use, land cover analysis and vulnerability assessment.

TRAINING MODULE FOR DECISION MAKERS

CLIMATE CHANGE COMMISSION

The Climate Change Commission, an independent and autonomous body that has the same status as that of a national government agency, is under the Office of the President of the Philippines. It is the lead policy-making body of the government which is tasked to coordinate, monitor, and evaluate programs and action plans of the government relating to climate change pursuant to the provisions of the Republic Act No. 9729 or the Climate Change Act as amended by Republic Act No. 10174 or the People's Survival Fund.

GLOBAL GREEN GROWTH INSTITUTE

The Global Green Growth Institute (GGGI) is a new international organization committed to strong, inclusive green growth. GGGI assists developing and emerging countries with integrating their ambitions for strong economic performance and environmental sustainability with the goal of bringing about poverty reduction, job creation, social inclusion, and climate change mitigation and adaptation. Headquartered in Seoul, GGGI was established by treaty in June 2012 at the United Nations Rio+20 Conference by an initial group of eighteen nations who share the organization's vision. To date, there are a total of 24 Member Countries who joined the organization. GGGI has a diverse portfolio of programs in developing countries around the world. These in-country programs, together with global products and services, focus on delivering results through an integrated approach of evidence based green growth planning and implementation aligned to countries' development priorities. The organization also focuses on knowledge development and management activities which build a strong theoretical and empirical basis for green growth, while providing concrete options and guidance for policymakers; as well as building the conditions for public and private green infrastructure investments.

PREFACE

The Philippines is highly vulnerable to the impacts of climate change. As witnessed through the devastation from typhoons Yolanda (2013), Glenda (2014), and Lando (2015), millions of Filipinos were affected and communities incurred costly damages and forced to rebuild. In anticipation of stronger typhoons hitting the country, climate change adaptation and mitigation is vital to the development and preparedness of Local Government Units (LGUs) and the people they serve.

The methodologies and tools offered in this publication are intended to raise national awareness and competence among national and local government institutions, civil society, private sector, and communities. This publication provides information outlining mechanisms on how to develop capacities of decision makers, local planners and trainers in integrating science-based assessments into policies, plans, and programs to make communities adaptive and resilient to climate risks.

This module is one of the many references that the users may utilize in developing their respective development plans.

The Climate Change Commission (CCC) is grateful to our partner, the Global Green Growth Institute (GGGI) – Philippines for providing the needed technical assistance in the development of this module together with the technical team composed of individuals from the Resources, Environment, and Economics Center for Studies, Inc. (REECS).

Disclaimer

This paper is a joint output of the Climate Change Commission (CCC) of the Government of the Philippines and the Global Green Growth Institute (GGGI) – Philippines. Neither the two parties nor any of its employees, nor any of its contractors, subcontractors or their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or any third party's use or the results of such use of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the CCC and GGGI – Philippines or their contractors or subcontractors. The views and opinions of authors expressed herein do not necessarily state or reflect those of the CCC and GGGI – Philippines. Past performance is no guarantee of future results.

Module on Geographic Information Systems for Decision Makers [electronic resource] / Published by the Climate Change Commission – Manila and the Global Green Growth Institute – Seoul: 2016.

Includes bibliographical references

ISBN 978-621-95649-8-4: Not for Sale

Contents

List of Figures

List of Tables

List of Acronyms

AHP	Analytical Hierarchy Process
CAD	Computer Aided Design
CLUP	Comprehensive Land Use Plan
CNCM3	Météo-France / Centre National de Recherches Météorologiques
CPDO	City Planning and Development Office
DEM	Digital Elevation Model
DENR	Department of Environment and Natural Resources
EDC	Energy Development Corporation
FAO	Food and Agriculture Organization
FMB	Forest Management Bureau
GCM	Global Climate Model
GIS	Geographic Information System
GPS	Global Positioning System
LCC	Land Capability Classification
LCCS	Land Capability Classifications Systems
LCE	Local Chief Executives
LDRRMP	Local Disaster Risk Reduction and Management Plans
LGU	Local Government Unit
LULUCF	Land Use, Land Use Change, and Forestry
NAMRIA	National Mapping and Resource Information Authority
NDRRMP	National Disaster Risk Reduction and Management Plans
MPDO	Municipal Planning and Development Office
PHILVOCS	Philippine Institute of Volcanology and Seismology
POI	Point of Interest
PPDO	Provincial Planning and Development Office
PRECIS	Providing Regional Climates for Impacts Studies
SEP	Soil Erosion Potential
SEI	Soil Erosion Index
USGS	United States Geological Survey
USLE	Universal Soil Loss Equation

Definition of Terms

Adaptive capacity - a determinant of vulnerability that refers to the general ability of institutions, systems, and individuals to adjust to potential harms such as climate change (Kovats *et al.*, 2003, cited in the PSNC). It is largely influenced by the system's access to financial, institutional, and technological resources. It also refers to the potential for adjustments, processes (both natural and human), practices, or structures to moderate or offset the potential for damage, or take advantage of opportunities, created by variations or changes in the climate.

Exposure **–** a determinant of vulnerability referring to the extent of the ecosystem or human settlements as well as the types and value of assets that are at risk or most likely to be affected by climate change and its attendant hazards.

Hazard - a potentially damaging event or physical disturbance, which can be categorized as natural (*i.e.,* soil erosion, landslides, flood, drought) and man-made (*i.e.*, deforestation/biodiversity loss, forest fire, water pollution).

Geographic Information Systems - a computer system for entering, storing, naming, retrieving, transforming, analyzing, and displaying spatial data.

Geospatial technology - a technology that integrates remote sensing and global navigation systems.

Geomatics - a scientific approach to the fundamental issues raised by the use of GIS and related technologies.

Sensitivity **–** a determinant of vulnerability referring to the degree to which a system will respond to a change in climatic conditions. The sensitivity of an ecosystem or human settlements varies according to the type of hazards brought by climate change. It also depends on the state of quality and location of ecosystems and human settlements. In particular, the level of social and economic status of human communities, including their demographic features, determines their level of sensitivity.

Risk - the possibility or likelihood of danger, disaster, harm, or loss.

Vulnerability - the degree to which a system is susceptible or unable to cope with adverse effects of natural or man-made (anthropogenic) hazards.

Vulnerability Assessment - a profile discussing the relationship between natural and anthropogenic hazards and recipient subject (watershed).

I. Introduction

1.1. Overview of the Module for Decision Makers

To help build the country's climate resilience and promote green growth, the Communities for Resilience (CORE) Initiative targets state universities and colleges (SUC) near the 18 major river basins in the country. Similar to the demonstration of the Ecotown Framework in 2014, the trainings aim to reduce the vulnerability of communities and ecosystems to climate change impacts and promote adaptation measures by building their capacities through a scientific approach.

In order to achieve these goals, appropriate data should be gathered and organized to determine the size of the locality, and the adaptation and mitigation activities that must be performed. This is done by utilizing Geographic Information Systems (GIS) that facilitate map generation in one location. Without this capability, a comprehensive risk and vulnerability assessment, land use zoning, and change modeling are impossible to identify.

This GIS module addresses the GIS users' domain focusing on decision makers. Important aspects of GIS will be explained relevant to the CORE Initiative.

1.2. Objectives of the Module

By the end of the module, decision makers will be be able to:

- Appreciate the role of GIS in the CORE Initiative Framework;
- Appreciate and understand the use of GIS-related information for policy and decision-making, planning for land-use; and
- Describe the significance of GIS for local governance such as planning and preparation of adaptation and mitigation projects and activities, disaster risk-reduction (DRR) management and monitoring purposes.

1.3. Brief Description

The GIS Module for Decision Makers focuses on topics that are needed by local and regional chief executives to mainstream climate change and DRR in planning and budgeting. These topics are GIS for local governance, GIS for land use decision-making, GIS, Hazards and Disasters, Change Analysis, and Transition Analysis.

1.4. Relevance of the Module for Decision Makers

As decision makers in their municipalities and regions, they are responsible in reviewing and evaluating Local Disaster Risk Reduction Management Plans (LDRRMPs) that will facilitate the integration of DRR measures into the local Comprehensive Development Plan (CDP) and Comprehensive Land Use Plan (CLUP), based on the National Disaster Risk Reduction and Management Act. Therefore, this module provides a foundation knowledge on the use of GIS, especially when applied to assessing said development plans.

1.5. Summary of Topics

The topics covered in the GIS module for decision makers are grounded on the following:

GIS for Local Governance

This section describes the importance of GIS as a tool for better decision-making. Local government units (LGUs) are probably the most effective players in mainstreaming the CORE Initiative. LGUs are considered at the frontline owing to their presence in various activities and developments in the area. Compared to other government agencies with similar concerns, LGUs have the ‘home advantage.’ In essence, having a GIS unit to handle the spatial databank of the organization is desirable.
As part of this module, the use of GIS in communities and poverty mapping are demonstrated, particularly in updating baseline data of the municipality.

GIS for Land Use Decision Making

One of the objectives of this module is to describe the land capability classification and zoning, which can be used by LGUs in prescribing appropriate management and adaptive activities. These become necessary when addressing continuously varying quantitative spatial properties, an issue typical to land use planning. The advantage of homogenous land units resulting from land classification procedure allows the land to be allocated in a rational manner. The allocation of land units depends on the capability as well as suitability to a specific land use. Land use zones are delineated based on land capability. Thus, the output zonation and the indicative land uses are intended to provide a scientific basis for allocating the lands for various uses adaptive to changing climate.

GIS, Hazards and Disasters

This part of the module describes the use of GIS in vulnerability assessment and mapping to characterize different areas’ (*i.e.,* barangay) vulnerability to climate hazards such as flood, drought, and rain-induced landslide. An appropriate Global Climate Model (GCM) is used to generate present and future scenarios (*i.e.,* present, 2020s, and 2050s). Hazard maps are prepared to show which barangay/s are highly susceptible to the adverse impacts of changing climate. Exposure, sensitivity, and baseline adaptive capacity, relative to specific exposure or hazard are interpreted for each sector.

Land Change Modelling

This part of the module presents the results of land use and land cover change, and transition analyses based on different time periods. Mapping and visualization of existing land cover is interpreted from the point of view of a decision maker. The spatial distribution and percent of total land area is described by land cover types. Analysis of forest loss is provided to serve as the basis for estimating emissions and formulating the appropriate restoration and/or reforestation interventions.

II. Module Content

2.1. What is GIS all about?

1. GIS for Local Governance

a. Integrating GIS in natural resource organizations

In the Philippine context, local government units are the most potent instruments for sustainable forest and natural resources management. Several reasons point to this observation:

- LGUs are at the 'frontline,' owing to their presence in all areas of the country especially where forest destruction occurs;
- LGUs have jurisdiction over upland dwellers, especially those at the boundary of forestlands and private lands (*i.e.,* 'forestline'), where conversion and resource extraction is apparent;
- LGUs are the most potent entities that can sustain efforts at protecting and restoring forests and natural resources. Compared to other government agencies with similar concerns, LGUs have the 'home advantage.'

For a natural resource manager, having a GIS unit to handle the spatial databank of the organization is desirable. In most cases however, GIS activities are ad hoc, and once the GIS has been plotted and printed, the GIS unit ceases to exist. More often than not, these activities are contracted out to GIS companies. Thus, the use of GIS must be institutionalized within the organization and not just an ad hoc activity.

b. Community-based GIS

Community-based GIS can be seen in terms of utilizing GIS technology in enhancing the capability of upland communities to better manage the natural resources around them. The process consists of the following:

1. Preparation and plotting of the GIS themes.
2. Conduct of an appreciation workshop on participatory mapping using GIS and 3D relief modelling.
3. Construction of the 3D relief model per barangay.
4. Transferring of 'mental maps' onto the 3D model.
5. Ground verification
6. Updating of the land use on the 3D relief model.

c. Poverty Mapping

Poverty stems from the lack of access to resources and opportunities that would enable a human being to a level of well-being. Thus, lightly defined, poverty is the ability (or inability) to attain a minimal standard of living. This minimum level is usually called the 'poverty line.'

Integrating GIS in mapping poverty, therefore, is a necessary task. A poverty map is a geographic profile indicating concentrations of well-being. Such maps are useful, for instance, in targeting interventions and policies geared towards alleviating poverty.

For instance, GIS-assisted poverty mapping, therefore, may be implemented based on the following:

- Accessibility to resources and services
- Biogeographical mapping
- Vulnerability mapping

d. LGU and Land Use Planning

The concept and interpretation of the comprehensive land use plan as embracing the entire LGU territorial jurisdiction derive from the reality that in any LGU territory there exists two, possibly three, property domains such as private, public, and ancestral.

- The private domain includes areas that had earlier been classified as alienable and disposable, and have since been titled to private owners or claimants. The private domain is completely under the authority of an LGU to regulate.

- Public domain lands such as forests, national parks and similar reservations, which are within the territorial limits of an LGU are traditionally the preserve of the national government. LGUs usually do not have anything to do with those areas. But now the national government intends to involve LGUs in the management of these areas and resources.

- Another domain that may occur within a territory of an LGU is the ancestral domain. The Indigenous People's Rights Act (RA 8371) declares these areas as exclusively for the use and occupancy of the particular ethnic and cultural group that had occupied the area since time long-established.

Management plans of ancestral domains/lands, nevertheless, shall be integrated into the Comprehensive Land Use Plan (CLUP) of the LGU having territorial jurisdiction (Figure 1).

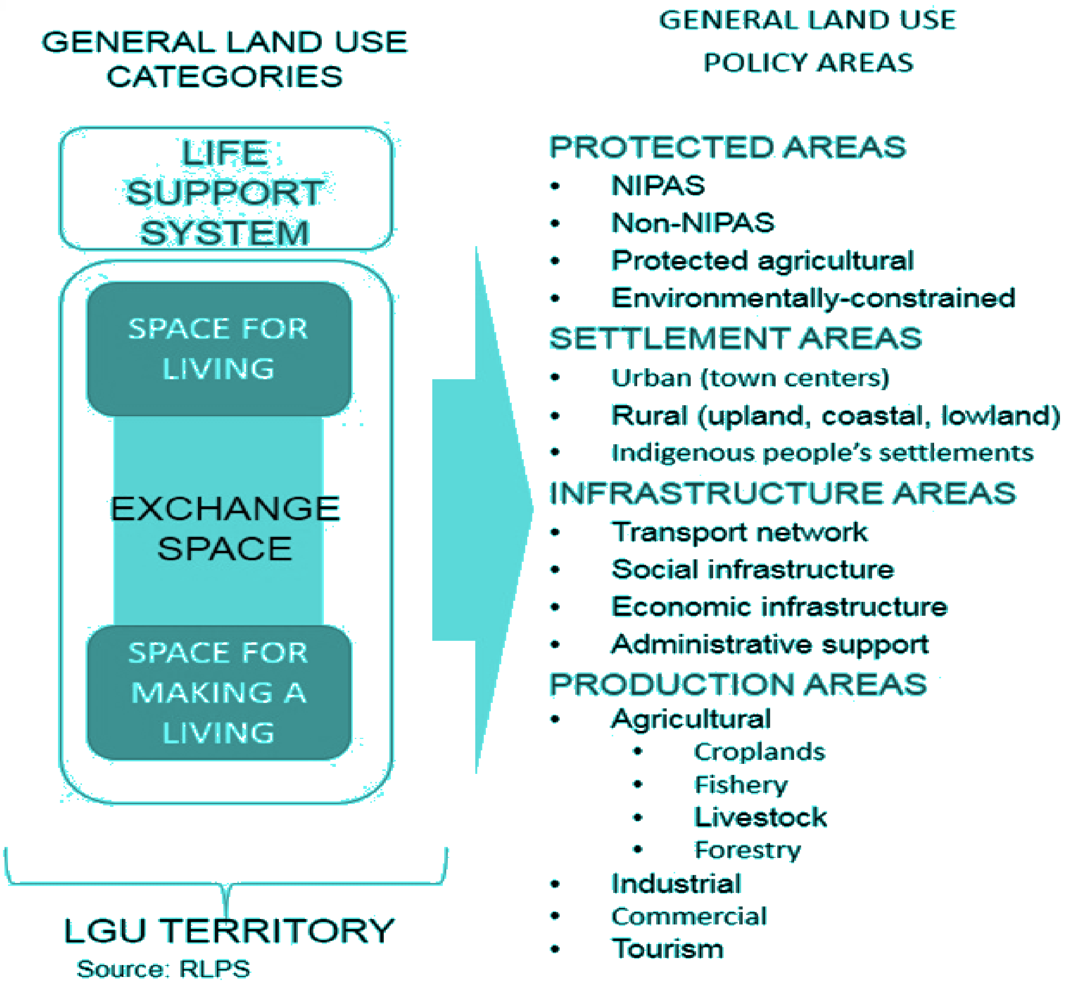

Figure 1. LGU basis for land use planning (Source: LGA-DILG, 2015)

Through GIS technology, intervention options or management prescriptions may be developed on the basis of the major strategies: protection, production, and intensive use. GIS can be used to assist the community transform their mental maps into tangible forms that can allow georeferencing and spatial analysis. GIS can help communities plan out the most appropriate farming system (*i.e.,* agroforestry) design. Implementation may be done by visualizing the land use location and allocation problem as a set of map layers or themes representing earth features. Generating thematic layers allows for selective combination that answers specific questions. Thus, GIS technology has allowed many LGUs to better manage their activities as well as identify solutions to pressing problems in a more responsive way.

2. GIS for Land Use Decision Making

a. Land evaluation

Land evaluation is a process whereby the potential of land for a particular use is estimated. It may be categorized as qualitative, quantitative, or economic evaluation. A qualitative evaluation is limited by its description of the landscape where land for alternative uses are expressed in terms of highly suitable, moderately suitable, or not suitable. Mabbutt (1968) discusses two types of qualitative evaluation: the generic and landscape approaches. The generic approach uses so-called natural regions based on climate, particularly precipitation. The landscape approach, on the other hand, is based on the analysis of the visible features of the area.

b. *Land capability classification*

Land capability is the capability of the land to sustain the forest ecosystem. Rainfall, soil, and topography are the factors considered to determine the survival of a forest ecosystem. These factors are accounted for land capability assessment for sustaining forests and (other) ecosystems. Before, land capability assessment is conducted without considering climate change. Today, climate change has been incorporated with land capability, since it will have an impact on forest ecosystems over time.

Land capability refers to the inherent capacity of land to support, on a sustained basis, a particular use or a set of uses. One may look at land capability as the carrying capacity of the land in terms of the uses that may be allowed in an area without leading to the degradation of the land and the resources found therein. In effect, land capability sets the limit to which a particular use of the land can be carried out safely beyond which the sustainability of the land and other resources suffer serious jeopardy. It is generally determined by the biophysical attributes of the area.

The process of land capability evaluation looks at the characteristics of each factor, and how it affects the land’s capability to sustain the forest ecosystem. This process is applied as a product of land capability classification, which can be undertaken using the potential soil erosion of an area as basis (Figure 2).

The concept of land capability has been widely used in land use planning as a tool for ascertaining the uses that are most suited to an area without resulting to land resources degradation. Land capability evaluation, defined as the subdivision of large tracts of land into capability classes each consisting of biophysically homogenous areas with distinct ability to accommodate a set of uses (*i.e.,* forest protection, forest production, agroforestry, agriculture, residential, commercial and industrial) on a sustainable basis, can be used in identifying the best development options for the project area. Specifically, the result of land capability classification is used to define the different land use zones in the municipality or project site in particular, and in the watershed in general.

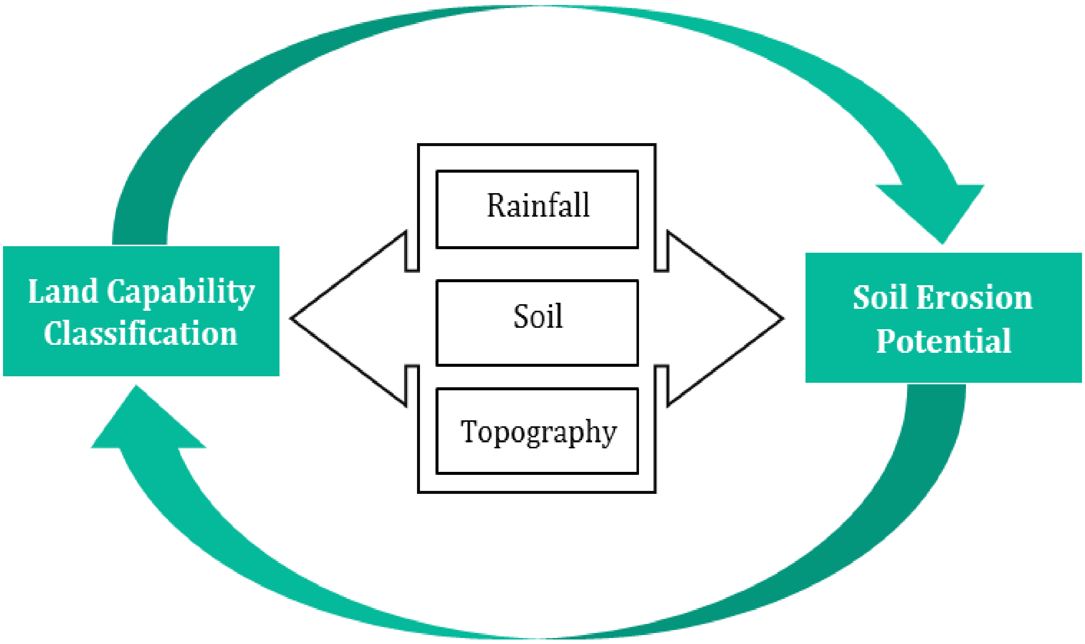

Figure 2 . Erosion-based land capability classification associated with biophysical factors (EDC, 2012; DENR-R4, 2015; CFSHD-DAP, 2015; USAID-DENR, 2015)

Land use zones can be delineated based on land capability as indicated by soil erosion index and other criteria as shown below (Table 1). Two (2) major zones, namely protection and production, are identified. Each major zone can be further classified into subzones. It is noted here that the output zonation and the indicative land uses in the area are intended to provide a scientific basis for allocating lands in the municipalities to various uses.

Table 1. Land capability classification criteria

Class	Land Classification	SEI	Considerations
I	**PROTECTION AREAS**		
IA	***Strict Protection Zone***	>3	All remaining natural forests; Areas with high erosion potential; Slope >50% All key biodiversity areas; All areas categorized as SAFDZ; All areas above 1,000 masl (DENR, 1991)
IB	***Protection Buffer Zone***		Banks of rivers and streams and the shores of the seas throughout their entire length and within a zone of 3 m in urban areas, 20 m in agricultural areas, and 40 m in forest areas, along their margins. (Section 17,

Class	Land Classification	SEI	Considerations
			Pres. Decree [PD] 705, and pursuant to the provisions of the Water Code)
II	**PRODUCTION AREAS**	0 - 3	
IIA	***Unlimited Production Zone***	0 - 1	Built-up areas; Slope less than 18%
IIB	***Multiple Use Zone***	1 - 2	Open brushland and grass land areas; Slope less than 18%
IIC	***Limited Production Zone***	2 - 3	Slope less than 18%

Zoning is not meant to be prescriptive in any absolute sense. The land capability zoning map is an ideal physical framework for allocating the lands within the area. The primary goal is to sustain the long-term productivity of the land and promote the sustainability of biodiversity, soil and water resources, and the delivery of key services of ecosystems in and out of the area. The decision on how the lands are ultimately used still rests with local executives, managers, farmers, and other stakeholders.

Management prescriptions of land capability classes are the following:

<u>Protection Areas</u>

Protection areas are designated mainly for the conservation of biodiversity; conservation of soil and water; protection of unique habitats, vegetation, geologic formation and landscape, and areas of sociocultural values; and minimization of climate-related and other natural risks and hazards associated with soil erosion, landslides, and floods.

<u>Strict Protection Zone</u>

Strict Protection Zone, as defined in Section 5.23, DENR Administrative Order (AO) 2008-26 Section 5.23, pertains to management zones of protected areas consisting of natural areas with high biodiversity value closed to all human activities except for scientific studies and/or ceremonial or religious use. It may include habitats of threatened species, or degraded areas that have been designated for restoration and subsequent protection, even if these areas are still in various stages of regeneration.

<u>Stream Buffer Zone</u>

The banks of rivers and streams and the shores of the seas throughout their entire length and within a zone of 3 m in urban areas, 20 m in agricultural areas, and 40 m in forest areas, along their margins, are subject to easement of public use in the interest of recreation, navigation, float age, fishing and salvage. This provision is mandated by law (Section 17, PD 705) and pursuant to the provisions of the Water Code. These areas are essential buffers for rivers that serve as filters to incoming sediments and other pollutants. These buffers that are supposed to be covered with vegetation, are also excellent protection of the streamflow against excessive solar exposure to keep water temperature at ideal level.

Production areas

The production zone is made up of lands that are suited for intensive land uses such as farming, multiple use forestry, and other uses requiring disturbance of the soil and other resources found in the area. This zone also includes areas that are used for settlement and urbanization and other built up purposes.

Multiple Use Zone

Multiple use zone, as defined in Section 5.10 of DENR AO 2008-26, pertains to the management zone of protected areas where settlement, traditional and/or sustainable land-use including agriculture, agro-forestry, and other income-generating or livelihood activities may be allowed consistent with the Management Plan. It also includes, among others, areas of high recreational tourism, educational or environmental awareness values, and areas with existing installations of national significance or interest such as facilities or structures for renewable energy, telecommunication, and hydro-electric power generation, among others. However, the land capability classification of the multiple use zone is placed under production areas since it requires intensive management requiring soil disturbances.

Limited Production Zone

Limited production zones can be allocated as agricultural areas that are classified within the alienable and disposable lands.

Unlimited Production Zone

Areas for settlement and commercial purposes consist mostly of areas that are currently used for the same purposes. As the town's population continuously grows, the settlement and community areas may expand only to production areas immediately adjacent to existing areas. By no means, the areas for settlement and community purposes should be permitted to extend in multiple use or even in the protection areas, as this will likely compromise the ecological and environmental integrity.

2.2. Why is GIS important?

GIS is designed as a generic system for handling any kind of spatial data. This technology can be used for scientific investigations, resources management, environmental monitoring and modelling, habitat assessment, vulnerability assessment, decision support systems, development planning, urban planning, and mapping among others.

Similarly, GIS provides techniques of investigation and knowledge of the watershed characteristic values, and to generate land use zone based on topography, land use and precipitation factors. It can apply in land use planning to classify a whole watershed area, which is heterogeneous in nature, into different homogeneous groups through the land capability classification technique. It can also be used to develop a model for land-use optimization in the watershed, investigate the effects of slope information on soil erosion estimates, and identify areas at risk of visual degradation.

For instance, GIS might allow planners to easily calculate emergency response times in the event of a natural disaster, or be used to find areas that need protection and rehabilitation.

In particular, GIS technology is often used in climate change vulnerability and impact assessment. GIS-assisted integration with climatic and biophysical information in other communities (*i.e.,* barangay, municipality, and region) is possible. Mapping can be done through the use of computer with GIS. Hence, training on use of GIS is necessary.

2.3. Application of GIS

1. GIS, Hazards and Disasters

Hazard assessments can be conducted based on different factors and their relative weights. Vulnerability maps to climate hazards for a climate scenario based on future with time periods of 2020 (base year 2006-2035) and 2050 (base year 2036-2065) can be developed following the processes as illustrated below (Figure 3).

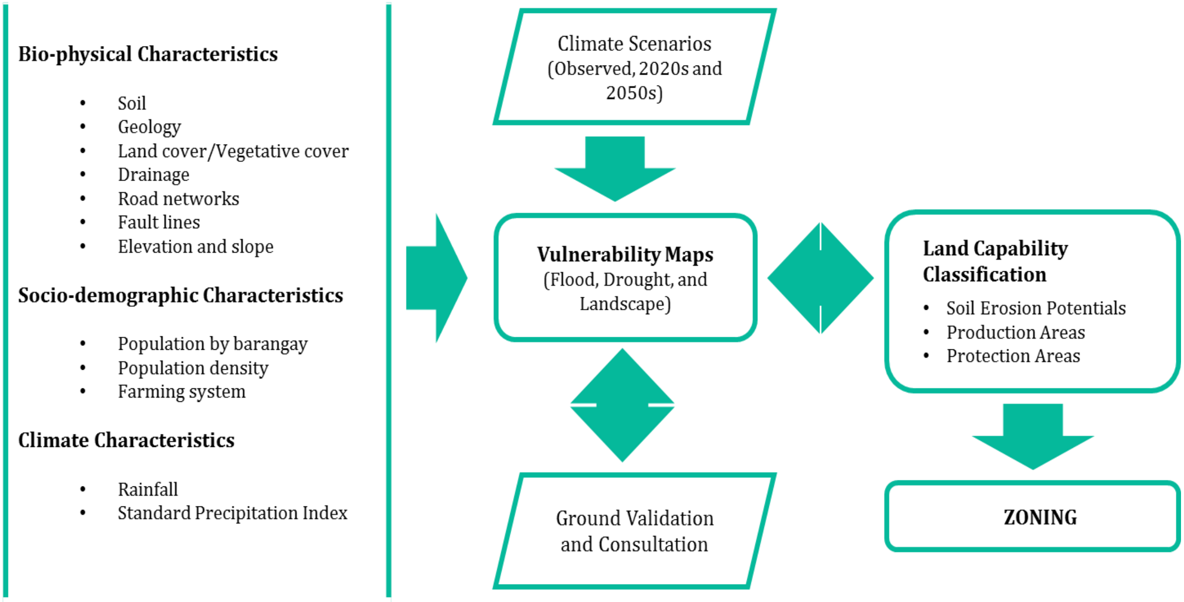

Figure 3. Vulnerability Mapping Framework (CFSHD, 2015; USAID-DENR, 2015)

a. Hazards assessment

A GIS-based mapping and assessment can be conducted to determine the area's vulnerability to climate hazards. The assessment can be undertaken by determining inherently sensitive areas due to topography and its exposure. Vulnerability or hazard maps are prepared to show which areas in the watershed or even municipality require immediate attention to minimize the adverse impacts of changing climate. Projected hazard maps may be simulated using overlay analyses associated with different variables based on the observed and projected climate scenarios. Of the many different types of hazards related to climate change, 1) flood, 2) drought, and 3) landslides are selected for assessment in the CORE Initiative. The selection is founded on the understanding that the projected climatic changes in the area involve significant variations in the amount, and seasonal pattern of rainfall. With shorter/ drier dry seasons and longer/ wetter wet seasons expected to become more prevalent, more frequent flood and drought events are expected to affect the activities of local communities.

i. Rain-induced landslide

Landslide is essentially described as the downward movement of a relatively dry mass of earth and rock. It is a process where soil particles are detached, transported, and deposited from one place to another. It is usually triggered by excessive rainfall or the occurrence of an earthquake strong enough to cause instability in the underlying rock layer. The rain-induced landslide hazard maps are assessed and generated based on physical conditions, vegetated factors, and climate change influences given the Global Climate Model (GCM) and scenarios.

The vulnerability to landslide is a function of different physical factors, and the different thematic maps (slope, soil, geology [geo-hazard], land cover, and climate). Essentially, each factor is assigned a relative weight according to its influence in landslide occurrence. Each factor, with the specific hazard values, can be prepared and analyzed for simulation. All physical factors follow the same scaling factor procedures. Degrees within each factor is given relative weights (from low to high) depending on the degree by which these could influence landslide susceptibility.

The susceptibility can be described in three (3) categories: low, moderate, and high. Areas that are assessed prone to geologic hazards have high exposure to impact of extreme climate variability. The attribute table can then be generated to determine the barangay/s exposed to rain-induced landslides. The spatial assessment indicates the total number of barangays that are highly vulnerable to rain-induced landslides (Table 2).

Table 2. Example of matrix for vulnerability to rain-induced landslide by barangay

Barangay/ Municipality	Observed	Validated	A1B Scenario		A2 Scenario	
			2020	2050	2020	2050
Barangay 1	Moderate	Moderate	Low	Low	Moderate	Moderate
Barangay 2	Low	Low	moderate	Moderate	High	Low
…	Moderate	Moderate	Moderate	Moderate	High	Moderate
…	Moderate	Moderate	Low	Low	Moderate	Moderate
…	Moderate	Moderate	High	High	High	Moderate
…	Low	Low	Low	Low	Moderate	Low
…	Low	Low	Moderate	Moderate	High	Low
…	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate
….	Low	Low	Moderate	Moderate	Moderate	Low
…	Moderate	Moderate	High	High	High	Moderate
Barangay n	Moderate	Moderate	Moderate	Moderate	High	Moderate

ii. <u>Flood</u>

Flood is commonly defined as an overflow of water onto normally dry land. It is also described as the inundation of a normally dry area caused by rising water in existing river networks and waterways. In flood assessment, scenarios can be generated given physical factors, vegetative conditions, and rainfall amounts based on the GCM with a scenario during the 2020s and 2050s periods.

The susceptibility flood hazard map can be generated based on different factors and its relative weights. The flood modelling is based on the overlay of contributing factors namely slope, land cover/land use, soils, elevation, sub-watershed shape, and stream buffer. Each factor is classified into five (5) categories ranging from very low to very high classes.

Based on the overlay analyses of these factors, different flood susceptibility models can be generated. Assigned or standard colors represent specific categories and translate into susceptibilities. In short, the possibility of floods is covered by each colored representation. However, susceptibility flooding, at any rate, cannot be equated to floodwaters. In particular, the blue color suggests that the areas covered are highly susceptible to flooding at any given event. Although it can be categorized in one single category, this does not mean that the entire town will be flooded all at the same time at any given event, but rather depend on the magnitude of rainfall and influence of associated factors. The attribute table can then be generated to determine the barangay/s exposed to flooding. The spatial assessment indicates the total number of barangays highly vulnerable to flooding (Table 3).

Table 3. Example of matrix for vulnerability to flooding by barangay

Barangay/ Municipality	**Observed**	**Validated**	**A1B Scenario**		**A2 Scenario**	
			2020	**2050**	**2020**	**2050**
Barangay 1	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate
Barangay 2	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate
…	Moderate	Moderate	Moderate	High	Moderate	Moderate
…	High	High	High	High	High	High
…	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate
…	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate
…	Low	Low	Low	Moderate	Low	Low
…	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate
….	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate
Barangay n	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate

iii. Drought

Drought is described as the unavailability of water due to extreme weather conditions such as long periods of abnormally low rainfall. It is also a condition of moisture deficit sufficient to have an effect on vegetation, animals, and man over a sizeable area. Basically, a drought-related hazard is an event in which a significant reduction of water brings about severe economic, social, and environmental hardships to the population.

Vulnerability to drought is the relationship of susceptibility to physical factors, exposure to climatic factors, and adaptability to anthropogenic factors. Basically, each factor can be assigned a relative weight according to its influence. Each factor, with the specific hazard values can be prepared and analyzed for simulation. All factors follow the same scaling factor procedures to assess and map out vulnerable areas. Overall, drought hazard maps for observed, 2020s, and 2050s periods may be produced based on different factors and its relative weights.

Climate-related droughts given three different periods can be generated and labeled as high (yellow), moderate (gray), and low (green). The attribute table can be then generated to determine a barangay's exposure to drought. The spatial assessment indicates the total number of barangays that are highly vulnerable to drought.

Table 4. Example of matrix for vulnerability to flooding by barangay

Barangay/ Municipality	Observed	Validated	A1B Scenario		A2 Scenario	
			2020	2050	2020	2050
Barangay 1	Moderate	Moderate	High	Moderate	Moderate	High
Barangay 2	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate
…	Low	Low	High	Low	Low	High
…	Low	Low	High	Low	Low	High
…	Moderate	Moderate	High	Moderate	Moderate	High
…	Moderate	Moderate	High	Moderate	Moderate	High
…	Low	Low	Moderate	Low	Low	Moderate
…	Low	Low	Moderate	Low	Low	Moderate
….	Low	Low	High	Low	Low	High
Barangay n	Low	Low	Moderate	Low	Low	Moderate

b. Validation on the ground

Ground validation or ground-truthing is one of the components of simulation and modelling. The product of simulation based on physical, demographic, vegetative, and climate data can be validated on a given site. Basically, stakeholders within the areas (*i.e.,* various municipalities) who are familiar with the physical conditions are considered key informants. Each informant will be asked of his/her observation on the degree of hazard susceptibility for each barangay. Normally, highly susceptible barangays are considered to have previous experiences of landslides, droughts, or floods.

2. Land Change Modelling

a. Change analysis

Change Analysis is a set of tools for the rapid assessment of change, allowing one to generate one-click evaluations of gains and losses, net change, persistence, and specific transitions both in map and graphical form. Using land change modelling, users are allowed to specify the essential files associated with the land cover change analysis of a specific area, as well as a project name. For the change and prediction analyses, a minimum requirement is the specification of two land cover maps that can be used as the basis of understanding the nature of change and the means of establishing samples of transitions that should be modelled. The two land cover maps must have matching backgrounds, legends, and spatial characteristics.

This analysis has the ability to create a variety of change maps, including maps of persistence, gains and losses, transitions, and exchanges.

b. Transition analysis

Two main types of forest change are of interest in the land use change analysis: forest to non-forest (forest loss) and non-forest to forest (forest gain). Forest loss (deforestation) is defined as the direct human-induced conversion of forested land to non-forested land or more specifically, as the conversion of forest to other land use or the long-term reduction of tree canopy cover below the minimum 10% threshold (Food and Agriculture Organization [FAO], 2010). Deforestation falls under the category on forestlands converted to other land uses based on the Intergovernmental Panel on Climate Change (IPCC) Good Practice Guidance on Land Use, Land Use Change, and Forestry (LULUCF). Other land uses as defined in this same framework include the following broad land use/cover categories, particularly: cropland, grassland, wetlands, settlements, and other land.

On the other hand, forest gain (forestation) is defined as non-forestlands converted to forestlands and is reflected in new forests being established (*i.e.,* afforestation and reforestation). According to the IPCC Good Practice Guidance on LULUCF, “afforestation” is the direct human-induced conversion of land that has not been forested for a period of at least 50 years to forested land through planting, seeding and/or the human-induced promotion of natural seed sources. On the other hand, “reforestation” is the direct human-induced conversion of non-forested land to forested land through planting, seeding and/or the human-induced promotion of natural seed sources, on land that is forested but has been converted to non-forested land.

For instance, land cover assessment can be utilized (2003 and 2010 land cover data produced by the National Mapping and Resource Information Authority [NAMRIA]) for generating activity data and analyzing forest cover change. Both the 2003 and 2010 land cover data can be generated using visual interpretation and manual editing of the from 30m-resolution Landsat data categorized into the FAO land use classes, which consist of: nine (9) forest classes, two (2) agricultural classes, three (3) wetland classes, four (4) grassland classes, and two (2) other-land classes.

III. Reading Materials/References

Arizapa J.L., Combalicer E.A. and Tiburan C.L. Jr. 2015. Landslide Susceptibility Assessment and Mapping of Pagsanjan-Lumban Watershed Using GIS and Analytical Hierarchy Process. Ecosystem & Development Journal 5(2): 15-24.

Bantayan N.C., Ong S.C.A. and Palijon A.M. 2000. Charting Landscapes the GIS Way. In: GEO Asia Pacific. December 1999/January 2000 Isuue. 21-25.

Bantayan N.C., Combalicer E.A., Tiburan, C.L., Barua, L.B., and Dida, J.J.V. 2015. GIS in the Philippines Principles and Applications in Forestry and Natural Resources. UPLB. 168p.

Burrough P.A. 1986. Principles of geographic information system for land resources assessment. Oxford: Claredon Press. pp. 1-12.

Carter J.R. 1989. On defining the geographic information system. In Ripple, W. J. (ed.). Fundamentals of geographic information systems: a compendium. ASPRS/ACSM, Fall Claursel, Virginia.

CFSHD-DAP. 2015. Vulnerability and Adaptation Assessment in Eastern Samar (Revised Initial Assessment Report). 177p.

Cruz, R. V. O., Lasco, R. D., Pulhin, J. M., Pulhin, F. B., and Garcia, K. B. 2005. Assessment of Climate Change Impacts, Vulnerability and Adaptation: Water Resources of Pantabangan-Carranglan Watershed. Environmental Forestry Programme. College of Forestry and Natural Resources. University of the Philippines Los Baños. Laguna. Philippines. Assessments of Impacts and Adaptations to Climate Change (AIACC), AIACC-AS21 Working Paper_N09, a joint project of START, the Third World Academy of Sciences, and the UN Environment Programme.

De Asis, A. 1998. A GIS-aided soil erosion potential based solution to UP Land Grant allocation problem. MS Thesis. UPLB, College, Laguna, Phil. 86 pp.

DENR Administrative Order 2008-26. Quezon City, Philippines

DENR-R4. 2013. Watershed Characterization and Vulnerability Assessment of the San Juan River Watershed. Volume 1. Calamba City. 156p.

Eastman, R. 1997. User's guide for IDRISI for Windows. Clark Univ., Worcester, USA. pp. 18-95.

EDC. 2012. EDC Water Balance Assessment Report. Ortigas, Manila. 59p.

Fisher P.F. and Lindenberg R.E. 1989. On Distinctions among Cartography, Remote Sensing, and Geographic Information Systems. Photogrammetric Engineering and Remote Sensing 55 (10): 1431-1434.

Food and Agricultural Organizations of the United Nations (FAO). 2003. The Digital Soil Map of the World (Version 3.6), Rome, Italy.

Itami R. and Rauling R. 1993. SAGE introductory guidebook. Digital Land Research, Australia. pp. 1-4.

Mabbutt J.A. 1968. Review of Concepts of Land Classification. In Land Evaluation. A paper of a CSIRO symposium, Edited by GA Steward. Canberra: MacMillan. 11-28.

NEDA-UNDP-Australian AID. Undated. Integrating Disaster Risk Reduction and Climate Change Adaptation (DRR/CCA) in Local Development Planning and Decision-Making Processes. Climate Change Sectoral Vulnerability Assessment (Tools and Training Modules). MDG Achievement Fund.

Nearing M.A., Lane L.I. and Lopez V.L. 1994. Modeling Soil Erosion. In soil erosion research methods. Edited by Lal R. Delray Beach: St. Lucie Press.

Plaster, E.J. 2003. Soil Science and Management. 4th Ed. NY: Clifton Park.

Presidential Decree # 705. 1975. Revised Forestry Code of the Philippines.

Republic Act No. 8371. An Act for Indigenous People's Rights. Manila, Philippines

Republic Act No. 10121. Philippine Disaster Risk Reduction and Management Act of 2010. Manila, Philippines

USAID-DENR, 2015. Baseline Assessment: Vulnerability Assessment of Northern Sierra Madre Natural Park (A Technical Report). Philippines Biodiversity and Watersheds Improved for Stronger Economy and Ecosystem Resilience (B+WISER) Program.

USAID-DENR, 2015. Baseline Assessment: Vulnerability Assessment of Quinali "A" Watershed (A Technical Report). Philippines Biodiversity and Watersheds Improved for Stronger Economy and Ecosystem Resilience (B+WISER) Program.

USAID-DENR, 2015. Baseline Assessment: Vulnerability Assessment of Mt Kitanglad Natural Park (A Technical Report). Philippines Biodiversity and Watersheds Improved for Stronger Economy and Ecosystem Resilience (B+WISER) Program.

USAID-DENR, 2015. Baseline Assessment: Vulnerability Assessment of the Bago Watershed (A Technical Report). Philippines Biodiversity and Watersheds Improved for Stronger Economy and Ecosystem Resilience (B+WISER) Program.

Wischmeier W.H. and Smith D.D. 1978. Predicting rainfall erosion losses. Agric. Handbook, 537.

Woodridge D. 1990. Manual on land-use survey and capability classification for upland watersheds. ASEAN-US Watershed Project, Coll., Lag., Philippines.

CLIMATE CHANGE COMMISSION PHILIPPINES

Address: Bulwagan Ninoy, Ninoy Aquino Parks And Wildlife Center, North Avenue, Quezon City, Philippines

Tel/FaxNo.: (02) 925-8954
Website: www.climate.gov.ph

Global Green Growth Institute

Address: 19F Jeongdong Bldg.
21-15 Jeongdong-gil
Jung-gu Seoul 04518
Republic of Korea

Tel. No. +82-2-2096-991
Website: www.gggi.org