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Landscape Planning Application for Biodiversity Conservation

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Abstract

Biological diversity or biodiversity for short is defined by the United Nations Convention on Biodiversity as the variability among living organisms from all sources including terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part of. In the Philippines, the country's biodiversity resources continue to be threatened due to the fragmentation of natural forests that are habitats of important flora and fauna species. The main government initiative to protect and conserve biodiversity has been the establishment of a system of protected areas through the National Integrated Protected Areas System (NIPAS) as provided for under Republic Act 7586. However, the system currently excludes Key Biodiversity Areas (KBAs) and the surrounding production landscapes which are important for connectivity of key biodiversity corridors. There is thus the need for an integrated landscape planning and management approach that can provide the framework for coordinated actions of all stakeholders. This paper presents an approach for landscape-level land suitability assessment that could provide the basis for the spatial structuring and land use policy framework to support the objectives of biodiversity conservation and the provision of ecosystem services consistent with the needs and development aspirations of the stakeholders in the planning region.

Key words: biodiversity, ecosystem, ecosystem services, landscape, land suitability assessment, ecological zones

1. Introduction

Biological diversity or biodiversity for short is defined by the United Nations Convention on Biodiversity (UN-CBD, 1992) as the variability among living organisms from all sources including terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part. Simply put, biodiversity is the variety of life forms on Earth.

Biodiversity is gleaned at three hierarchical levels of biological organization – genes, species and ecosystems. Genetic diversity is the variety of genes, the diversity within species while species diversity refers to the variety of different species or the diversity between species (Fernando, 2013). As reflected in Figure 1.1, biodiversity likewise includes expansive landscapes of different ecosystems such as forests, rivers, lakes, farmlands, urban areas, and the coastal and marine areas, that host these living things including humans. This is referred to as ecosystem diversity. Biodiversity also concerns the relationships between and among these living creatures and their communities.

They are linked in a network of relationships and their conditions and survival regulated by cooperation, competition, predation, symbiosis or parasitism (Regunay, 2015).

Furthermore, and as shown in Figure 1.2, biodiversity provides the foundation for the efficient functioning of ecosystems including the provision of ecosystem goods and services that sustain and fulfill human life such as seafood, forage, timber, biomass, fuels, natural fiber, and many pharmaceuticals, industrial products, and their precursors. The harvest and trade of these goods represent an important and familiar part of the human economy. In addition to the production of goods, ecosystem services provide the regulating and actual-life-support functions, such as cleansing, recycling and renewal, and they confer many intangible aesthetic and cultural benefits. In turn, biodiversity and ecosystems provide goods and services that affect human well-being through impacts on security, the necessary material for good life, health, and social and cultural relations (MEA, 2005).

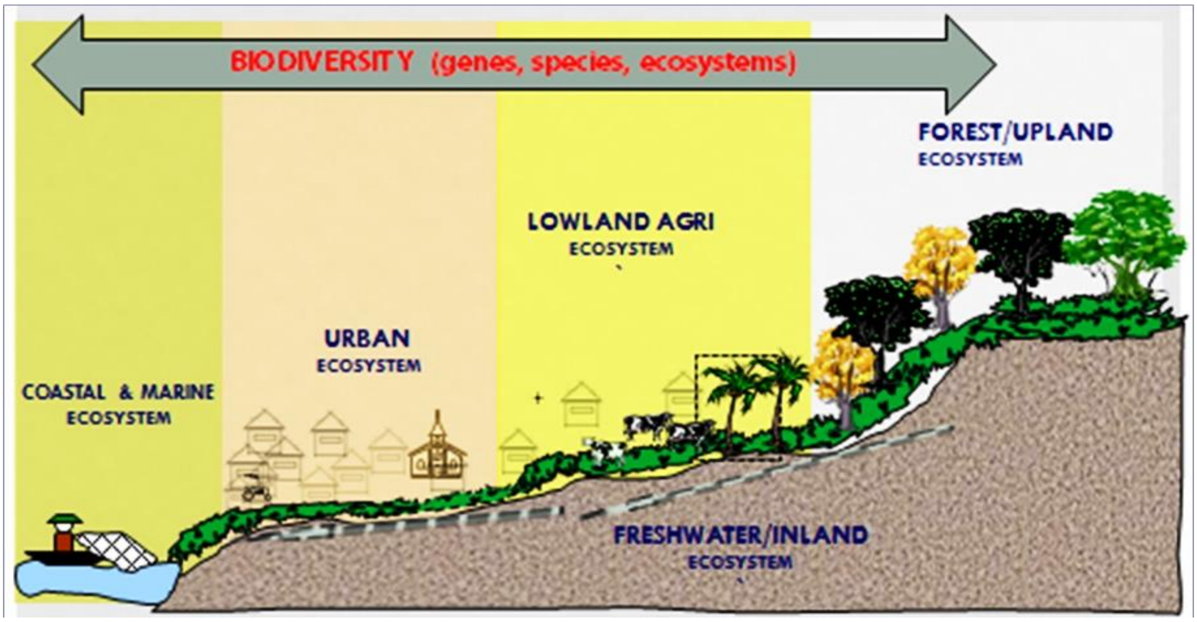

Figure 1.1 Biodiversity exists within and across ecosystem
Source: Regunay (2015)

Despite its significance to the very existence and survival of human communities, biodiversity continues to be impaired by an ever increasing population that now has the technical means to fulfill its expanding material desires and enterprises (Daily, 1997). The case of the Philippines, which is among the world's 17 megabiodiversity countries, is no different. The country's biodiversity resources continue to be threatened due to the fragmentation of natural forests that are habitats of important flora and fauna species. The main government initiative to protect and conserve biodiversity has been the establishment of a system of protected areas through the National Integrated Protected Areas System (NIPAS) as provided for under Republic Act 7586.

However, the system currently excludes other areas of critical connective habitats and other sites which are globally significant for biodiversity conservation. These are the Key Biodiversity Areas (KBAs) and the surrounding production landscapes which are important for connectivity of key biodiversity corridors. The result is a highly fragmented landscape, consisting of unsustainable agricultural and natural resources production systems and incompatible land uses which further expose the remaining natural habitats to threats (Regunay, 2015). The 4th National Report (4NR) to the Convention on Biological Diversity of the DENR-PAWB (2009) specifically cited the fragmentation of natural forests and habitats as the major threat to the country's biodiversity resources.

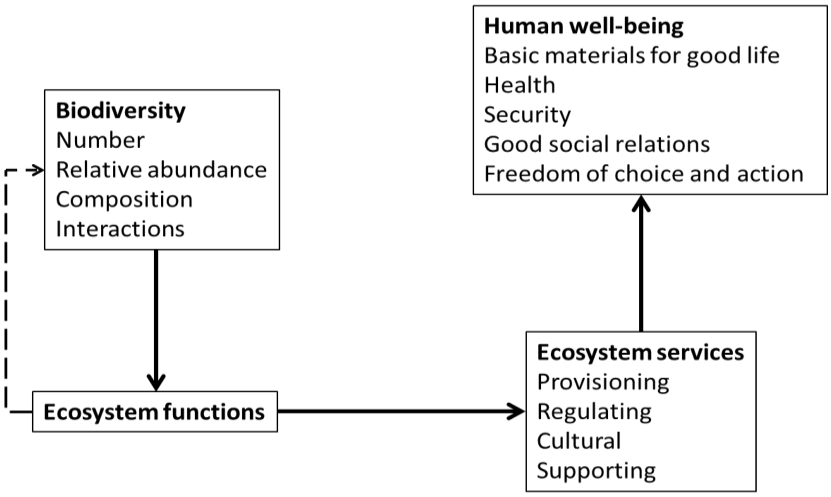

Figure 1.2 Relationship of Biodiversity, Ecosystem Functions, and Human Well-being
Source: Millennium Ecosystem Assessment (2005)

Further compounding the problem of biodiversity loss from habitat fragmentation is the weak integration of biodiversity concerns in landscape-level planning and development that, in turn, results to land use plans that are not environmentally-sensitive, uncontrolled land development and conversion of ecologically fragile uplands and important biodiversity-rich areas for agricultural and other extractive uses (UNDP, 2010). Often, the spatial and socio-economic development planning is along administrative jurisdictions of local government units (LGUs) and fails to recognize the link and inter-connectivity with the broader landscape encompassing multiple LGUs. This dilemma results to uncoordinated at times inconsistent and conflicting plans, policies, and activities of LGUs that embrace common ecosystems, most specially those covering KBAs and other areas of high biodiversity values.

While it would be ideal to have the KBAs declared as PAs and come under the sphere of the NIPAS law, the process for this is quite tedious and a protracted one. Also and because most of the KBAs already contain human communities and subject to varying types of land uses, the potential for conflict between development and the protection of natural resources thus becomes imminent. An option therefore is to develop an approach that could reduce the land use pressure on KBAs while providing for opportunities to accommodate certain economic activities and other income-generating opportunities. An integrated landscape planning and management approach thus can provide the spatial framework for coordinating actions of government agencies, businesses, community leaders, land owners, and other stakeholders within and around the KBA to ensure biodiversity objectives are included in the overall planning and management process.

This paper presents the result of a study for the development of an approach for landscape-level land suitability assessment (LSA) that could provide the basis for the spatial structuring and subsequent land use policy framework to support the objectives of biodiversity conservation and the provision of ecosystem services consistent with the needs and development aspirations of the stakeholders in the planning region.

Scope and Limitations

This study for the landscape-level LSA to support biodiversity conservation covered the Northeastern Cagayan Key Biodiversity Area (NECKBA) as the case study area based on a number of criteria that include the availability of secondary data and maps, spatial scale, habitat systems, accessibility, and representativeness. In addition, while the spatial coverage of NECKBA include both terrestrial and coastal/marine components, this study mainly dwelt with the terrestrial elements of biodiversity due to the unavailability of sufficient secondary data for the coastal and marine ecosystems. The analysis of the existing biodiversity resources including the socio-economic conditions of study site were based mainly on secondary data obtained from previous and on-going inventories and studies done for NECKBA including those generated under the Biodiversity Partnerships Project (BPP) of the Biodiversity Management Bureau (BMB).

2. Conceptual Framework

The Landscape Continuum

The concept of the landscape continuum provides the central management focus and incorporates the notion of linked systems between and among the different components of the landscape. Drawn from the field of landscape ecology, the concept of landscape continuum, as reflected in Figure 2.1, recognizes the landscape as the composite features of one part of the surface of the earth that distinguish it from another area. It is a combination of the biotic, abiotic, human elements including the uses of land (Steiner, 1999). Furthermore, the landscape continuum concept recognizes the natural ecosystems from the forest in the upper slope downstream towards the agricultural croplands onto the mangroves and other habitats in the coastal and marine ecosystems. The landscape continuum provides the spatial construct for the definition, delineation, and characterization of the habitats/ecosystems.

Spatial Framework and Policy for Biodiversity Conservation

The significance of biodiversity in the functioning of ecosystems and the provision of ecosystem goods and services including the fact that biodiversity exists in all ecosystems point to the need for planning and management model that maintain diverse ecosystems to assure the sustained production of ecosystem goods and services. Within this context, a Spatial Framework for Biodiversity Conservation across the entire landscape can be drawn from the construct used in the preparation of the Subic Bay Protected Area Management Plan. As provided in Figure 2.2, the framework draws upon the idea of a concentric zonation from the strict protection area with high biodiversity values extending outwards to the forest production areas to the external agricultural land use economic setting to the marine environment.

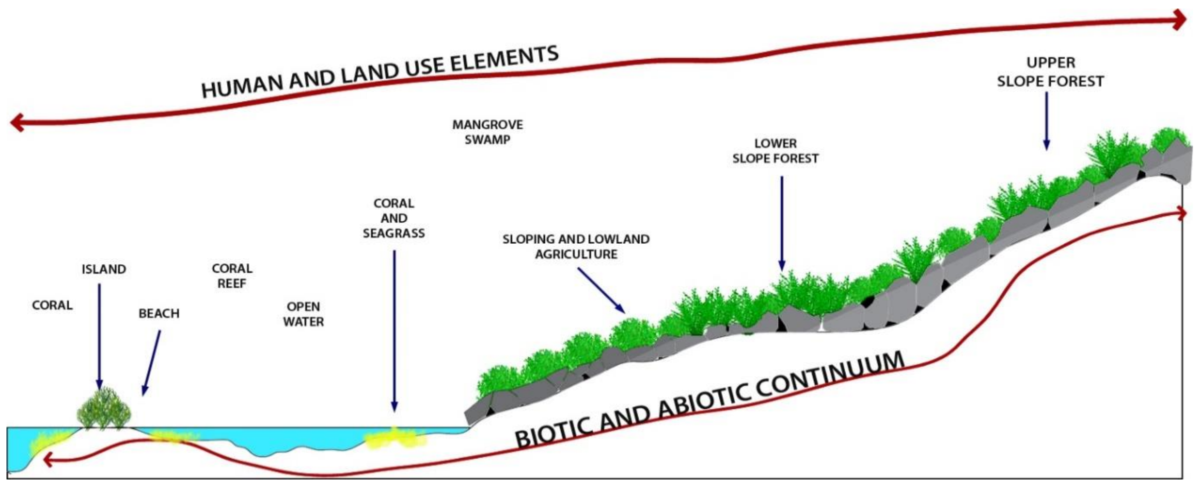

Figure 2.1 The Landscape Continuum

The graded continuum of zones reflects the general concept of the intensity of biodiversity protection being identified and situated towards the center of the landscape model, with increasing accommodation of activities, human uses, and land use activity progressively downstream to the coastal areas/marine environment. The model likewise depicts the connectivity of the zones through the natural corridors that spread across the landscape.

The Spatial Framework also clearly recognizes that the natural processes including problems of biodiversity and habitat loss in key biodiversity areas are part and affected by pressures and influences external to these areas of high biodiversity values (Regunay, 2015). The model explicitly recognizes that the KBA extends over terrestrial and marine environment, alike.

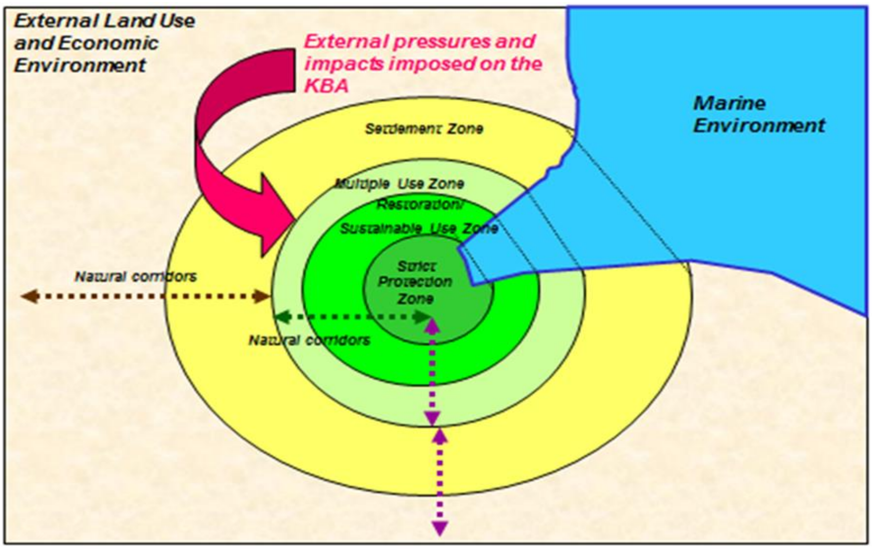

Figure 2.2 The Landscape Continuum
Source: Regunay (2015)

Ecological Planning Model

The need to address biodiversity conservation at the landscape level requires a planning approach that takes stock of social and environmental concerns, transcends administrative jurisdictions, and relates people to the other elements of the landscape. Ecological planning responds to these requirements. Steiner (1999) defined ecological planning as the use of biophysical and socio-cultural information to suggest opportunities and constraints for decision-making about the use of the landscape. Citing McHarg, Steiner further defined ecological planning as the approach whereby a region is understood as a biophysical and a social process comprehensible through the operation of laws and time. This can be reinterpreted as having explicit opportunities and constraints for any particular human use. A survey will reveal the most fit locations and processes.

The central underpinning principle of the ecological planning approach is thus stated as follows: "The fittest environment for any organism, artifact, natural, and social ecosystem, is that the environment which provide the energy needed to sustain the health or well-being of the organism/artifact/ecosystem" (Johnson, 1981). The ecological planning method is primarily a procedure for studying the biophysical and sociocultural systems of a place to reveal where specific land uses may be practiced". Steiner (1999) added that the "method defines the best areas for a potential land use at the convergence of all or most of the factors deemed propitious for the use in the absence of all or most detrimental conditions. Areas meeting this standard are deemed intrinsically suitable for the land use under consideration".

3. Methodology

Land Suitability Assessment

Consistent with the elements of the Conceptual Framework and central to the Ecological Planning Model is the formulation of an analytical tool for land suitability assessment (LSA) framed within a planning construct for landscape-level biodiversity conservation. LSA, based on land suitability theories, links the inventory and analysis information to the definition of problems and vision/goal setting. LSA is the process of determining the fitness or appropriateness of a given tract of land for a specified use (Steiner, 1999). According to McDonald (2006), every portion of the Earth's landscape is characterized by a different set of features that render it more suitable for certain uses than others. The concept of land suitability for particular uses is successfully developed by the late Ian McHarg, former professor of urban design and landscape architecture at the University of Pennsylvania. Ian McHarg's influential work, Design with Nature (1969), propounds that each place on the land is a sum of natural processes and these processes constitute social values. If said values (i.e. protecting water quality while fostering economic growth) are accepted, then inferences may be drawn regarding the utilization of places to ensure optimum use and enhancement of social values. After 47 years since its inception, McHarg's conceptual development of land suitability remains exceptionally pertinent today.

The LSA method for landscape-level biodiversity conservation planning, as drawn from the University of Pennsylvania Suitability Analysis Method, was basically a sieve mapping/data-overlay technique to determine the most and least suitable land for a specific land use intention using a set of criteria and rating system. This study used GIS computer mapping software (ArcGIS and Manifold) to facilitate the overlay analysis including the production of suitability maps. The LSA method used for this study is outlined in Table 3.1 below.

Ecological Zones

The categories of ecological zones used in this study including their corresponding definition are in Table 3.2 below.

Table 3.2 Categories of Ecological Zones for NECKBA

ECOLOGICAL ZONES	DEFINITION
Strict Protection Zone	Areas of maximum protection, mainly in natural and unmodified condition with high biodiversity values
Restoration Zone	Areas with degraded or modified environments and are with remnant environmental, ecological, and ecosystem values
Sustainable Use Zone	Areas containing varieties of vegetation communities and habitats in which the management focus is on conserving and maintaining the ecosystem functions and the forest landscape
Multiple Use Zone	Partially or significantly modified areas subject to existing different forms of land use as intensive timber extraction, grazing and pastures, agriculture and infrastructure development
Settlements Zone	These are the built-up areas largely devoted for urban land uses

Table 3.1. Steps in Land Suitability Assessment for Landscape-level Biodiversity Conservation

1	Identify and provide definition of the ecological zones
2	Specify the criteria/factors including the weight and rating scales for each factor for each of the ecological zones
3	Map suitability rating for each single factor using one set of maps for each ecological zone
4	Overlay single factor suitability maps to obtain composite suitability maps and prepare ecological zone opportunities maps
5	Identify and map constraints to the potential ecological zones
6	Overlay maps of opportunities and constraints and, with rules of combination, develop a map of suitabilities for various ecological zones
7	Develop a consolidated ecological zones maps indicating highest suitabilities for biodiversity conservation and other uses

Source: Modified from Steiner, 1999

Table 3.3 Parameters and Variables in Land Suitability Assessment for NECKBA

Parameters	Variables	
	1st Order Variables	2nd Order Variables
Abiotic	Slope	Slope classification
	Elevation	Elevation categories
	Land classification	Land classification and regulatory status
	Soil erosion	Soil erosion classification
	Flooding	Flooding intensity
	Geologic and natural hazards	Geologic hazard susceptibility
Biotic	Land cover/vegetation	Land cover/vegetation types
	Presence of trigger/ indicator species (flora and fauna)	Conservation status of trigger/ indicator species
Socio-economic	Community perceived values of biodiversity resources	Degree of community values of biodiversity resources

Parameters and Variables

The parameters and variables used in the land suitability assessment are shown in Table 3.3.

4. Results and Analysis

Thematic Mapping

This study required substantial mapping work. To facilitate the mapping process, the study employed the ArcGIS computer-based geographic information systems technology. The thematic maps produced and used in the LSA primarily were drawn from the DENR-Region 2, the Provincial Planning and Development Office (PPDO) of Cagayan, and the Biodiversity Management Bureau.

Single Factor and Multi-criteria Suitability Rating

The first critical step in the land suitability assessment work was to specify the criteria and rating scale for each of the identified ecological zones. The rating scales that were adopted and used were drawn up and agreed during one of the consultation workshops with the stakeholders.

The suitability assessment for each of the ecological zones involved a stepwise process where single factor rating was carried out initially and then combining the single factor scores into a composite score:

Sj = Σ wk sjk
Sj = weighted sum of the scores for each of the criteria
W = is the assigned weight for each criterion
k = is the criterion
sj = rating/score for the criterion

A GIS-based algorithm program using the ArcGIS software was devised to facilitate the spatial representation of the suitability scores for each of the ecological zones. The application of the algorithm produced a set of graded suitability maps showing the scores representing congruence of the different factors that depict the intrinsic suitability of distinct parcels of land in the NECKBA landscape for each of the ecological zones. Figures 4.11a1-a5 provide the graded suitability maps for the ecological zones.

Suitability indices (Table 4.1), using the rules of combination outlined in Table 4.2 were formulated to generate the suitability maps for each of the ecological zones (Figures 4.11b1-b5) of the different factors that depict the intrinsic suitability of distinct parcels of land in the NECKBA landscape for each of the ecological zones. Figures 4.11a1-a5 provide the graded suitability maps for the ecological zones. Suitability indices (Table 4.1), using the rules of combination outlined in Table 4.2 were formulated to generate the suitability maps for each of the ecological zones (Figures 4.11b1-b5).

Table 4.1 Ecological Zones Suitability Indices

Ecological Zones	Suitability Index
Settlement zone	≥2.2
Multiple Use Zone	≥2.0
Sustainable Use Zone	≥1.55
Restoration Zone	≥2.0
Strict Protection Zone	≥2.4

It must be noted that the application of the rules of combination was based on articulated logic rather than on quantitative methods.

Table 4.2 Rules of Combination Factors

Factors	Definition
Footprint	Refers to the overall shape of the area, with particular consideration for avoiding narrow, elongated areas with extended arms and narrow cross sections.
Consolidation versus Fragmentation	An important consideration in designating zones and boundaries is to ensure that areas encompassing particular environmental values are as consolidated as possible. Fragmented zones are not advisable.
Area	Refers to the relative size of the area
Perimeter to area Ratio	Refers to the need to designate zones with an area to perimeter ratio that is appropriate for the intended conservation management objectives. This involves consideration of the theory of Island Biogeography.

Source: Modified from the Subic Bay Protected Area Management Plan, 2001

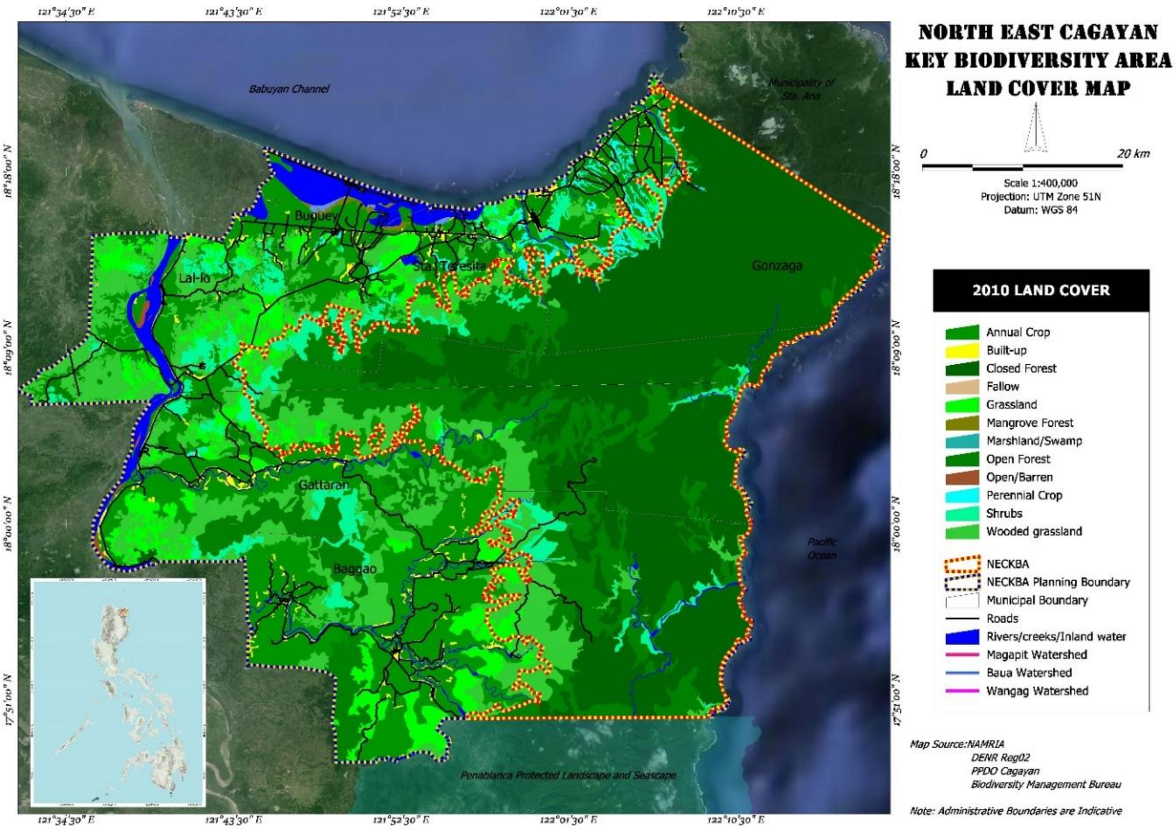

Figure 4.5 Land Cover Map of NECKBA

Source: DENR Region 2, PPDO Cagayan, Biodiversity Management Bureau

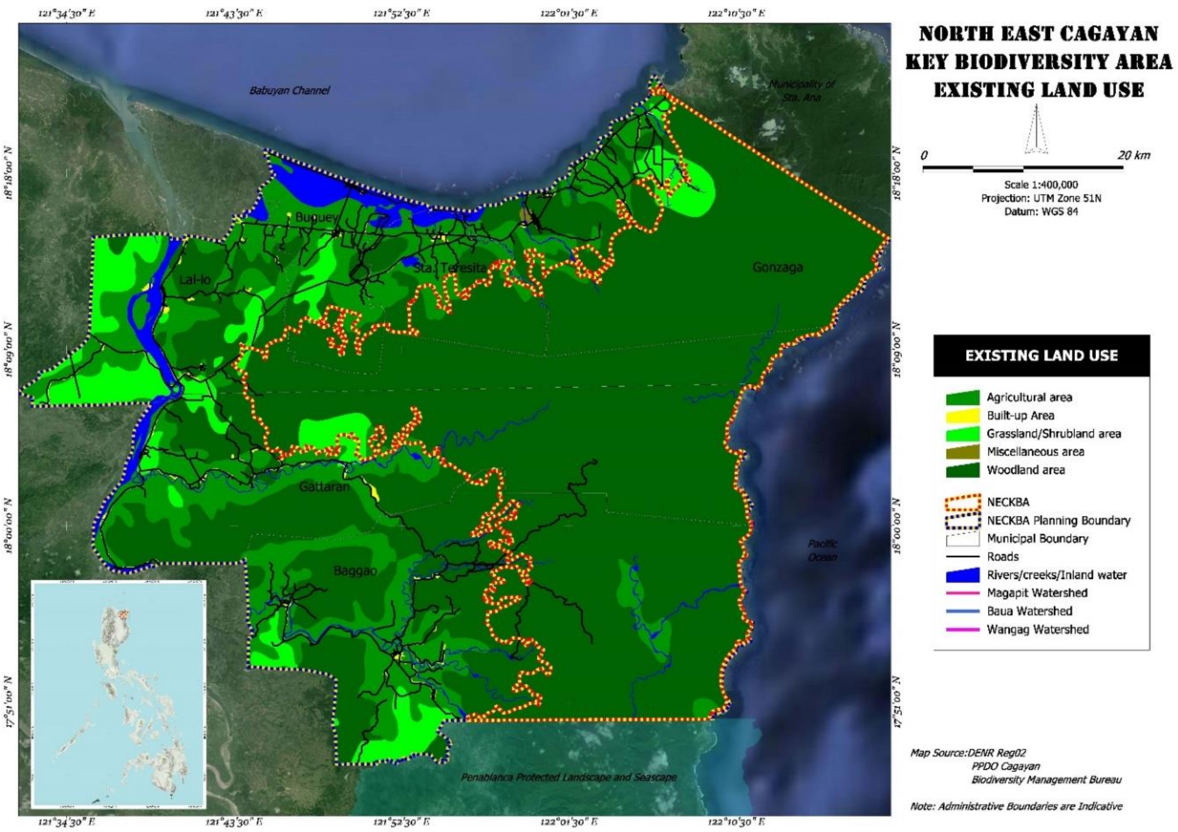

Figure 4.6 Existing Land Use Map of NECKBA

Source: DENR Region 2, PPDO Cagayan, Biodiversity Management Bureau

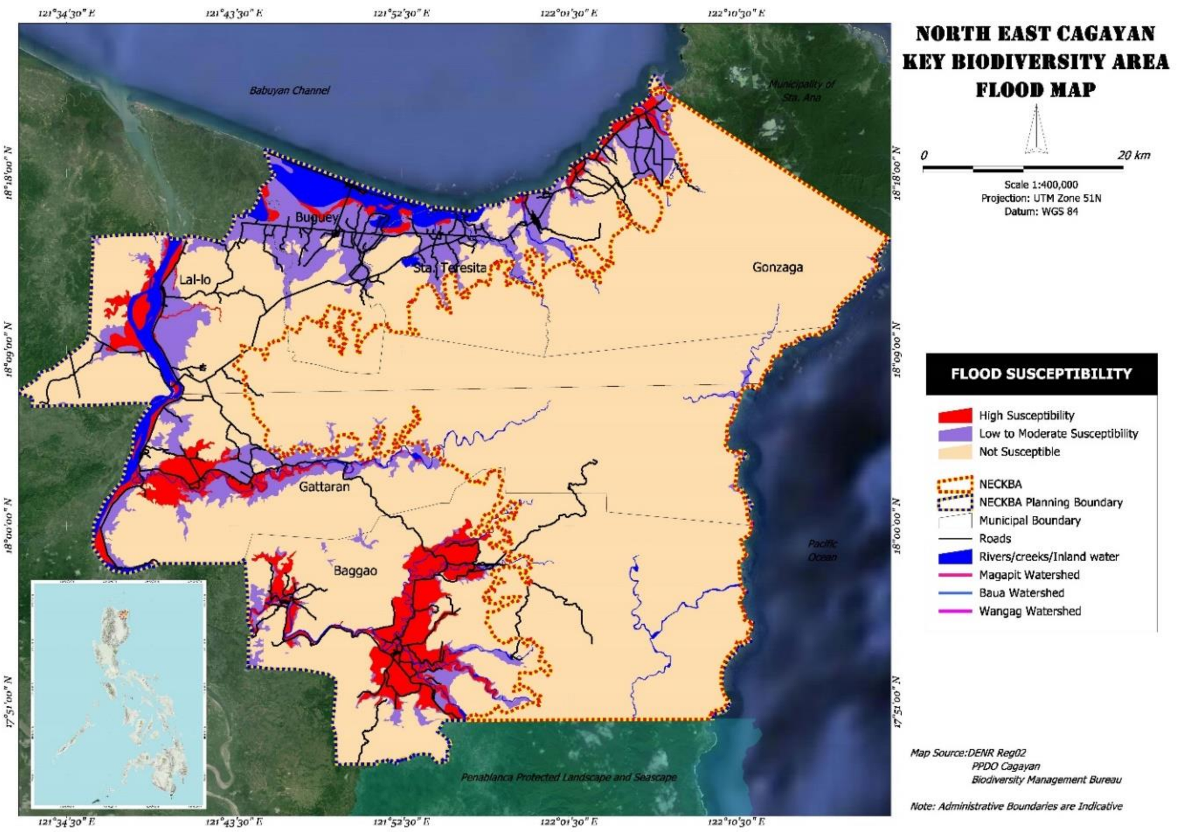

Figure 4.7 Flood Susceptibility Map of NECKBA

Source: DENR Region 2, PPDO Cagayan, Biodiversity Management Bureau

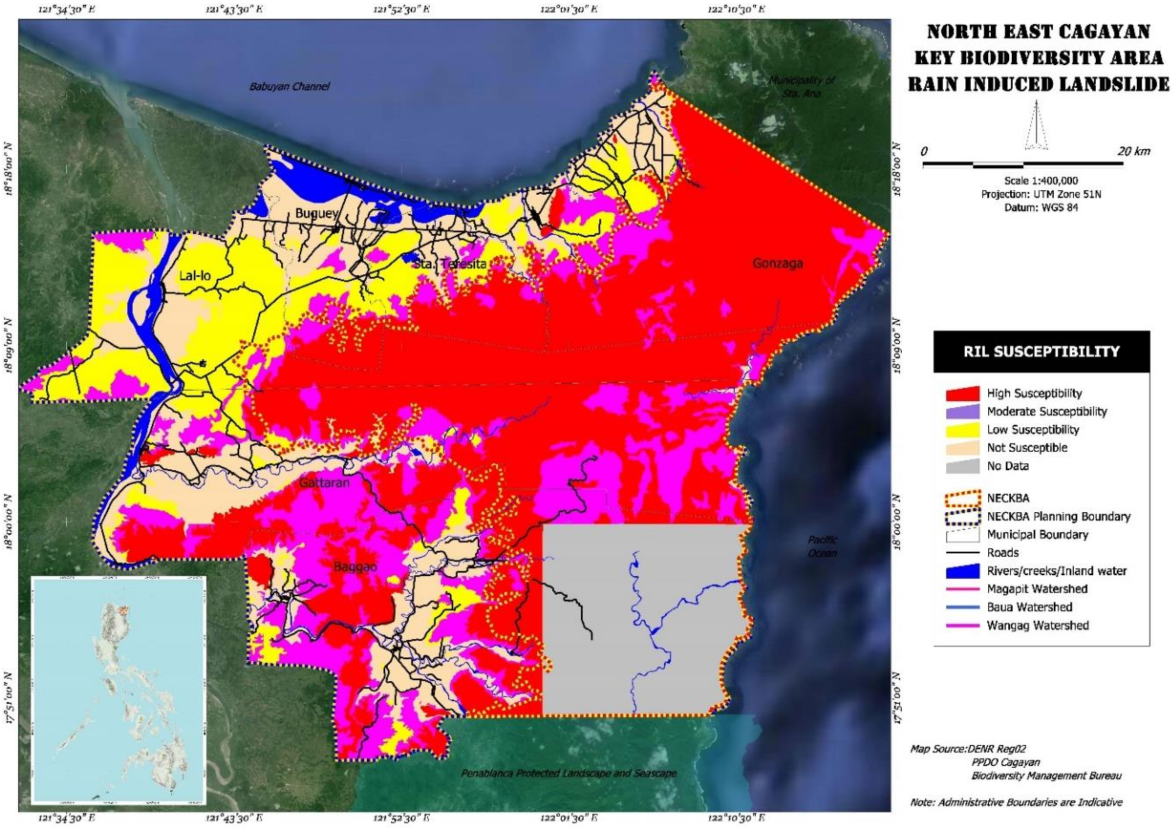

Figure 4.8 Rain-induced Landslide Map of NECKBA

Source: DENR Region 2, PPDO Cagayan, Biodiversity Management Bureau

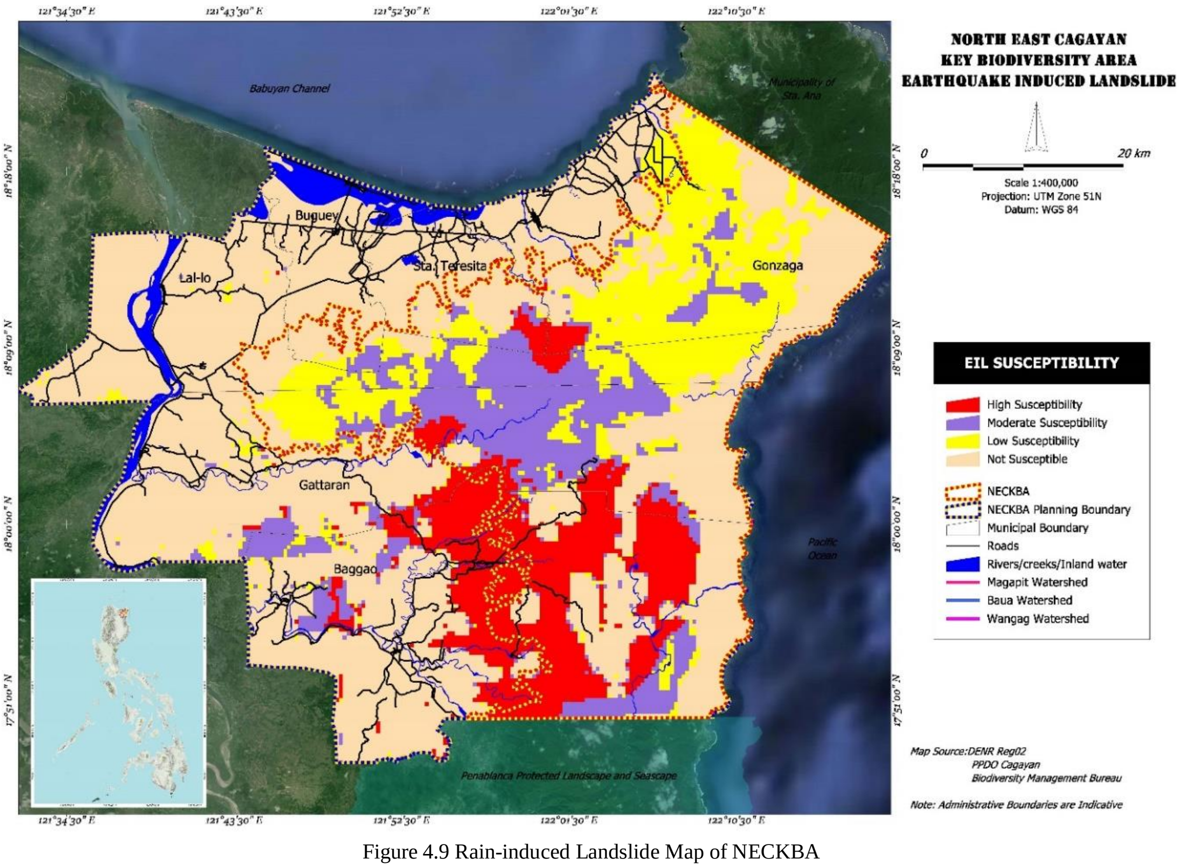

Figure 4.9 Rain-induced Landslide Map of NECKBA

Source: DENR Region 2, PPDO Cagayan, Biodiversity Management Bureau

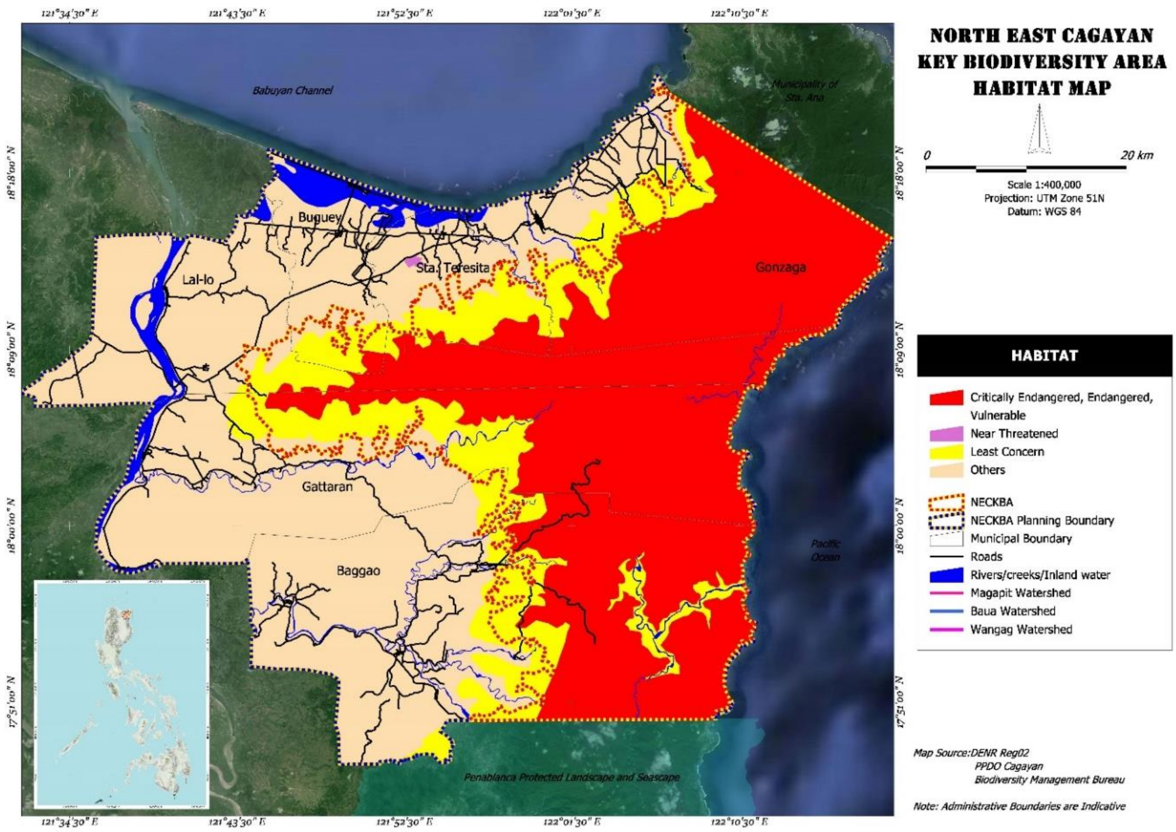

Figure 4.10 Important Habitats Map of NECKBA

Source: DENR Region 2, PPDO Cagayan, Biodiversity Management Bureau

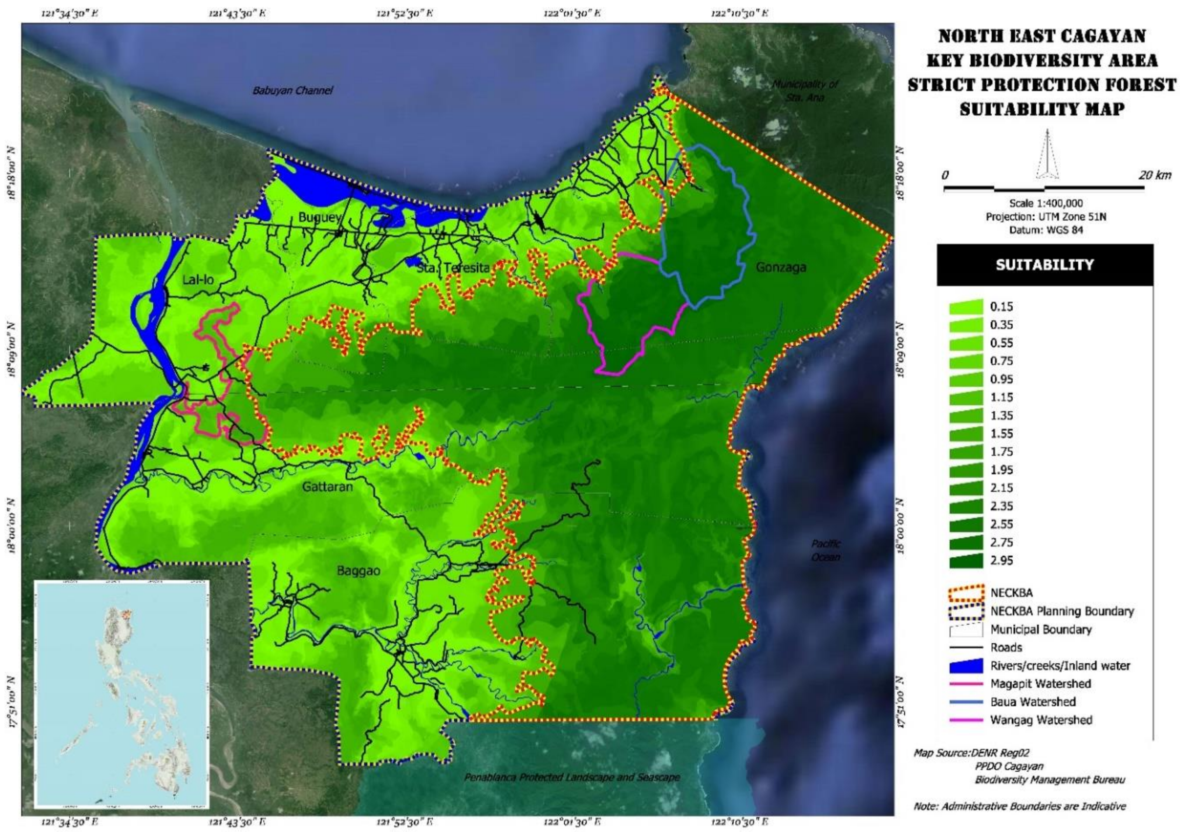

Figure 4.11a1 Graded Suitability Map for Strict Protection Zone

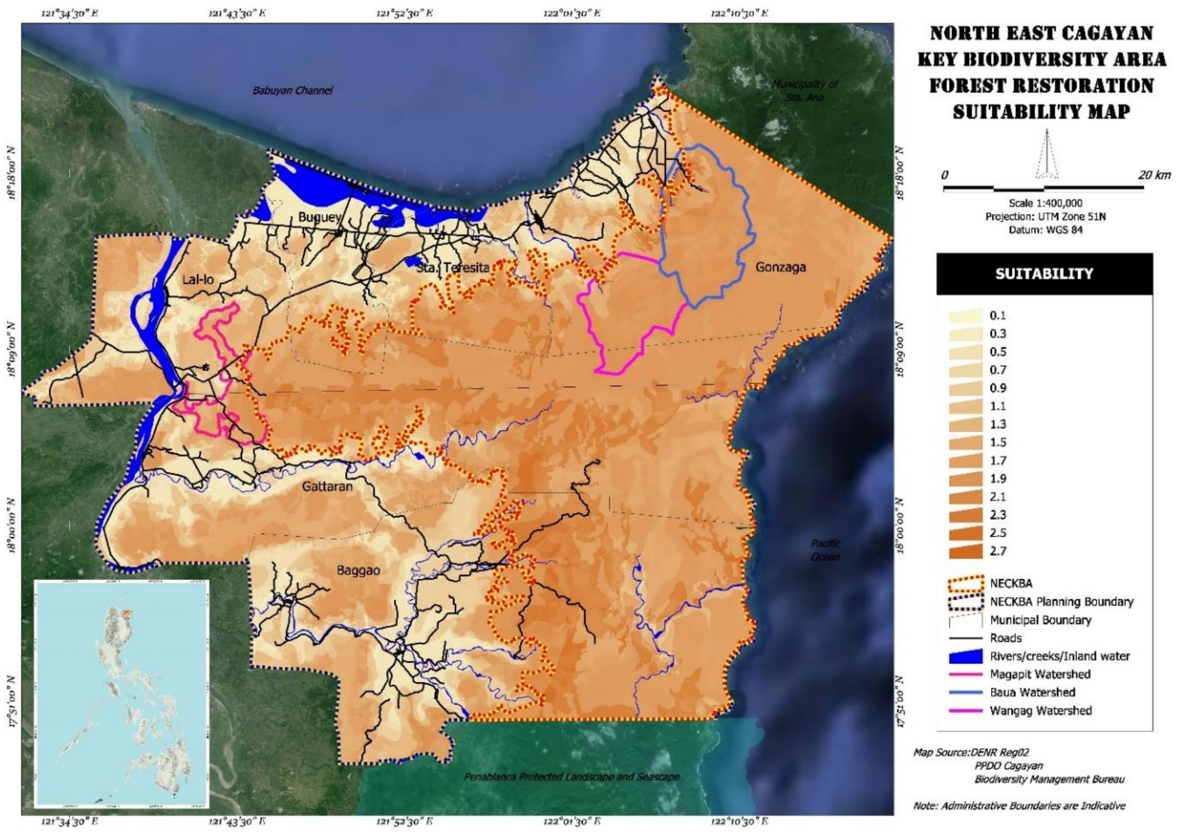

Figure 4.11b2 Suitability Map for Restoration Zone

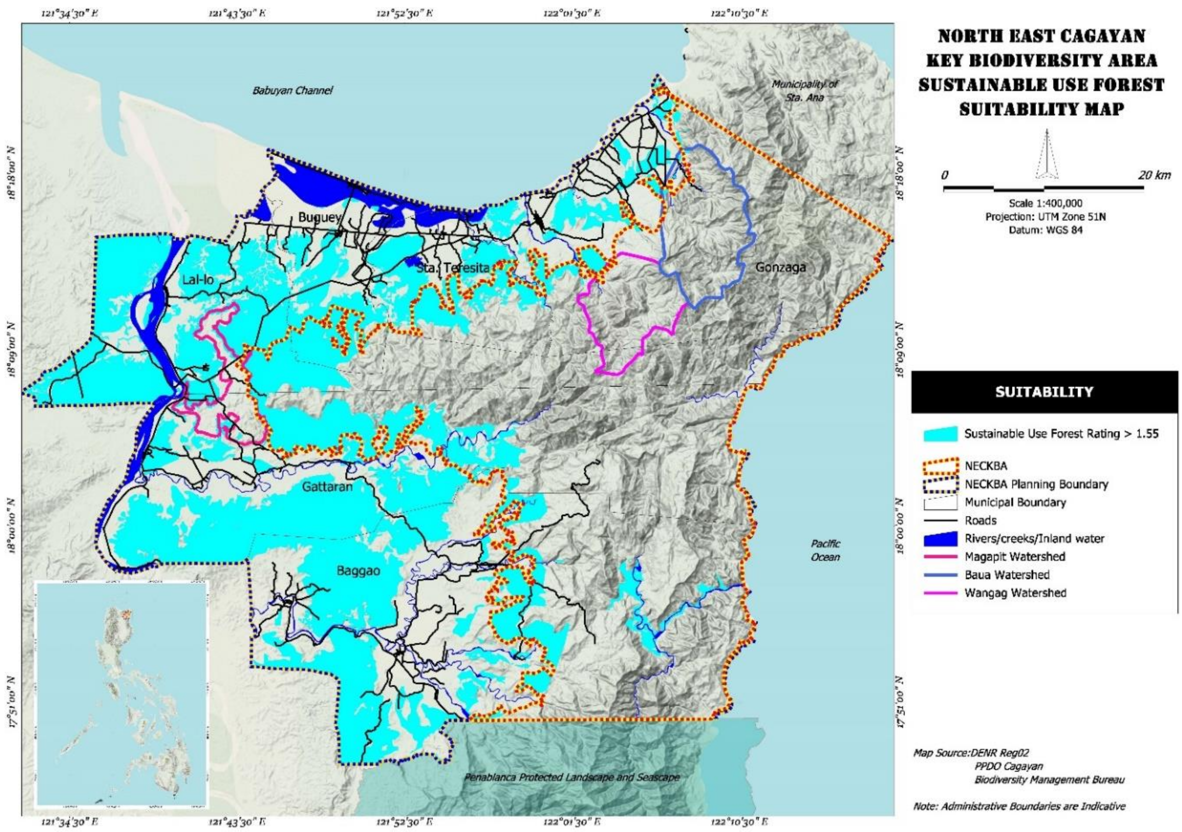

Figure 4.11a3 Graded Suitability Map for Sustainable Use Zone

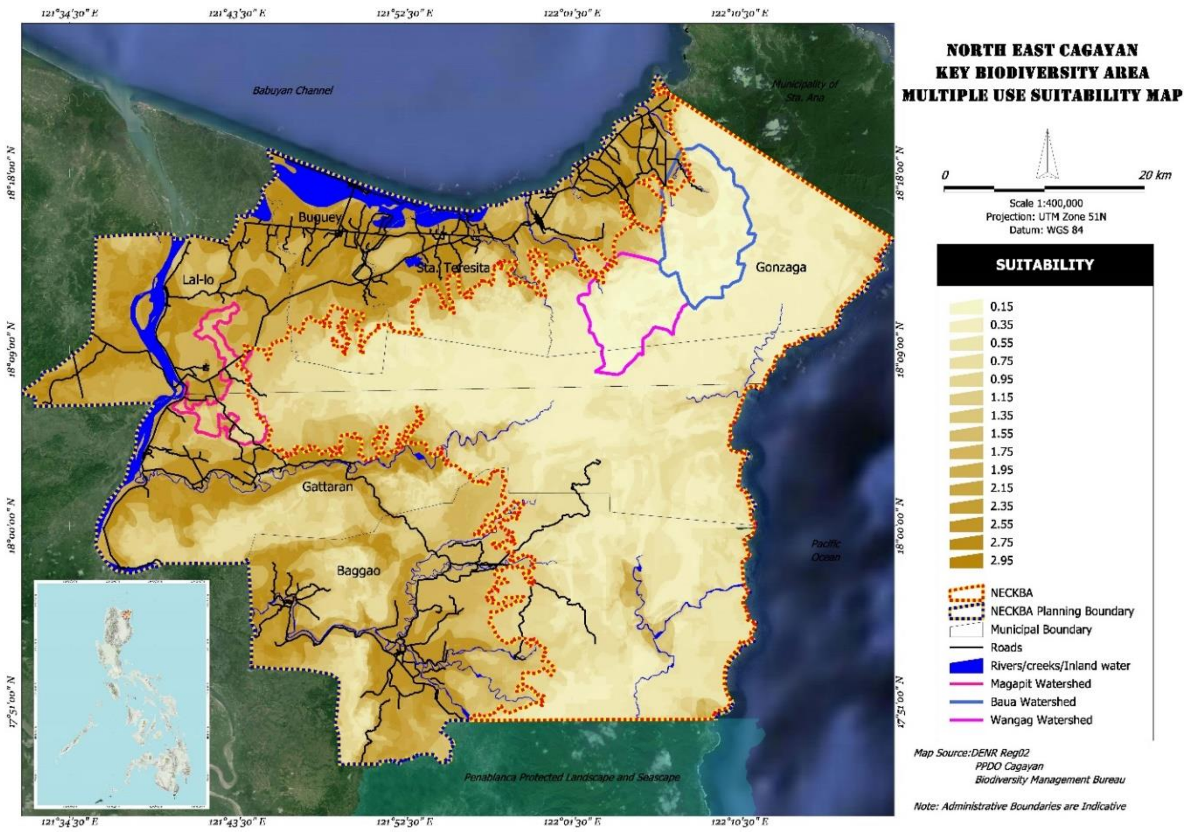

Figure 4.11a4 Graded Suitability Map for Multiple Use Zone

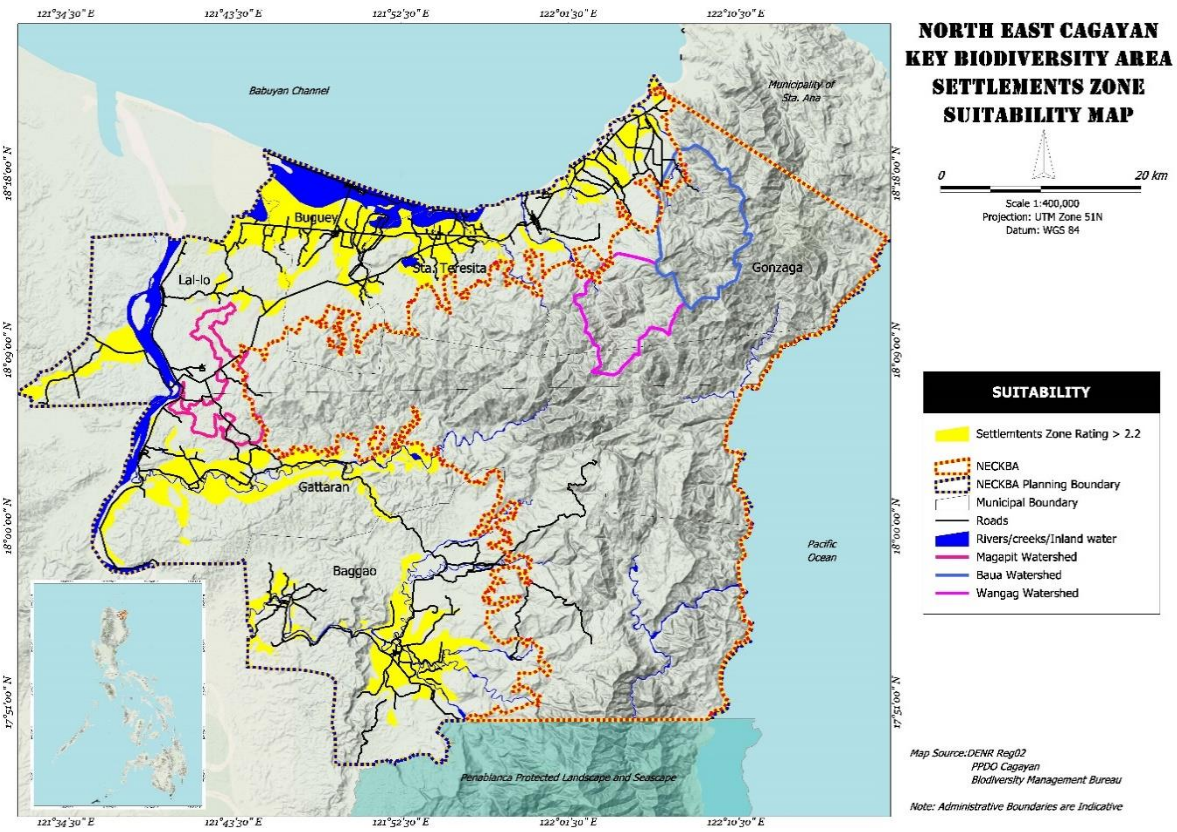

Figure 4.11b5 Suitability Map for Settlement Zone

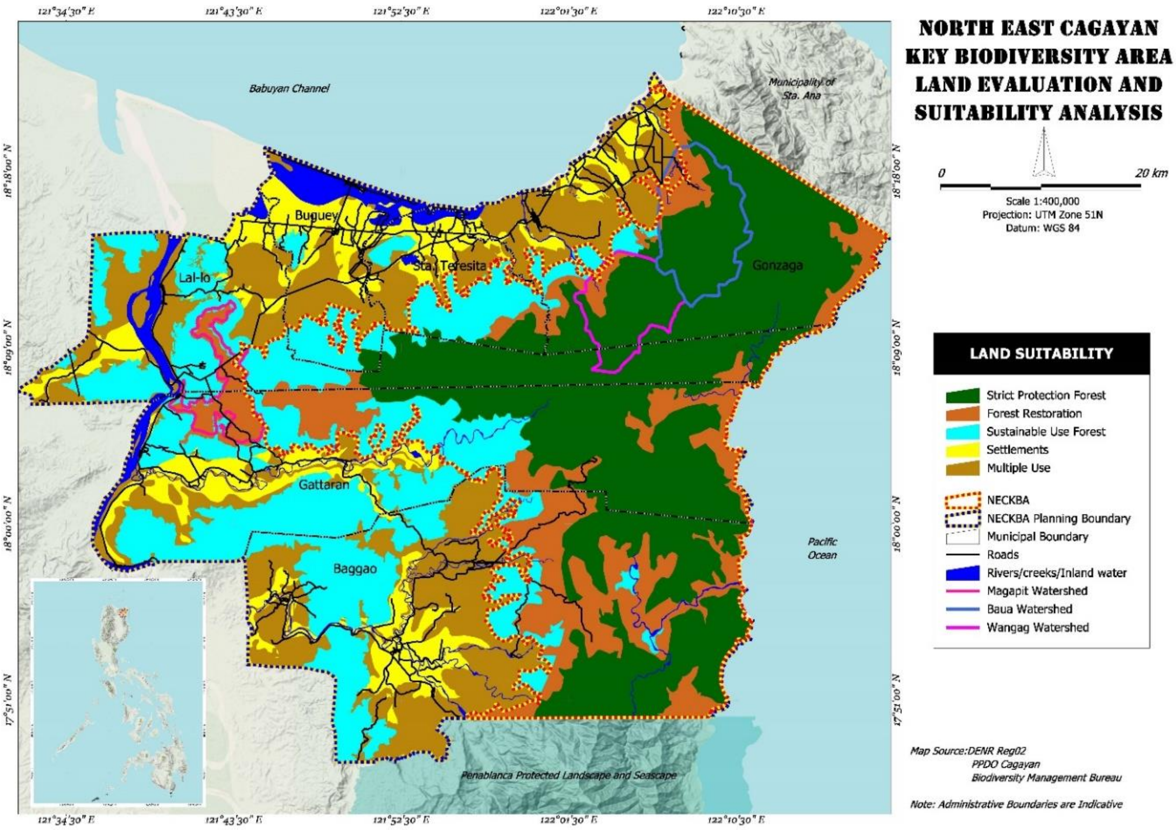

Figure 4.12 Composite Ecological Zones Map

Finally, the combination of the ecological zone suitability maps produced the composite ecological zones opportunities map (Figure 4.12.). This map outlines the landscape-level spatial structure that represents the intrinsic suitability of the study area to provide the multifarious biodiversity values and corresponding ecosystem services.

5. Conclusions

The results of the study provided significant insights into the elements and processes for landscape-level land suitability assessment as an approach and tool for the spatial structuring of key biodiversity areas and surrounding landscapes support the objectives of biodiversity conservation and the provision of ecosystem services. Given the multifarious values and uses of biodiversity, it will be important to consider both the bio-physical/ecological factors of the landscape and the land use/human use values in the spatial structuring of the KBA. The use of the multi-criteria analysis to assess the land suitability for biodiversity conservation including the engagement of the stakeholders and community members on how should these factors should be treated and analyzed are critical for the formulation of a biodiversity-enabled spatial structure and policy for the KBA and downstream landscapes.

Acknowledgment

This paper was based largely on the doctoral dissertation of the author entitled "Spatial Integration of Biodiversity in Transboundary Plans Towards Meeting Community Well-Being: The Case of Key Biodiversity Areas" in the School of Urban and Regional Planning-University of the Philippines. The research made substantial use of the data, maps, other information generated under the Biodiversity Partnerships Project of the Department of Environment and Natural Resources.

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