A Study on Ecological Planning for the Resilience Management of Metropolitan Manila
(マニラ首都圏のレジリエンス・マネジメントのための
エコロジカル・プランニングに関する研究)

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ABSTRACT

The Metropolitan Manila is an urbanizing megacity found in the Philippines. The Philippines is located in Southeast Asia. Its geographic location placed the country along an active volcano belt called the Pacific Ring of Fire and typhoon route in the Pacific. Metropolitan Manila is the prime urban center of the Philippines, in which the capital city of Manila can be found. The Metropolitan area has a total land area of 636 square kilometers, composed of 18 cities and one municipality. It serves as the center of politics, culture, economy of the country.

The metropolitan area has historically been susceptible to various disturbances such as flooding and typhoons, droughts and sea level rise. The situation is exacerbated by the presence of large population under poverty, considered to be the most vulnerable sector to disasters. Because of the bio-physical and socio-cultural conditions of the Manila, the city is considered second most vulnerable coastal city in Asia along with Jakarta, Indonesia after Dhaka in Bangladesh according to World Wildlife Foundation Climate Vulnerability Ranking.

Human activities have vastly altered the structure of natural watersheds and their ecosystems through accelerated conversion of forestland and wetlands to agricultural or urban land, excessive application of fertilizers and pesticides, vast modifications of hydrological pathways, and concentrated industrial development. As a result, the distributions of energy and matter fluxes in the watershed and their ecosystems have also been altered both spatially and temporally.

The purpose of the research is to develop a framework to create an ecological planning methodology for the resilience management of Metropolitan Manila. It aims to address the issues of biodiversity, flooding, poverty, and cultural heritage loss. The research methodology involves several levels of analysis and evaluation to come up with proposals for the ecological planning. The methodology uses two major aspects of methods: Ecological Structure and Ecological Management to develop Ecological Planning for Resilience Management of Metro Manila.

Ecological Structure uses biotope in defining the ecological units and structure of Metropolitan Manila. Biotope mapping of Metropolitan Manila is an important contribution of this study in ecological planning in the Philippines. It utilizes biotope as the means of identifying the ecological spatial units, in which important components of the ecological structure are defined. The study found 29 different biotope types, 21 of which are classified as natural biotopes, while eight (8) are built-up biotope types. The natural and built-up biotope types are analyzed based on their environmental and urban characteristics. Both biotope types are also evaluated based on their function that is comprised of Biodiversity, Flood, Culture, Poverty, Amenity, and Productivity. The evaluation is based on how each biotope type is influenced by the different functions and is given valuation, in which strategies are proposed as reflected in the Ecological Structure Planning.
From the biotope map, the ecological structure is defined, serving as the basis in the creation of the green structure, which are: core, corridor, edge, and patch network.

The composition of the network is based on their function as indicated by their area (size), location, and form.

Ecological Management employs watershed as planning method in which the four pillars are evaluated and assigned with values to determine the influence of the four different issues to the watershed. The issues of Metropolitan Manila are clarified in which four of the most pressing issues are chosen as the four pillars for evaluating the threats faced by the city. These four pillars, which are biodiversity, flood, poverty, and culture, are spatially definable and interrelated in which strategies and management based on ecological planning are proposed. The evaluation of the ecological management is represented with values that reflect the evaluation of the four pillars. Based on the valuation of the watershed, strategy for the watershed is reflected in the Ecological Management Planning.

In Ecological Planning, the two major planning methods are merged to form the ecological planning for resilience management. The ecological planning reflects the strategies and management interventions from both planning methods to provide comprehensive proposal to make an integrated network of green spaces and area management that serve the purpose of creating a more resilient Metropolitan Manila. Each of the different components of the ecological structure is proposed with different strategies to improve connectivity and linkages. Strategies for ecological planning for core include core preservation, core conservation, core improvement, and creation of new green spaces within the core (core creation). Core preservation protects the existing green spaces within the core, ensuring that no conversion or change in the classification and form of the vegetation. Core conservation allows limited modification in the use and form of green spaces to optimize the function of the core with intervention Strategies for ecological structure planning include preservation, conservation, improvement, and creation for ecological structure planning of core, while The ecological planning for resilience management addresses the optimization of the landscape by reducing risk to the most vulnerable sector, preserving spaces with biodiversity and at the same time has high cultural heritage value, and creating space for the integration of biological and cultural processes.

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1. INTRODUCTION

Historically, cities emerge near or close to bodies of water as settlements first began to appear. These cities depended much of their basic needs, agriculture, transportation and trade from condition and bounties that can be derived or product of the processes of being close to water. Food was easily available from various streams and fishing grounds, while land periodically exposed to flooding resulted to fertile agricultural fields. Rivers and seas served as important means of travelling from one place to another. Notwithstanding is the presence of water, which is an essential element in the formation of life, is abundant on this part of the earth. Thus it is not surprising that, at present, some of the major cities and megacities are found along coastal zone.

However, as cities expand and resource utilization becomes more intensive and extensive, coastal cities are facing environmental challenges due to exponential increase in population and rapid urbanization. Population pressure heightens the reality that land is limited while resources are being depleted as consumption continues to rise. Human activities and decisions have led to more paved surfaces and natural processes interrupted and disrupted, leading to polluted streams, groundwater, air and soil. Natural-occurring spaces such as forests, grasslands, wetlands and marshes are transformed into artificial spaces to accommodate human demand, which in the processes displaces flora and fauna leading to biodiversity loss. The modification of the urban environment has resulted to changes that could be irreversible or might take a long period of time to reverse the course of urbanization.

While cities are faced with these challenges, another issue they need to contend with is the vulnerability of cities. More than ever, despite advances in infrastructure and technology, coastal cities are being exposed to more environmental risks in increasing frequency and magnitude. The coastal environment is an ecologically sensitive zone, an interface between land and water where a number of natural processes occur. In the context of urbanized spaces, these natural processes may result to losses of lives and properties and disruption of human activities, thus the idea of disaster. Natural processes such as floods, fires, landslides and earthquakes have been labeled as causes of risks or disasters, making them lie outside the realm of human/urban processes. As a response, massive engineering innovations and infrastructure have been proposed as a solution but still problems continue to be present. In many instances, the effects of these processes have even escalated to a higher level showing more evidence that many of these “disasters” are human-aggravated. Being an anthropomorphic in perspective, concerns are being raised as how cities respond to these “disruptions” and how “resilient” these cities are to disasters.

1.1 Background of the Study

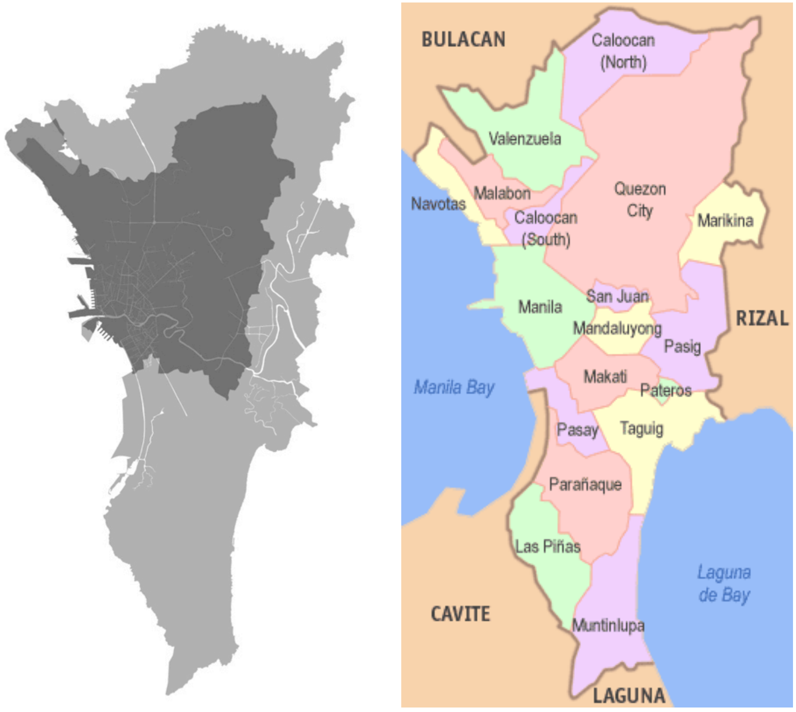

Figure 1: Map of Metropolitan Manila

Being one of the emerging megacities in Asia, Metropolitan Manila (Figure 1, image to the right from http://www.emb.gov.ph/) is in a very interesting situation in which its future will be decided on the decisions made by the present. Located in the coastal zone, the metropolitan region is faced with environmental threats often faced by other coastal cities such as flooding, storm surge, tsunami, rising water level, land subsidence and intrusion of saltwater to the groundwater. On the end of the spectrum of its problems are the environmental concerns associated with urbanization: polluted streams, proliferation of solid waste, contamination of soil, biodiversity loss, air and noise pollution. On another front are the issues that are directly related to urbanization: insufficient housing, inadequate water and sewerage facilities, conversion of agricultural field into paved or built-up spaces, lack of open spaces and urban blight. All of these issues confront the city, creating vulnerability that it needs to address in order to sustain the current relevance of cities.

Figure 2: Images of Challenges Faced by Metropolitan Manila

Foremost of these challenges of a developing country with still expanding population is the threat posed by flood. As shown in Figure 2 (uppermost left and lowermost right images from http://www.westernpacificweather.com), flood permeates all sectors of society, affecting and or immobilizing the whole city as it ravages many parts of the city. It causes huge amount of money in terms of damages and opportunity loss and even lives. In recent years, the extent of flood has worsened as changes in the global climate have affected the pattern and frequency of flood. Rainfall pattern has become erratic and extreme while the occurrence of typhoon has become more frequent. This is exacerbated by the deterioration of urban condition such as subsidence of land along coastal zone and the disappearance of mangroves that serve as buffer to storm surges and sediment trap, while the upland ecosystem has been altered as vegetation regime has been severely modified. Runoff patterns have also been changed as more surfaces are being paved, thus affecting the stormwater management in urban areas. The after effect of flood comes in the form of damages in civic infrastructure and personal property, communication and transportation breakdown, water-borne diseases and displacement of people.

The most vulnerable sector in the event of flood is the informal communities. Having not enough opportunity, informal communities are often found in flood-prone areas, very poor sanitation and hygiene, insufficient recreational and social facilities, disease-infested and with poor human security. Informal communities have become a common sight in most cities that their presence has become ingrained in the social fabric in the urban environment. Their ubiquity has raised issues among urban policy makers and academicians whether they are considered as the result of marginalization in the socio-economic activity or an urbanization phenomenon which needs to be provided "solution" with. On the other hand, their presence could be a symptom of social inadequacies that still need to be considered in a bigger urban perspective. The bottom-line is informal communities present a challenge on how cities are planned and on how to make cities more resilient amidst the environmental challenges they face.

1.2 Research Purpose

With the different issues faced by Metropolitan Manila, the need to have a framework in terms of analyzing, evaluating and proposing ecological plan has never been as urgent. The lack of comprehensive framework has resulted to urban planning decisions that are fragmented and have overlooked the complex relationships of different issues. Thus, this research aims to develop a framework for ecological planning of resilient Manila that addresses the complex urban and environmental issues through ecological structure and ecological management.

In pursuit of this main research purpose, the objectives of the research are as follows:

To Identify and Define Issues Faced by Metropolitan Manila
Metropolitan Manila is facing myriad of issues that challenge the vulnerability of the city against urban and environmental issues. Among these issues, it is necessary which of these issues can be addressed by ecological planning given that these issues are complex and, oftentimes, interrelated. These issues need to be the most pressing in terms of challenging the current urban form and system of the city. As an urban planning framework, these issues need to be spatially definable to be able to be provided with planning solution.

To Develop a Methodology for Ecological Planning for Resilience Management

The complexity of the issues needs a methodology that addresses multiple issues of Metropolitan Manila. Each city has its own particular issues in which a methodology should take into consideration the uniqueness of its challenges. The specific physical, social and environmental situation of Metropolitan Manila requires a methodology that will result to an ecological plan that responds to its vulnerability. The methodology needs to utilize ecological concepts that relate ecological spatial and process components to the issues and also provide strategy on how to address them. These ecological concepts reveal the particular ecological structure and ecological management of Metropolitan Manila.

To Clarify the Ecological Structure

The physical and environmental character of the city is reflected in its ecological structure. In an urban setting, the ecological structure oftentimes merges the natural and built-up components since urbanization tend to influence all spatial components. The importance of ecological structure is that it reveals the ecological-based spatial units and how the urban and environmental issues have affected the connectivity of different natural/semi-natural spaces. Similarly, it also provides potential for re-creating links and connectivity by defining the components of the ecological structure.

To Clarify Ecological Management

In relation to the emphasis on the ecological spatial components in ecological structure, the Ecological Management emphasizes the ecological processes. It acknowledges the different factors that affect the urban environment, which shape the present urban form and systems. Strategies for management based on ecologically-defined units are also proposed to improve resilience of the city.

To Propose an Ecological Planning Methodology for Resilience Management

The framework responds to condition of environmental vulnerability in analyzing the condition and in coming up with resilience management plan for the metropolitan area. The ecological planning strategies integrate ecological concepts, both the biotic and abiotic components to present a comprehensive perspective on the current state of the environment of Metropolitan Manila. It similarly integrates human components and effects of urbanization and how these influence the ecological planning of Metropolitan Manila. The urban setting of the study necessitates the integration of these of conceptual pillars to present the condition and consequently provide resilience management of the city.

1.3 Hypothesis

The research hypothesizes that the ecological structure and ecological management need to be clarified in order to come up with an ecological plan for the resilient management of Metropolitan Manila. This means integrating the concept of biotope mapping in the analysis, evaluation and definition of the ecological structure, which has been missing in other urban plans for the metropolitan area. It similarly utilizes the watershed as the basic frame and basis of analysis and evaluation of level of resilience of Metropolitan Manila to the different issues of biodiversity, flooding, informal community, and loss of cultural heritage. Taking into consideration the human influence on the watershed, it evaluates the landscape in terms of their landscape capacities, potential, and limitation in forming resilience management. The watershed forms a scale and timeframe in responding to issue of vulnerability to flood and biodiversity, especially the informal communities, which is considered to be the most vulnerable sector in the city. Further, being the cultural center of the country, Metropolitan Manila is the location of cultural heritage artifacts that date back from the Spanish colonization to the American period, conservation of these important components of the city's identity along with other pillars make the ecological planning more comprehensive and holistic. The different levels of analysis are envisioned to provide insights on the different spatial units and how these spaces can be managed in the context of resilience management of the watershed and urban growth.

1.4 Significance of the Study

Recent practice of urban planning in the Philippines has emphasized the importance of social and economic connectivity and relations. On the other hand, planning has been delegated to the local government and technocrats. This has resulted to a planning system that concerns mainly on the socio-economic aspect of the urban environment within its defined political boundary. Not since the Burnham Plan has there been an ambitious attempt to come up with a comprehensive plan that clearly reflects the ambition and potential of Manila.

The research is significant in different levels. At the level of the practice of urban planning in the Philippine, it can contribute to the diversity of planning strategy that emphasizes ecological based planning. It introduces the concept of biotope as an important planning tool as basis for clarifying the ecological structure. The ecological structure constitutes the existing condition of Metropolitan Manila in which strategies for improving this structure can be based from to form a city that remains resilient despite disturbances. The concept of watershed has been used in other studies and analysis of Metropolitan Manila. However, in this research it is extensive utilized in terms of analyzing and evaluating the effects of the different issues to the present condition of the city. It is also a vital component in coming up with ecological management in which the existing condition and proposed strategies are based on the watershed as the unit and basis of analysis and evaluation. With these two main concepts forming the ecological planning for the resilience management of the city, this opens opportunities for future urban planning in the Philippines, not only in Metropolitan Manila.

The decentralized nature of planning in the Philippines has left a gap in terms of possible collaboration and coordination between government agencies, planning units and stakeholders in the country. The proposed framework in this research encourages multi-agency and integrative approach in urban planning in decision-making. The framework necessitates that government agencies, planning units, and stakeholders to look beyond their legally-mandated jurisdiction and instead consider a more comprehensive scenario in making decisions. Agenda should be taken into account as to how they will affect the overall city and how feedback mechanisms can be instituted as part of ecological planning.

In terms of contribution of the discipline of Landscape Architecture, the research contributes to the literature related to urban planning, specifically in ecological planning. Discussing units and terms in landscape architectural term (biotope and watershed), it provides a platform to create methodology for ecological planning within the realm of the discipline. It presents the discipline's potential in providing strategies in multi-levels, which has been the inherent character of the discipline in confronting challenges. In effect, this research explores the extent of intervention that the role of Landscape Architects in urban planning. In the Philippines, the role of Landscape Architects has been perceived to be limited to providing aesthetic solution to urban and or environmental problems. However this research demonstrates the possibility of managing urban environment in landscape units and terms and methodology. This can help involve and broaden the discipline's participation and contribution in providing solution to complex urban problems, particularly with the issues faced by Metropolitan Manila.

1.5 Metropolitan Manila

1.5.1 Country Profile

Figure 3: Regional Location of the Philippines

The Philippines is an archipelagic country found in Southeast Asia surrounded by the Pacific Ocean on the east, West Philippine Sea on the West, and Sulu Sea on the south. Formed by more than 7,000 islands, the country's location has placed it in a strategic maritime location. This location, on the other hand, placed the country in one of the most disaster-prone areas in the world as being within the typhoon belt and Pacific Ring of Fire, a very active seismic and volcanic belt in the world. It has tropical climate, experiencing only two seasons annually, the wet (rainy) and dry (summer) seasons. In recent years, the occurrence of these seasons have also shown extreme weather condition with the intensified typhoons and longer drought spell.

The country has an estimated population of 94 million (2010) [1] with an average population fertility at 2.17 percent annually, with the population growth rate declining since 2000, from 2.94 percent to 1.94 percent in 2010. The population composition is considered young with 34 percent are aged under 14 years old. United Nations-Habitat (2009) estimates that 43.7 percent of the population lives in slums. It is considered a middle-income country by World Bank. It is hit by at least 20 typhoons every year based on the record of International Federation of Red Cross (2009).[2]

[1] www.indexmundi.com/philippines/population.html

[2] Roberts, Brian (2011) Manila: Metropolitan vulnerability, local resilience. Planning Asian Cities: Risk and Resilience. Hamnett Stephen, Dean Forbes (ed). Routledge, New York. 287-321. In English

1.5.2 The Metropolitan Manila Region

Metropolitan Manila is the primary urban center and serves the political, social, economic and educational capital of the Philippines. It is composed of 16 cities one municipality, of which Manila is considered the political and cultural center. Also known as the National Capital Region (NCR), other cities that comprise the metropolitan area are Caloocan City, Las Piñas City, Makati City, Malabon, Mandaluyong City, Marikina, Muntinlupa, Navotas, Pasay City, Pasig City, Parañaque Quezon City, San Juan, Taguig and Valenzuela, and the municipality of Pateros. Quezon City has the largest land and most populated area among the component cities. The metropolitan area has a total land area is 636 square kilometer. The metropolis is considered a polycentric megacity with a population of more than 12 million, of which 20 percent fall under the poverty level. The population is expected to climb 13.4 million by 2020.[3] Metropolitan Manila is considered one of most vulnerable among coastal megacities in Asia, being ranked as second in terms of overall vulnerability after Dhaka, Bangladesh[4]

1.5.3. Planning and Development

The history of urbanization of Manila started with the arrival and settlement of Spanish conquerors in 1570 on the shores of Manila, thereby pushing the original inhabitants into the pariah and hinterlands. The first detailed plan by the Spanish colonial government was made in 1831, and was revised in 1842 and 1851. The plan was eventually expanded in 1863 and 1884. At that time they established their colonial city in the walled city of Intramuros.

By 1889, the United States of America took over the colonial rule. In 1905 renowned City Beautiful Movement planner Daniel Burnham was commissioned to draw a plan for Manila. The plan was initially implemented but was halted during the outbreak of two world wars. After the war, rebuilding of the city was inaugurated, which coincided with the expansion and rapid urbanization of the city. In an effort to address the emerging issues of an urbanizing metropolis first Inter-agency Committee on Metro Manila was established in 1972 by the Marcos administration, and consequently paved the way for the founding of Metro Manila Commission (MMC). In 1977, a masterplan for the National Capital Region (NCR), which is mainly composed of the cities that comprise Metropolitan Manila was developed, but not implemented. With the ouster of the Marcos administration, the newly installed Aquino administration established the Metro Manila Authority (MMA) in 1986 to form an overseeing and coordinating body to address metropolitan-wide urban issues. This agency became the Metro Manila Development Authority (MMDA) in 1995. In 1996, MMDA prepared "The Physical Framework Plan for Metropolitan Mania, 1996- 2016, which is subject for periodic review to assess the accomplishment of the agency concerning its target concerns. In 2012, MMDA, with coordination with City Alliance and AustralianAid, came up with the proposal "Metro Manila Greenprint 2030". The complete report and vision paper is expected to be completed on June 2013.

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[3] Roberts, Brian (2011) Manila: Metropolitan vulnerability, local resilience. Planning Asian Cities: Risk and Resilience. Hamnett Stephen, Dean Forbes (ed). Routledge, New York. 287-321. In English.

[4] World Wildlife Foundation. (2009) Mega Stress for Mega-Cities: Climate vulnerability ranking of major coastal cities in Asia. WWF International, Switzerland, 39 pages, in English.

1.5.4. Urbanization of Manila Since the Burnham Plan

A century before, with the vision to develop Manila into a premier capital city in Asia, The United States of America, sought the service of Daniel Burnham to design the masterplan of Manila.[5] The plan resembled the Chicago Plan with its wide boulevards and expansive public open spaces.[6] Being one of the main proponents of the City Beautiful Movement, the masterplan emphasized the importance of large public open spaces. The City Beautiful Movement saw the provision of parks and open spaces as the panacea to the aftereffects of industrialization, such as pollution, urban congestion, public health issues, lack of utilities, and general lack of order.

Previous researches on the Burnham Plan[7] have mainly focused on the analysis of the different urban forms that have evolved since the plan was submitted and subsequently implemented to a certain extent. Santiago (2003) noted that the Burnham plan had integrated the proposed POS with the existing open spaces, particularly Intramuros. The plan provided linkages with the city center using different open spaces, creating an integrated historical core in the city of Manila.[8] On the other hand, Hines (1972) and Lico (2008) both looked at the Burnham plan as a means of enforcing the imperial ambition of the colonizer (United States of America) to the colony (Philippines). Interpreting the wide boulevards and extensive transportation networks that connect the areas of political and economic importance as a means of achieving more political and economic hegemony, it reinforced the ideal embodied in the ideology of the colonizer. These studies have contributed to putting the overall Burnham plan in the context of the urbanization of Manila, while research on the effects of the proposed POS to the present condition of the Manila's POS leaves a gap.

Some of these POS proposed in the plan of Burnham remain at present, some of them have evolved in different form and functions. However, many of the proposed public open spaces remain unrealized and or converted into non-functional definition of POS. The importance of these public open spaces in urban life has never been emphasized enough, especially for a developing country with a capital city that has a population of 1,660, 714 (2007)[9]. Pressures of urbanization have resulted to piecemeal development of public open spaces, lack of adequate maintenance of existing POS, and continued threat of converting POS into more other uses. As an important component in the urban environment, POS provides structure and form to the city, gives identity to different urban communities, maintain the balance of

[5] Hines, T.S. (1972) The imperial façade: Daniel Burnham and American architectural planning in the Philippines. In Pacific Historical Review, Vol. 41 No.1 University of California Press, 33-53 (in English)

[6] Lico, G. (2008) Arkitekturang Filipino. The University of the Philippines Press, Quezon City. pp. 243-250

[7] Plan of proposed improvements (1905). In United States Philippine Commission. *Annual Report of the Philippine Commission, Bureau of Insular Affairs, War Department*. Government Printing Office: Washington, D.C.

[8] Santiago, A.M. (2003) The restoration of historic Intramuros: a case study in plan implementation. School of Urban and Regional Planning University of the Philippines and UP Planning and Development Research Foundation, Inc. pp. 50-54 (in English)

[9] http://ww w.citypopulation.de/Philippines-MetroManila.html

land use, provide spaces for recreation, preserves spaces with scenic and historic qualities, protect important ecological resources and natural systems.[10]

It has been observed that the POS, which forms the basic green infrastructure of the urban environment, suffers the effects of urbanization. To present the change in the urban environment before Manila experienced rapid urbanization, an evaluation of the Burnham plan is conducted to present how this has influenced the formation of POS in Manila. The present condition of Manila's POS is evaluated using the typology of Burnham's open spaces and analyzed using the Functional Approach to determine if the present POS serve similar function and form and what function and form of the present POS have evolved.

The POS in the Burnham plan of Manila can be classified into six major typologies based on their function. These typologies include: (1) Sea Boulevard, (2) River Drive, (3) New Luneta, (4) Parks and Parkways, (5) Play Fields, and (6) Informal Parks. The Sea Boulevard is basically a 250-foot wide parkway that connects the government main mall and the neighboring province of Cavite. It is a wide boulevard that has tramways, bridle path, plantation and broad sidewalks. Similarly, the River Drive is an esplanade that follows the form of the Pasig River, mainly for recreation and to ameliorate the tropical heat.

The New Luneta was an expanded open space formerly known as Bagumbayan, which Burnham proposed to extend towards the Manila Bay to take advantage of the scenic panorama of the Manila Bay. This area is envisioned to become a large pleasure park that will play an important role in the civic activities and political exercise.

Scattered around the city are the Parks and Parkways, which are open spaces intended to provide "breather" in the more urbanized center of the city. The Play Fields are actually nine public resorts with facilities for both indoor and outdoor sports, leisure facilities, and social halls. These are strategically located around the city to afford all quarters equal opportunity to enjoy the facilities. On the other hand, the Informal Parks are a series of parks around the periphery of the city to contain further expansion of the city. This forms a parkway that allow continuous connections between parks while at the same time serve to house some of the government and semi-public facilities.

When geo-referenced to the existing Geographic Information System (GIS) database of Manila, the POS in the Burnham plan constitute a significant area in the total land area of Manila, which is 35,349,260 square meters. POS comprise more than18 percent of the total land area, in which the rest is devoted to built-up areas and Others (roads, transportation lines, ports, and utility spaces). Among the POS significant typologies are classified as Informal Parks, which occupy 14 percent of the total area, and Parks and Parkways (2.61 percent), and playfields (one percent). The result of the tabulation is summarized as follows:

The 2003 Land Use data of Manila shows the city in a remarkably different condition. The analysis area is similar to the planning area used in Burnham Plan to present a comparative scenario as to how different the present condition of POS in Manila. It also shows a different layout of many of the different POS. Major clusters of POS are concentrated in the old urban core, in the central part of the city along the bisecting river (Malacanan Palace Park) and the

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[10] Quoted from Northeastern Illinois Metropolitan Area Planning Commission. Open Space in Northern Illinois: Technical Report. No. 2 Chicago. In Rye, RD.S. (1997) Open Space Planning for Quezon City. In Philippine Planning Journal 29 (1), pp. 25-51.School of Urban and Regional Planning, Quezon City. (in English)

northern part (Manila North Cemetery) What is considerably similar is the layout of the (New) Luneta and the adjacent open spaces which constitute the traditional urban core of Manila. The Sea Boulevard has been realized, but is shortened, terminating within the political boundary of Manila.

Comparing this data with the Land Use of 2003, there is a substantial difference in the total available POS as built-up spaces rose to 86 percent of the total land use, leaving about 14 percent to POS. There is a substantial decrease in the area occupied by Informal Parks, which have been mainly overtaken by urbanization. However, there is an increase in terms of area occupied by the (New) Luneta, Sea Boulevard, and River Drive. The increase in area for Sea Boulevard can be attributed to the reclamation of some parts of the Manila Bay to make way for the esplanade, the continuous development of river walk, and the expansion of (New) Luneta (or more popularly known now as Rizal Park). In the process of the evaluation, several POS have emerged which are not encompassed by the classification of Burnham. The typology “Others” is used to classify spaces which are remnants of previous land use but have become POS. These spaces include the former Smokey Mountain, which is basically a hill of decomposing garbage which has been vegetated, a water treatment plant, and other neglected spaces. In terms of definition of POS, these spaces are limited in terms of accessibility since most of these areas are restricted from public use.

Of the nine playfields proposed by Burnham, only one has been realized. This playfield (Rizal Sports Stadium), is the only one that is functional as a sports facility. However, unlike Burnham’s vision of a publicly accessible facility, the Rizal Sports Stadium is only open for use by people authorized by the Philippine Sports Commission, which oversee the facility. Similarly, the Informal Parks, which constituted a sizable area in the proposed plan of Burnham, have virtually vanished and what remains is the Manila North Cemetery.

Comparing the percentage of the different land uses and POS of the Burnham plan of Manila and 100 years after implementation of plan will present a vastly different scenario. The built-up area has dramatically increased from the proposed 69 percent of the total land area, to 86 percent by 2011. This leaves only about 14 percent for POS, from more than 30 percent in the proposed plan. The figures also demonstrate a substantial reduction of Informal Parks from 24 percent to only 2 percent by 2011. Other areas have both increased in relative and absolute value, such as the Sea Boulevard, River Drive and New Luneta.

The figure compares the different land uses between the proposed Burnham plan and the present condition. With the population of Manila in 1903 at 223,029, the POS per capita would have been 27.77 sq. meters, compared to only 5.26 sq. meters by present standard. This reduction of POS to the people of Manila, as exacerbated by the present environmental challenges have an impact on the quality of life of the people.

In terms of urban spatial structure, Wu and Plantinga[11] have identified the effects of open spaces in the structure of the city. They have projected that the city will expand to encompass the open space. This is especially true in the case of the Informal Parks which have disappeared due to its proximity to the city center. Urbanization proceeded at the

[11] Wu, J. and Plantinga, A. (2003) The influence of public open space on urban spatial structure. In Journal of Environmental Economics and Management 46, pp. 288-309. in English.

expense of the open spaces. They have posited also that development is likely to occur in areas with open spaces, meaning POS spur the development of areas that would have otherwise remained undeveloped if there are no open spaces. This is the case the urbanization experienced by the city which has seen the conversion of many of its open spaces into amenity areas, like its esteros, riverbanks, floodplains into places of habitation, and densification of human population around these open spaces.

Analyzing the different POS according to the Functional Approach, Pozo (1979) emphasized that urban designs especially applied to developing countries with historic environment often lose the original intended function of the open spaces. This could probably provide explanation on the preservation of (New) Luneta and its adjacent open spaces. Luneta, being a popular tourist destination, makes it an ideal space for economic activities, while functioning as a political space with its capacity to draw audiences from various socio-economic backgrounds. Contrast of different social groups seeking to find common spaces has led to the specialization of Luneta and the consequent preservation of its original function.

In terms of implementation and management of the different POS, it has been noted that there is no masterplan or agendum regarding open spaces among the overseeing agencies. The overseeing agency has been included to present the reality of the effect of implementation to the overall urban structure of the city of Manila, in which the multitude of implementing agencies have not developed a coherent spatial structure of the urban environment. Different government bodies are managing different open spaces, ranging from the smallest local government unit to the national government. The national government, with the Department of Tourism as the lead agency manages (New) Luneta and Paco Park, both spaces with historical significance. On the other hand, with their different thrust and mandate, the Philippine Sports Commission and the Pasig River Rehabilitation Commission have continued to proceed with their development of their respective POS without reference to a system of POS. The local units of the city government of Manila manage most of the Parks, such as plazas, circles, and community parks.

1.6 Issues of Metropolitan Manila

The research is a multi-level analysis and evaluation of the resilience of Metropolitan Manila. The issues can be classified into two main issues: the biophysical and socio-cultural issues. Biophysical issues pertain to the challenges rooted from the hydrological, geomorphic and biological state of the metropolis. Examples of these include rising ocean level, tsunami, storm surge, and flooding. Some issues such as pollution and biodiversity loss are heavily influenced by anthropomorphic agents, but the main system affected are the biotic and abiotic components such as water, soil, and flora and fauna. Socio-cultural issues, meanwhile is rooted on the influence of the human activities and consequently how these activities resulted to urban problems. Examples of these issues are problems on solid waste, inefficient transportation, visual blight, loss of cultural heritage, proliferation of informal communities and inadequate housing. These issues are included in recognition on the dominance of the influence of human activities in the urban environment and how they have shaped the present condition of the metropolis.

For this research it is particularly focused on responding to the challenge of periodic flooding in which residents of the metropolis are constantly exposed to, most vulnerable are the economically underprivileged such as the residents of the informal communities. Many of the informal communities are located in flood prone floodplains and along easements along water channels. The condition and location of these informal communities expose them to the danger of flooding which occurs several times in terms of frequency every year.

On the other hand, the continuous urbanization of the metropolitan region has resulted to the de-emphasis on the preservation and conservation of greenspaces. These greenspaces are important urban components in the provision for recreation amenities, psychological well-being of the residents, and for ecological function, maintaining the natural hydrological processes, pollution absorption, flood alleviation and for maintaining biodiversity of the city. Biodiversity serves as link of the residents to nature, in which it serves multitude of ecosystem benefits. It also serves as indicator as to the livability of the city and how the urban environment can respond to the vulnerability of the city.

One of the significant green spaces in the highly urbanized cities such as Metropolitan Manila is the cultural heritage areas, which have been preserved and conserved because of their cultural value. These spaces, although are being legally protected, are still being under threat as urbanization diminishes their impact amid the conversion of these spaces into other uses and the degree of neglect due to prioritization of other agenda.

These four different issues, having their own issues and impact on the urban environment are considered in this research for having interconnected relationship and needing the most pressing attention in terms of addressing in ecological planning. These four issues discussed specifically as to their impact in Metropolitan Manila and the Philippines.

1.6.1 Flooding

1.6.1.1 Flooding History

Bankoff (2003) provided a historical perspective on the occurrence of flood in Metropolitan Manila, which he explained could actually provide a more in-depth understanding in terms of the interplay of both the environmental and urban factors that have led to the vulnerability of the metropolitan region to flood.

Flood in Manila has been documented as early as 19^{th} century when strong rains coincided with high tide could render the area now known as the City of Manila as a virtual “lake” requiring its residents to use canoe to navigate the flood. As the city expands to the surrounding marsh, the frequency and magnitude of flood intensified, in which workers in cigar factories in Arrocerros are known to have worn high-heeled sandals to reach their workplace.

In 1950 areas below 12.5 meters above sea level such as Tondo, Sampaloc and Santa Mesa and low-lying barangays in Quezon City, San Juan and Mandaluyong were periodically flooded. Prior to this, in 1942, the first widely-recorded when the city was submerged for several days. The effect of urbanization has seen its effect as the city spread to the east of Manila and the built of structures along the banks of Pasig River have led to the narrowing and reduction of depth of drainage channels by late 1950s. By 1960, as much as 70 percent of the city was submerged to flood with depth ranging from 3.6 to 4.5 meters. Many of the highly dense communities that have sprouted along the Pasig River were highly vulnerable to being swept away by floodwaters due to flimsy construction.

Soil erosion, resulting to murky floodwaters, along with siltation and deposition of garbage along drainage channels, restricted the flow of water in 1970. Residents of Malabon and Navotas along with Manila, Quezon City, Pasay and San Juan experienced regular flooding. The accumulation of silt has reduced the water-holding capacity of Laguna Lake by 64 percent while surface runoff from biologically-altered watersheds increased flood depth by 2.7 meters, thereby resulting to the worsening of flood conditions in low-lying communities along the banks of Laguna Lake in 1980. The level of flood continues to rise in 1990 particularly especially in the south and south-east and in the northern cities of Caloocan, Malabon, Navotas and Valenzuela. Major flood events recorded are in 1948, 1966, 1967, 1970, 1972, 1977, 1986 and 1988 when water overflowed from the main rivers and canals. The floodwaters brought by Typhoon Miding (1986) covered as much as 103.6 square kilometers or more than 16 per cent of the total land area of Metropolitan Manila. Typhoon Unsang in 1988 caused severe flooding in the Marikina basin and the surrounding communities around the Laguna Lake. On 28 July 1995, thousands commuters were stranded on the streets of Manila after heavy downpour. Similar flooding occurred on 28 May 1996 and 18 August 1997.[12] Recent major flood events that affected the whole Metropolitan Manila are caused by typhoons Milenyo (Xangsane) in September 2006 and Ondoy (Ketsana) in September 2009, and during the occurrence of monsoon or Habagat in August 2012.

1.6.1.2 Flood Management

The ubiquity of flood in Manila has prompted governing powers to minimize the effects of flooding in Manila. Bankoff (2003) chronicled the various efforts to manage flooding. During the Spanish occupation, a plan was proposed to rehabilitate the existing water channels or "esteros" for drainage. Due to financial constraints, the plan however was only partially implemented at the end of the Spanish colonization in the Philippines. During the American administration, a sewerage system was constructed from 1904 to 1911. The sewerage system however was designed to serve only half a million urban population. During the two world wars, Manila incurred heavy damage that it took several decades to rebuild the city of Manila. Between 1974 and 1978, the Overseas Economic Cooperation financed a major flood mitigation program which resulted to the raising of the walls along the Pasig River and the installation of seven pumping stations, two floodgates and four drainage mains. This program was initiated after a major flood in 1972.

The Mangahan Floodway Project was inaugurated in 1980 which included the digging of a 10-kilometer long diversion channel to connect the Marikina River and the Pasig River to the Laguna Lake. The lake serves as a catchment basin for 70 percent of the inflow of water from the Marikina River and to avoid inundation along Pasig River. Concerns have been raised since the floodwater only accumulates in the Laguna Lake without any other outflows other than the Pasig River, which inadvertently resulted to what the plan has

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[8] Bankoff, Greg (2003) Constructing Vulnerability: The Historical, Natural and Social Generation of Flooding in Metropolitan Manila. *Disasters,* 27(3): 95–109, in English

intended to avoid – the inundation of areas surrounding the Pasig River. It has been said that there was a proposed floodway outflow channel, but unfortunately did not materialize.

At present the issue of flood management lies on different government agencies, mainly the Metropolitan Manila Development Authority (MMDA) and local government units, depending on the extent of flood. Until 2002, flood management was the responsibility of the Department of Public Works and Highways (DPWH).[13]

1.6.1.3 Present Flooding Condition

Due to low-lying condition of most of the last area of Metropolitan Manila, more than 1.5 million people live in areas less than one (1) meter above sea level.[14] Pasig River is the primary waterway with numerous tributaries that eventually drains to Manila Bay. The city developed from an alluvial deposits at the mouth of Pasig River, while some of the present spaces along Manila Bay are reclaimed lands. It faces serious environmental and urban problems, such as water and solid waste pollution, limited greenspaces and biodiversity loss, traffic and infrastructure inefficiency, and housing problems. It is estimated that almost 60 percent of water pollution is caused by untreated residential sewage being discharged into open waterways or drainage channels, while 5,500 metric tonnes of solid waste are generated every day. The World Wilidlife Fund (2009) ranked Metropolitan Manila as second in rank along with Jakarta in the overall vulnerability assessment of Asian Cities. [15]

1.6.2 Biodiversity
1.6.2.1 Urban Biodiversity

Biodiversity in urban areas is considered an important component of the urban environment. Focusing on the urban flora, it represents the most obvious state of the ecosystem in terms of composition and abundance within the system.[16] It is often characterized as intensively under the influence of anthropogenic activities, that their degree of naturalness has been discussed in urban studies. Traditional studies on urban flora has focused on remnant vegetated areas such as forest and wetland. Current urban biodiversity studies have shifted to include areas that are the result of urban processes such as derelict spaces or wastelands and brownfields, domestic gardens, and matrix level vegetated spaces. Urban spaces, being the center of transportation and commerce, experience high level of traffic, thus resulting to greater chances of introduction of new

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9 Bankoff, Greg (2003) Constructing Vulnerability: The Historical, Natural and Social Generation of Flooding in Metropolitan Manila. *Disasters,* 27(3): 95–109, in English

15 Roberts, Brian (2011) Manila: Metropolitan vulnerability, local resilience. Planning Asian Cities: Risk and Resilience. Hamnett Stephen, Dean Forbes (ed). Routledge, New York. 287-321. In English

16 World Wildlife Fund (2009) Mega-stress for mega-cities: A climate vulnerability ranking of major coastal cities in Asia.1-39, in English.

16 Cilliers, Sarel S. and Siebert, Stefan J. (2011) Urban flora and vegetation: Patterns and processes. Urban Ecology: Patterns, Processes, and Applications. Oxford University Press: Oxford. 148 – 148, in English.

species. This could lead to another particular characteristic of urban flora which is the high species richness. The presence of large number of plant species in urban environment has been attributed to the large number of exotic and introduced species in the urban setting. This may also be due to the adaptation of invasive plant species to the urban condition. There is also bias on certain plant species that are used extensively for urban use, and those species that thrive on being maintained by mowing or from trampling and soil compaction.

1.6.2.2 Biodiversity Research in the Philippines

There has been long history on the literature concerning the flora diversity of the Philippines with Manila as the center of botanic research. The most prominent of these literatures is the Flora of Manila (1912), which detailed the anatomy of the plants and the 1,007 different species found in Manila. It emphasized that there was uniform distribution of plant species in different coastal cities of the country that the species in Manila discussed similarly reflects the species found in places with low altitude in the rest of the Philippines. The coverage of the compilation of the book ranged from Malabon, the northern part of Manila, to Paranaque found in the southern bay south of Manila, with an approximate 100 square kilometer study area. At this period, it mentioned that the area of study is below 50 meters altitude, absence of pristine natural environment, and that the environment has already been modified by urbanization.

It also traced the history of the botanic research in the Philippines with the publication of the first book by Francisco Manuel Blanco's Flora de Filipinas in 1837. Blanco, an Augustinian priest, recorded and classified about 1,150 plants found in the Philippines. The popularity of the book saw six volumes, gaining relevance as an important study on the botanic study of the Philippines at that time. Another notable book is by Sebastian Soler Vidal entitled "Sinopsis de Familias y Generos de Plantas Leñosas de Filipinas" (1883), which is an introduction to the woody plant species in the Philippines. Another notable literary source on the Philippine plant species is by Harry Nichols Whitford, with his inventory of vascular plant species in Philippine lowland forests, "Forests of the Philippines" (1907).[17] Recent contribution on botanic and vegetation biodiversity of Manila is by Armando Palijon, one of which is his collaboration with Noriko Moriwake and Kazuhiro Takeuchi entitled "Distribution of and Structure of Green Spaces in Metro Manila (2002), which surveyed the different tree species distribution of different land uses in Metropolitan Manila. It determined the characteristics of urban green spaces based on their green cover and vertical structure. The paper concluded the need for environmental improvement in built-up areas, maintaining of existing greenery by restricting lot subdivision, and the adoption of rural aspects of greening in urban areas.[18]

[17] Merrill, Elmer Drew (1912) Flora of Manila. Manila: Bureau of Printing, Book, in English.

[18] Moriwake, Noriko, Palijon, Armando M., Takeuchi, Kazuhiro (2002) Distribution and structure of urban green spaces in Metro Manila. Metro Manila: In Search of Sustainable Future. Ohmachi, T and Roman (E.R.(eds) Quezon City: University of the Philippines Press, 185-198. In English.

1.6.3 Poverty
1.6.3.1 Informal Community in Metropolitan Manila

The extensive presence of informal communities in Metropolitan Manila reflects the extent the problem of poverty has affected the social environment of the metropolis. Aside from poverty, the issue of informal community is the result of inability of the government to provide effective housing, particularly for the low-income sector, the burgeoning population, and continuous movement of rural migrants in search of better opportunities in the city[19]. Most of these informal communities can be found along coastal area and water channels, many of them subsisting in poor living conditions. Their condition of which is vulnerable to flooding and their difficulty in recovery after the flood make them the most vulnerable sector in the urban area that experiences frequent flooding.

The Metropolitan Manila is composed of 16 cities and municipalities, foremost of which is Manila - the capital city of the Philippines. It has a population of 11,855,975 (2010), most populous of which is Quezon City (2,761,720), and followed by the city of Manila (1,652,171) and Caloocan (1,489,040).[20] By virtue of the Local Government Code of 1991, the different cities and municipalities are mandated to plan and implement the development of their jurisdiction.[21] It has population density of over 18,000 per sq.km.[22] It is estimated that more than 20 percent of residents live in this polycentric megacity under poverty level. The Asian Development Bank (2003) calculated that 35 percent of the population live in informal settlements It has a population growth rate of 1.5 percent every year. The population is expected to reach 13.4 million by 2020.[23] It is ranked as fifth largest urban population in the world, and second in Southeast Asia[24].

The large number of informal communities in the metropolitan region presents a challenge not only in terms of instituting urban policy, but more so in managing risks to this sector which is often the most at risk among other socio-economic groups. They are distributed all over the metropolis, of which 60 percent are found along ecological corridors or rivers and streams. Industries have been traditionally located along rivers and streams on which it is easier to transport cargoes from water vessels to the factories and some of the these factories also pump nearby water for industrial use and for cooling engines. With the existence of these industrial plants follow the demand for inexpensive housing for their workers, in most cases emerged informal communities. This set-up

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[19] Zoleta-Nantes, Doracie B. (2000) Flood hazards in Metro Manila: recognizing commonalities, differences, and courses of action. Social Science Diliman. Vol. 1, No.1, 60-105, (in English).

[20] www.citypopulation.de/php/philippines-admin.php. accessed 2012 July 08.

[21] www.chanrobles.com/localgov1.html#.T_h71mjTUWE. Accessed 2012 July 08.

[22] World Wildlife Fund (WWF) (2009) Mega-stress for mega-cities: A climate vulnerability ranking of major coastal cities in Asia.1-39, in English.

[23] Roberts, Brian (2011) Manila: Metropolitan vulnerability, local resilience. Planning Asian Cities: Risk and Resilience. Hamnett Stephen, Dean Forbes (ed). Routledge, New York. 287-321. In English

[24] World Wildlife Fund (WWF) (2009) Mega-stress for mega-cities: A climate vulnerability ranking of major coastal cities in Asia.1-39, in English.

between industries and informal settlement created a unique relationship between the two in which their proximity and functional relations have become inextricably linked, resulting to spatial and environmental dilemma to provide affordable safe and more sanitary housing for the workers while still accessible to most workers of the factories. This dilemma is further confounded by the condition in which many of the rivers and streams often are flood-prone, putting a lot of the people in informal communities at greater risk.

1.6.3.2 Risks in Informal Communities

Informal communities, aside from the apparent disaster risk they face, have poor quality of life. The subsistence kind of lifestyle of their residents reflects the substandard living condition that requires intervention from concerned agencies to uplift them from their squalor condition. Their plight has been often been ignored and tolerated, often attributed to the incapacity of the local government to provide the residents with decent housing and urban facilities. In some instances, the sight of informal communities have been rendered invisible by the government that is trying to boost its tourism by building walls around them or through superficial beautification campaign. These measures, particularly the walling of informal communities have said to have resulted to tragic outcomes when fire spread within the walls and effectively trapping the residents inside them. Further, their existence has been largely tolerated since they provide convenient and cheap labor to the different industries and commercial establishments in the metropolis.

Residents of informal communities need to contend with unhygienic and unsanitary environment everyday. With the absence of proper sewerage and waste management, human waste are often discarded wherever is convenient, mostly along water channels. Garbage are strewn everywhere. Shelters are made of makeshift construction from discarded materials in which household members need to eat, sleep and bathe in very cramped space. In conditions where they are located near major road or rail, houses are daily subjected to noise pollution from passing vehicles. Roads/paths are narrow and irregular leading to spaces that do not receive any sunlight. Open spaces are bare existent in which everything competes for space. Common space exists in the form of basketball courts and chapels. Vegetation hardly have space to grow and flourish, except for some potted plants and existing trees that have been integrated as part of structural support for their structures.

Entering an informal settlement, one would be met by words of caution to avoid being in really narrow space and to have someone from the community as a guide. Informal communities have been suspected of harboring unwanted personalities and a hotbed for criminal activities. What is commonly observable in informal communities is the density of people everywhere, and during most time of the day.

1.6.3.3 Adaptation of Informal Communities

In terms of adaptation, people have learned to live with the reality of flood in their everyday life. Residents who have the means and are often exposed to periodic flooding construct their residence with at least two storeys made of concrete to serve as evacuation area in case of flood. Some have raised the elevation of their residences by filling soil to their lot and by constructing stilts. In one community in Barangay Panghulo, Malabon, public utility vehicles have raised their floor elevation to make it them functional even during flood. The municipality of Obando, Bulacan has also raised portions of their sidewalks to make them accessible even during occurrence of localized flooding.

1.6.4. Culture

1.6.4.1 Cultural Heritage in Metropolitan Manila

The presence of significant quantity and quality of artifacts that have cultural heritage value in Manila makes it necessary to incorporate the concept of culture in the holistic planning of the city. The cultural heritage presents the identity of the city and how the city has able to withstand several disturbances by the preservation of its cultural heritage artifacts.

The location of the most artifacts reflects the development of Manila from a coastal settlement into its present urbanized state. The early settlement of Manila started with the small settlements ruled by tribal leaders along the mouth of Pasig River and Manila Bay. It is where they engage in barter trade with other navigators in from China and other Southeast Asian neighbors. When the Spanish colonizers came, they decided to settle in the same area because of its strategic location for trading post and navigational purposes. Similar to the fortifications found in Europe, they constructed the fort surrounded with walls to protect from possible invaders and to define the concept of pueblo. Only those who are part of the Spanish government post and their families are allowed to stay within the walls of Intramuros. The rest of the residents of lived in pariah or outside of the walls, mainly the indigenous residents of the lowland of Manila. As the city of Manila expanded, most of the indigenous residents are forced to live upstream, while the downstream is occupied by the Spanish colonizers and those assimilated to the Spanish-governed society.

In 1898, the Philippines was ceded by the Spanish colonizers to the American administrators. During the American occupation, the capital city of Manila was maintained and they made an effort to create a comprehensive plan of the city by commissioning noted City Beautiful Movement planner Daniel Burnham. The resulting plan was adopted and partially implemented until the onset of the World War I. After the war, the American occupation shifted to the Commonwealth period in which the administration of the government was gradually turned over to the local elite. This change in governance was also reflected in the decision to move the capital to then undeveloped and sprawling Quezon City. The start of the World War II similarly affected this decision and implementation that after the war, the capital was moved back to Manila.

1.6.4.2 Urbanization and Cultural Heritage

The history of Manila and the capital of the Philippines ha dramatically affected the distribution of cultural heritage artifacts listed by NHA. Most of the artifacts are found along the original coastline of Manila and the mouth of Pasig River. They are basically concentrated around the Intramuros in which the original Spanish settlement was made. Civic buildings during the Spanish period are mostly around the vicinity of the Intramuros. However, civic buildings during the American period are found within the vicinity of the Rizal Park, which was conceptualized during the time of Burnham. Although the Bagumbayan existed before, which would eventually be transformed into the Rizal Park, it was not intentionally developed as a public open space. The idea of public open spaces is confined to the plazas formed by the basic layout of the pueblo, as an open space that divide the Catholic Church and the government building. The concept of public open spaces (POS) is embodied in the urban planning during the American period in which they allotted POS in different parts of the Manila. The provision of POS at that time did not only respond to the recreational needs of the residents but also to provide a venue for political exercise, public hygiene, and gain greater hegemony on the people. This is evident in the number of parks found outside the walls of Intramuros, such as the cemetery, botanic gardens and pocket parks.

The shift of the capital to Quezon City has also resulted to the location of important artifacts in the proposed new government center. The new capital is proposed to have the new state university and government center that will house all the branches of the national government. Because of the halt in the implementation, some of the national government buildings are found while others remain in Manila. The extensive open space similar in concept to the Central Park of New York was converted into mid-level residential areas. What remains is the monument of President Quezon, who served as the president during the Commonwealth period, and the contemporary designed church inside the University of the Philippines.

2 METHODLOGY

2.1 Research Framework

The research starts with the inquiry on the existing condition of Metropolitan Manila. As an urban environment, various issues are discussed as to how these affect the condition of the metropolis. The most pressing issues are identified and inter-relationships of these issues are clarified. Since the main issues of the urban areas are mainly environmental and how conflict of these different spaces resulted to the present urban issues, an environmental planning approach is proposed to offer strategies to make the metropolis resilient to the different environmental challenges.

An ecological approach is used in the methodology due to the following reasons: (1) spatial units should be defined according to understanding the environmental conditions and, consequently, strategies, (2) it presents the urban areas based on environmental units, transcending political boundaries, which limit the analysis and evaluation of the environmental conditions, (3) despite being highly urbanized, environmental processes are still present in the urban environment that the neglect of these processes often result to the present problems experienced by Manila, (4) it presents less impact on the environmental processes and respects the environmental pattern and memory, and (5) it is holistic and comprehensive that ecological plans actually translate into resilient management of Metropolitan Manila.

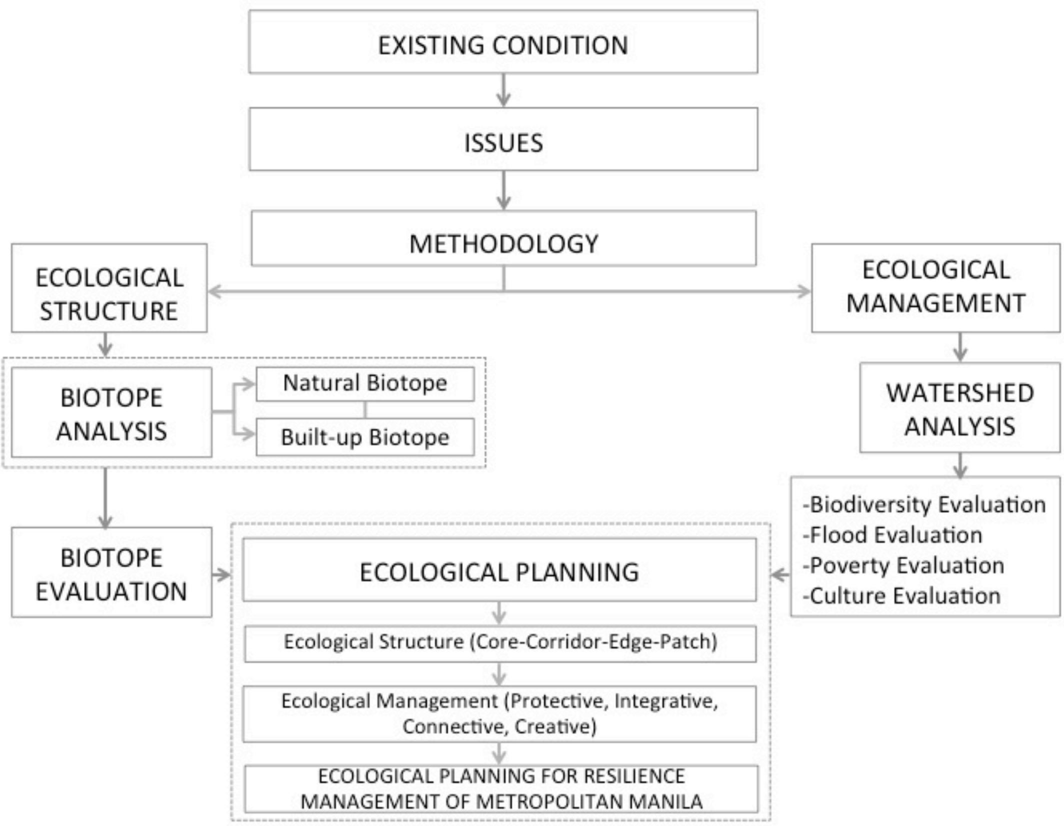


Figure 4: Research Framework Diagram and Research Flow

The biotope is an important tool in understanding the present condition of Metropolitan Manila. It utilizes information about the geography, soil, and landcover to show the present structure of Manila. These information are combined to form an ecological based analysis, showing both the natural or semi-natural components of the environment and the built-up spaces, in which how these spaces should be managed can be proposed to improve the current condition. The different typologies are reflected on the data sheet and consequently translated into a biotope map, which is an important information from where analysis, evaluation, and strategy can be deduced.

Following the clarification of main issues faced by Metropolitan Manila the research flow follows the succession of analysis, evaluation, and provision of strategies of the ecological structure. The ecological structure is based on the existing and potential connectivity of different ecological functions of different green spaces, delineating the spaces as core, corridor, and edge. With the ecological structure formed, the spatial units of the different ecological functions are analyzed based on the biotope types that comprise them.

Ecological management concerns with the use of watershed as the basic unit in which the different issues are evaluated. Basic watershed unit as micro scale is derived that comprise the overall regional watershed that forms the macro scale. Each basic watershed unit is evaluated in terms of its composition of biodiversity, flood risk, prevalence of informal community, and presence of cultural artifacts. These issues represent the major issues faced by Manila, namely biodiversity, flood, poverty, and cultural heritage.

With the definition of the ecological structure and evaluation of the different issues in ecological management, the ecological planning is the final stage in which strategies are proposed for resilience management. The resilience management is based on creating connectivity and linkages to optimize ecological performance of the ecological network. An optimally functioning ecological network translates to the ability of the environment to absorb and develop new stable condition in the face of disturbance. This ability of the ecological network makes the environment resilient against the environmental threats that affect the biodiversity, danger of flood, exposure to risk of informal community, and loss of cultural heritage artifacts.

2.2 Research Method

Spatial units are defined by geographic and hydrological characters such as landform and soil type. Landforms are both the result and part of the process that shape the geology. Slopes and shapes of the land can serve as both indicator of the hydrological processes and disturbances in the landscape. Soil type, on the other hand, is a product of a long period of weathering, the most potent of which is the hydrological processes. The kind of processes and vegetation is manifested on the type of soil. Certain vegetation types are adapted to certain hydro-geophysical conditions such as the coastal zone where drainage is different compared to higher terrestrial zones and slopes where erosion is a constant presence resulting to thinner soil cover. Even for highly urbanized condition, these factors contribute to the definition of spatial units of the watershed. These information are reflected in the data sheet of the biotope typologies. Aside from those mentioned, the data sheet includes information on the species composition of typical vegetation or urban regime, wildlife that are present, description and character of the typology, distribution of the typology over the region, and analysis according to the different functions such as biodiversity, flooding, poverty, culture, amenity, and productivity. The analysis represents the value of the biotope type in responding to the different function, such that biotope type that maintains more natural vegetation structure has higher value in diversity and in their ability to withstand disturbance of flood. Biotope type that has been protected form encroachment of informal communities will have high value in terms of presence of informal communities. Biotope type that has been designated as cultural heritage sites will similarly have higher culture value. Those that serve as an important space for leisure and recreation have higher amenity value, while those that are used in the production processes, such as for agriculture and aquaculture, have higher productivity value.

The different pillars, namely biodiversity, flooding, poverty, and culture, are evaluated to relate to the concept of resilience management. Common response using this approach is the removal and changing of land use from the disturbed areas so as to minimize damage and loss such as in the case of flooding in certain areas where those affected are removed. The most common affected sector is the informal community that is located in highly flood-prone areas. On the other hand, the other concept of resilience management, which serves as the central focus of this research, is the promotion of resilience management. Resilience management looks beyond the need of the immediate but responds in terms of providing a lasting response to the inherent vulnerability of the metropolis. The reality of flood is accepted as an event that occurs periodically and that to fully attain long-term resilience, spaces that are highly vulnerable to flooding needs to be reconsidered in terms of use and have to be integrated to the overall structure of the urban environment. This implies the need for an ecological structure in which the different patches of greenspaces in the urban environment are connected to other patches, particularly the ecological core which serves as genetic bank for species dispersion and linked by corridor that serves for the migration and movement of species. The concept of culture is further added to reinforce the long-term resilience management in which these cultural heritage artifacts have lasted for a long time and that their historical significance should be extended for the next generation to witness and to promote the identity of the Philippines. They also reinforce the need to provide more greenspaces that serve as buffer from activities and land uses of the surrounding urban environment. Watershed management considers the hydro-geological processes in analyzing and evaluating the space. Spatial units are defined according to the different factors that shape the basic watershed units. The basic watershed unit forms the smallest unit and can serve as the smallest scale in analysis in landscape scale. One of the basic features in using the watershed as the basis is the flexibility of scale of analysis, in which the basic watershed unit basically resembles the larger watershed scale since it follows the function of water in a basin. The watershed defines the spatial boundary, which in most cases transcend artificial boundary. The system form by streams and basins are present in all spaces, making it applicable in most cases for ecological study, and hence ecological planning.

The basic watershed units were derived using spatial analyst tool of the Geographic Information System (GIS). The principles used in classifying the stream hierarchy utilize Strahler's system of classification, in which the watershed units are generated using geoprocessing tool by analyzing the hydrology of the different drainage basins. The stream hierarchy uses up to the fourth order of the stream to define the basic watershed unit.[25] The ground elevation was set at zero (0) meter above sea level. The watershed region map of the metropolitan region was generated by determining the adjacent polygons connected by streams covering the greater part of the metropolitan region. The connected polygons form a larger scaled watershed, or in this case sub-watershed. In the regional scale, it is defined by a system of sub-watersheds that form the structure of the stream regime for the specific region

[25] Strahler, A.N (1957) Quantitative analysis of watershed geomorphology. Transactions: American Geophysical Union, Vol. 38, No. 6, 913-920. In English

2.3 Planning Concepts

Foremost of the concepts used in this research is **Urban Resilience**. It is defined as of the "the degree to which cities are able to adapt to the consequences of catastrophic events, failures or changed environments situations, often by reorganizing themselves around a new set of structures and processes" (Alberti et al., 2003). Disturbance in the context of research is based on the effects of the four pillar on the present ability of the urban environment to develop adaptation to the this disturbance. The disturbance comes in the form of biodiversity modification, flood, exposure to risk of informal communities, and loss of cultural heritage sites. This is strongly correlated to the concept of the green structure, which for the purpose of this research is used interchangeably with **Ecological Structure**. The green/ecological structure is defined as "all public and private urban spaces that are not built or otherwise fully impervious" (Jense et al., 2000). Aside from providing habitats for flora and fauna, it serves amenity purpose, the construction and maintenance of which to different degree limits of biodiversity.

Different ecological functions that comprise the ecological structure include the traditional concept of core, corridor, and matrix. The Core is "green areas with significant ecological values that need protection and management appropriate for maintaining both biodiversity and recreational and cultural values" (Lofvenhaft et al., 2002). **Cores** are important spaces in that serve as environmental anchors having potential for being the source of genetic supply and should have ecological integrity. For the purpose of this research and definition, these cores are limited to those with land area of at least 100 hectares, complex vegetation structure, and has potential for connectivity with the corridor. The **Corridor** is "narrow strip of land which differs from the matrix of either side; may be isolated strips, but are usually attached to a patch of somewhat similar vegetation (Forman and Godron, 1998). Any other spaces that exist between the core and corridor, having smaller patches against the background of prevailing environmental character, in this case most probably built-up spaces, are considered as the **Matrix**. It is defined as "a surrounding area that has different species structure or composition" (Forman and Godron, 1998). Because of the sensitivity of the interface between the land and water processes being in the coastal environment, additional function is added to form the ecological structure. The **Edge** represents the coastal zone, which serves as transition point between the terrestrial and aquatic environment. It is the "outer band that has environment significantly different from the interior of the patch" (Forman and Godron, 1998).

2.4 Analysis Method

Flooding is considered in urban context as the cause and effect of urbanization. The assumption is that flooding is a natural event and that urbanization occurs along flood plains in coastal cities due to the rich soil on the floodplains. The deposition of organic materials along the floodplains resulted to intensified agriculture, which leads to higher productivity. This phenomenon allows the community to flourish and served as a magnet to other people from other places, thus leading to inflow of migration. The concentration of people in the very limited land in the flood plains has resulted to urban problems, primary of which are inadequate housing and alteration of natural drainage pattern. The changes in the natural drainage pattern, consequently led to the worsening and increasing frequency of flooding in urbanized areas.

The flooding is analyzed based on the intensity and frequency of flooding. The flooding map is based on the Flood Map produced by the Mines and Geosciences Bureau of the Department of Environment and Natural Resources. The map from the bureau indicates the flood prone areas according to the two (2) to 10 year-cycle and 50 to 100 year-cycle. The flood map is geo-referenced to the regional watershed map of Metropolitan Manila in which the macro flood hazard map is determined. To examine the effects of flooding on the meso-scale, flooding map of the Pasig sub-watershed is derived.

The micro scale is focused on the community of Baseco Compound which has been historically recorded to have experienced flooding. This is also reflected on the macro and meso-scale maps. The effects of flooding to the community is analyzed based on a respondent survey among the residents in which their demographics, awareness, experience and adaptation to flood is recorded and analyzed. Further, certain factors are also used to study the associative relationships of certain characteristics of the respondents with regard to flooding.

Biotope is defined as "a living place which can be separated from the physical environment around it by features like land shape, structure and even living communities within it, which has a certain size and homogenous characteristic"[i] The importance of biotope maps include: (1) preservation of existing urban ecosystem; (2) transfer of ecological legacy to future generations without disrupting the analysis and interpretation of biological assets; (3) obtain information that can be useful for ecological planning and protection of nature; (4) maintaining the living environment that serves as habitat for both human and non-human inhabitants of the city; (5) protection of the surrounding rural areas; and (6) optimization of sustainable planning decisions related to urban development.[26] Various vegetation types (function) and topographical character and natural connective links (structure) are identified to form the basic green structure of the region.

With emphasis on the hydro-geological aspects of the biotope, the mapping of the different spatial units with the inclusion of the vegetation and cultural components reflect the relationship between the biotic and abiotic components. The degree of urbanization as measured by paved surface and the presence of vegetation affects the drainage pattern, thus influencing the flow. In the case of highly modified environment, vegetation cover

[26] Yilmaz, B., Gulez S., Kaya, L.G (2010) Mapping of biotopes in urban areas: A case study of the city of Bartin and its environs, Turkey. Scientific Research and Essays Vol. 5 (4), pp 352-365, in English

has been altered so as to reflect the typology of the watershed, certain areas still exhibit the influence the type of vegetation in specific hydro-geological character.

In terms of analysis, the biodiversity is analyzed based on Species Importance Value and Species Richness. The Species Importance Value is the sum the different indices such Relative Density, Frequency, and Coverage. The resulting value is then rank to determine the dominant species within a specific biotope. Important factors that are significant in theis analysis are the dominance of the species in terms of size (height and diameter at breast height (DBH) and the frequency of the species in the biotope. The formula for the Species Importance Values is as follows:

Importance Value (IVi) $IV_i = RD_i + Rf_i + RC_i$

Where: Relative density (RD) $RD_i = n_i/\Sigma n_i$
Frequency (Rf) $Rf_i = j_i/k$
Coverage (C) $C_i = (a_i)(D_i)/n_i$

The vegetation structure serves as the basis in terms of complexity and their potential in perpetuating dispersal of species and their adaptation to disturbance. Biotope areas that have more complex vegetation structure and exhibit stable composition, such as those that have mature trees and mangroves are considered biotopes with high biodiversity. On the other hand, grasslands and extensively utilized greenspaces such as for agriculture and aquaculture are considered moderate in terms of biodiversity because of the inherent transient characteristics of their species composition. These different measures of biodiversity are then analyzed as to their relationship with the watershed, particularly the how the stream system (upstream, midstream, and downstream) relates to the biodiversity.

2.5 Data Setting

The research utilizes a multi-level approach to come up with the analysis and evaluation of the ecological planning of Metropolitan Manila. The research recognizes the limited information related to the topic that most of the research data need to be generated or that information available need to be further processed to be useful for research. The sources of information that are used for the research are: the Department of Environment and Natural Resources (DENR) for the Soil Map and Flood Map, the Metro Manila Earthquake Impact Reduction Study (MMEIRS) for the baseline GIS information of Metropolitan Manila and topographic map, the Rizal Library of Ateneo de Manila University for the Burnham Plan, and the National Commission for Culture and Arts for the list of cultural heritage sites and monuments. The rest of the data, particularly maps used in this research have been generated using GIS, Google Earth, Aerial photographs, photo-documentation, field survey, respondent survey and informal interview, and secondary sources and references (books and journals.

The different phase of research includes the following methods:

Determine an ecologically-based boundary of research area.
Since the research site has been decided to be Metropolitan Manila, an approach is needed to determine the extent of area of study that have ecological basis aside from the politically and economically defined boundary of Metropolitan Manila. In this case, a watershed analysis of the metropolitan region is used to determine the different watershed basins that comprise Metropolitan Manila. Using Geographic Information System (GIS)'s Spatial Analyst tool, the watershed boundary is derived in which the basic watershed units were generated. The principles used in classifying the stream hierarchy utilize Strahler's system of classification, in which the watershed units were generated using geoprocessing tool by analyzing the hydrology of the different drainage basins. The stream hierarchy uses up to the fourth order of the stream to define the basic watershed unit.[27] The ground elevation was set at zero (0) meter above sea level. The watershed region map of the metropolitan region was generated by determining the adjacent polygons connected by streams covering the greater part of the metropolitan region. The watershed region is formed by determining the major stream system(s) that forms the various webs of tributaries and distributaries that consequently connect the basic watershed units. Based on the major stream system(s), different sub-watersheds that encompass the watershed region is determined.

Since the watershed boundary transcends political boundaries, only watershed functions that cover most metropolitan region, using stream system as a basis of determining the relationship of different polygons, which translates into basic watershed units are considered. On the other hand, there are instances when certain basic watershed units extend beyond the metropolitan area, these units are considered as part of the watershed region since they are part of the whole system.

Define the different spatial units using geo-physical and biological characters.
Once the boundary has been established based on the geographic and hydrologic character of research area, geo-physical and biological characters need to be considered in determining the different spatial units. In this case, the biotope is used to define the spatial unit using abiotic and abiotic components.

The abiotic component is composed of geo-physical character which is composed of landform and soil. Relating to the watershed basis in determining the basic watershed units, geo-physical character similarly reflects the abiotic component that shapes the biotope character. The landform is shaped by various environmental processes that consequently affects the biotope character. Factors such as elevation and topography influences the processes and community of organisms that exist in a defined area. Similarly, soil, which is function of biological-physical (bio-physical) processes are differentiated depending on their composition, structure and texture. The kind of soil determines the communities of both flora and fauna, and similarly these communities have an effect on soil character. Certain plants are adapted to specific kinds of soil that any change in the soil character would have adverse impact on the plant community, and the effect extends to the animals that developed their habitat in the community. On the other hand, leaf litters, latext and acidity of decomposed plants similarly affect the soil

[3] Strahler, A.N (1957) Quantitative analysis of watershed geomorphology. Transactions: American Geophysical Union, Vol. 38, No. 6, 913-920. In English

quality. In the context of the watershed, the soil regime is heavily influenced by hydrological processes as agent of nutrient carriers and break down of soil. Furthermore, the role of human communities affects the soil as they alter the permeability, porosity, compaction, and hydrology of soil by virtue of their activities and development.

Meanwhile, biotic components is composed of green and cultural spaces. Green spaces pertain to both natural and human-modified spaces that allow perpetuation of biological processes characterized as self-regulating and requires little or no human interference.

Identify and classify the different spatial units according to ecological structure model.
Different spatial units are classified according to their function to the ecological network. Basic ecological network classification includes patch, corridor and matrix. For this research, the ecological network is modified as to include the core, corridor, edge and matrix. Core is used instead of patch to assign spatial unit or units that serve as significant species database and as a green space that optimize the function of natural processes. Meanwhile, edge is added as a significant part of the network since the coastal character of the Metropolitan Manila requires to view the coastal environment as an interface between the terrestrial and marine environment in which major processes occur, including flood.

Analyze and evaluate the composition and character of the different composition of the ecological structure.
Different spatial units are characterized based their hydro-geologic and biotic characters. Hydro-geologic characters refer to features that include abiotic component, specifically the landform and soil type. These abiotic components are considered more of as the watershed character of the spatial units. On the other hand, biotic components include biological classification such as forest, grassland and mangroves, as well as product of human arrangement such as residential, commercial, institutional and industrial, which are all under the classification of "urban", and informal communities.

Identify factors that challenge to the ecological management.
The different spatial units, having their specific role as part of the ecological network, are assessed in terms of their vulnerability to flood. The edge plays a very important role in terms of how it processes the interface between the marine and terrestrial environment in the coastal environment. The corridor serves as main a conduit of the hydrological flow from the upstream biotope down to the downstream biotope and edge, and eventually to the Manila Bay. The core, on the other hand, serves as interceptor of runoff and sponge to absorb runoff. Cores found in the upstream in particular play important role in optimizing hydrological processes such as soil infiltration and percolation and also in reducing the velocity of runoff.

Propose a strategy that aims to improve the ecological structure for resilience management.
Using the ecological network structure, biotopes are identified that are vulnerable to flood and that can accommodate the function of natural processes. These spaces need to be, as much as possible unpaved and minimally built-up so as to optimize the natural processes without human intervention. Other spaces such as the matrices serves as urban centers in which human communities can be developed. The resulting urban structure within these communities is going to be compact and dense to optimize utilization of land while allowing green spaces to accommodate hydrological and biological processes.

Being a multi-scale research, it is important to analyze and evaluate the green structure in various scales to gain greater insights on the present condition and potential of the green structure. For this research a hierarchy of research area is used: these are regional (macro scale), district (meso scale), and community (micro scale). The ecological planning of Metropolitan Manila is evaluated based on the varying scales that encompass the planning area. Based on the watershed analysis of the region, different habitats have been determined. Habitats are patches in macro scale which are composed of various biotopes

2.6 Review of Related Literature

The importance of analyzing urban spaces using ecological approach has been gaining grounds and various approaches have been initiated to offer alternative or supplement the current paradigms. The concept of resilience has been gaining grounds in the field of ecological planning that the need to integrate it has never been as relevant. The concept of resilience management has been explored in various literature of ecological planning. Ecological planning utilizes basic concepts such as watershed and sustainability, in which various literatures covered these topics.

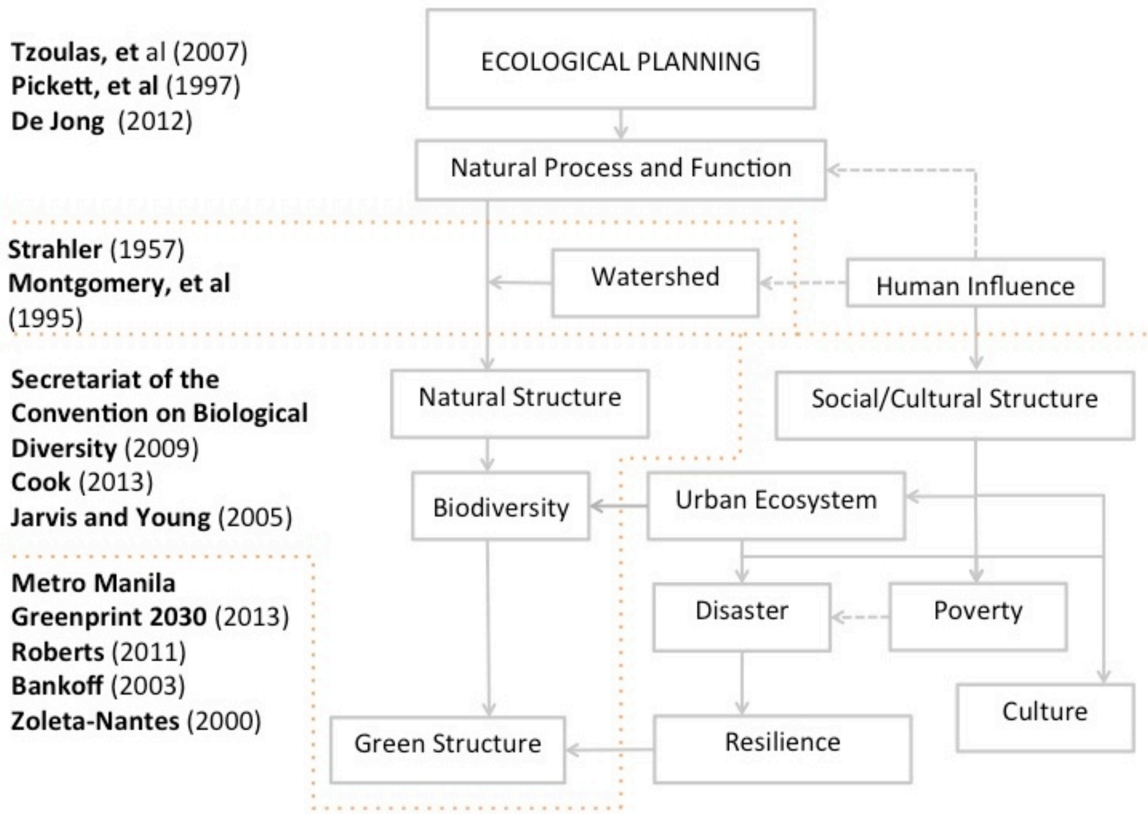


Figure 5: Diagram of Topics Discussed in Review of Related Literature

Strahler, Arthur N. (1957) Quantitative Analysis of Watershed Geomorphology. Transactions, American Geophysical Union. Vol. 38, No. 6. 913-920, in English.

In 1957 Forman laid out the basic principles of landscape ecology, emphasizing the importance of these watersheds as unit of analysis and how these drainage basins are modified over time and by intervention of humans, and in turn affects the landscape and spatial pattern. He reviewed the progress progress made in quantitative landform analysis applied on watersheds, which is based on dimensional analysis and principles of scale-model similarity. He assigned streams with certain order in which the smallest tributary is designated as Order 1, while Order 2 is formed when two first orders are joined, and so forth. The main stream on which all the water is drained is the stream with the highest order. The importance of this principle of stream order is that the size of the watershed is reflected on the order of the streams, which makes it possible to have similar quantitative basis in determining the spatials scale of watersheds for comparative study. Other implications of this principle are: length of stream reflects the scale of units of the drainage network, area of the basin reveals the total runoff or sediment yield and the positive relationship between area of the basin and stream order.

Montgomery, D.R., Grant, G.E., and Sullivan, K. (1995) Watershed analysis as a framework for implementing ecosystem management. Water Resources Bulletin, Vol. 31, No. 3, 369-386, in English.

This groundbreaking research resulted to more examinations on the role of watershed in the landscape. Analysis using the watershed framework presents a more comprehensive landscape scale context in integrating environmental and ecological processes in coming up with environmental management decisions. The article espouses the utilization of water analysis as basis in ecological management. It aims to reconcile the current practice of using land use in making decisions in terms of managing land and resources. The paper discusses the importance of ecological management in current practice, which emphasizes project-based based approach in managing resources. The current practice resulted to continuous degradation of the environment, thus the need to come up with a framework that addresses the balance between economic and ecological concerns in land management.

Ecosystem management involves the application of ecological principles in making land use decisions and condition of the environment. It is principally based on fundamental maintaining ecosystem integrity while being able to keep the benefits humans derived from the environment. In the process, it requires reconsidering the historical practices of land use planning and decision-making by evaluating the impact of projects. It calls for preemptive approach in terms of mitigating future impacts of certain decisions or projects. The following are the principles behind ecological management: (1) preservation of ecological integrity by maintaining the reproduction of population of all species present; (2) customizing land management based on landscape conditions, limitations, and potential; (3) recognition of the different capacities of various parts of the landscape in accommodating various activities over time and potential for disturbance; and (4) empirical-based information centered on resource management is given more weight rather than proposed projects.

In this aspect, watershed-based analysis is proposed as a viable framework in ecological management. It clarifies that it does not determine the management option that should be taken but provides information in which land management decisions can be based. It can provide watershed-based information and practical framework for spatially-defined units to characterize the physical and biological processes that exist. These processes can be further analyzed based on their spatial distribution, history, connections and systems. It basically considers three dimensions of planning: time, space, and process. It relies mostly on the integration of field analyses and assessment, in which constant monitoring is necessary to supplement management plans to achieve the planning objectives.

In terms of application, it is an important tool in analyzing multi-scale spatial units. It identified usual spatial hierarchy: regional, provincial, watershed and project. It mentions the importance of regional planning concerning development and flood control. Because of the inherent differences in various spatial scale and processes that are present in different watersheds, the authors admitted that there is no uniform procedure and analysis for each case. However, it utilizes question-driven approach in implementing input management. Basic questions, including (1) the processes present in the landscape, (2) history of disturbance, (3) current conditions, (4) patterns of change, and (5) sensitivity of the ecosystem to future land management, need to be considered in coming up with informed decisions.

The ecosystem management framework in an important work in terms of ecological management since it asserts the importance of ecologically-spatially-defined units in planning. Comparing it to other landscape-level analytical tool, it addresses the major concerns of landscape capacities, ecosystem integrity, empirical basis, flexibility, ecologically-relevant units, and multi-scale as a planning framework. It relies heavily on watershed and geomorphologic-based analysis, while covering, to a certain extent, biological processes, it is necessary to incorporate biological component and urban-related concerns since a lot of studies have been centered on extensive utilization of resources in urban areas. It also carries certain similarities with other ecological-based frameworks, such as the environmental planning assessment, which do not fully explore the urbanizing condition of most spaces.

He, Chansheng, Malcolm, Stephen B., Dahlberg, Kenneth, A., Fu, Bojie (2000) A conceptual framework for integrating hydrological and biological indicators into watershed management. Landscape and Urban Planning, No. 49, 25-34, in English.

Watershed management is an important framework in planning urban areas, particularly in urban areas. The main objective of the framework is to modify the landscape structure towards a desirable state. The article proposes a conceptual framework to consider both hydrological and biological indicators to understand the condition of the watershed in different spatial scales. The indicators are used to monitor changes in the environment and their effects on "ecological services, human health, aesthetic and recreational activities, and the degree of integration of human, natural, and management sciences". The indicators serve to document the changes in the landscape structure that is reflected on the flow of energy and species composition. It takes into consideration the effect of human activities that modified the environment thus resulting to the distribution of energy and the spatial and temporal changes in the watershed and ecosystem. Analysis of these factors can indicate the performance of the landscape structure.

Considering the effect of human activities on the watershed, the framework prescribes the intervention of human associations to enable the landscape structure to reach its optimum level. Watershed management requires partnership among the local government, business sector, research and the academia and the stakeholders. Using information generated from this interaction can result to more informed information which can lead decision-makers and planners to more effective watershed management.

Strahler set the foundation of the basics of watershed as a basis in ecological planning. Because of the presence of watershed in all areas of ecological planning, the watershed concept becomes an important component in terms of defining the structure and setting the boundary of research in ecological planning. Montgomerry et al on the other hand focused on the application of watershed principles in planning, emphasizing potential and and impacts of watershed in the ecosystem. This is further elaborated in He et al's discussion on watershed used as a framework in various scales.

The concept of resilience management is considered under the rubric of sustainability and ecological planning. Short-term resilience management is discussed in the following literature:

Roberts, Brian (2011) Manila: Metropolitan vulnerability, local resilience. Planning Asian Cities: Risk and Resilience. Hamnett Stephen, Dean Forbes (eds). Routledge, New York. 287-321, in English.

In a compilation of country studies of different Asian countries, Planning Asian Cities: Risk and Resilience (2011), different megacities in Asia are analyzed in terms of the risks and threats they are facing and how they managed these challenges. These megacities experienced rapid development and urbanization, resulting to a population of at least 10 million. The first chapter introduced the concept of megacities and how these cities evolved, mostly coinciding with the emergence of nation-states in mid-20th Century. This has further intensified at the last quarter of the century as the world entered the era of integration of their economies to the world economy or globalization. While each country have varying degrees of success in terms of economic development, all of the countries, including Tokyo, Beijing, Shanghai, Seoul, Taipei, Hong Kong, Singapore, Kuala Lumpur and Putra Jaya, Jakarta, and Manila, are all considered to strive or maintain a world city status.

Different authors tackle each city study starting with the discussion of the urbanization and development experienced by the city. It acknowledges the following factors that contribute to urbanization: rural-urban migration, fertility rate in cities, and the shifting of boundaries as cities encroach on adjacent or neighboring rural areas. Evaluation of different governance framework on policies for spatial development and citizen participation in the planning process is given emphasis, citing the case of the recovery effort after the Kobe earthquake. The Kobe earthquake experience is an example that demonstrates the importance of social capital at the local level.

In terms of vulnerability, these cities face increased risk and exacerbated disasters due to poor land use planning, mismanagement of the environment, and lack of regulation. The concept of vulnerability covers risks and disasters from three dimensions: economic, social, and environmental. It asserted that poverty contributes to the increased vulnerability of these cities and restricts their recovery. As a framework, it reiterates the importance of having an anticipatory planning approach to hazard, emphasis on moral rather than actuarial planning, the participation of the citizens in planning, and a bottom up approach in recovery planning.

The case of Metropolitan Manila is discussed by Roberts (2011) on the chapter "Manila: Metropolitan vulnerability and local resilience". The author started with the concept of urban resilience, highlighting the impact of seemingly localized phenomenon to the city and even in the global scale. The complexity of risks faced by cities has created a gap in the policy among city and government managers to address disaster prevention, management, and recovery. The author devised a multi-level framework to assess risk and resilience. The first level elaborates on the different types of risks that affect Metropolitan Manila and how they are mitigated and responded to. The second level focused on three case studies of local governments' responses, and the third level summarizes the lessons learned to improve resilience. The author proceeded on tracing the development and planning of Metropolitan Manila, and how the absence of an effective metropolitan governance and planning has resulted to Manila's inability to effectively manage its urban development and prepare for its future environmental, economic, and social challenges. He attributed the unsustainable patterns and increased risk to ineffective planning and lack of political will of various levels of government to implement plans or enforce regulations. Inadequate and failing infrastructure and informal settlements in high-risk areas led to a megacity exposed to high levels of social, economic and environmental risks. Concerns are raised regarding the condition of the urban poor living in informal settlements living in flood-prone areas, making them the most vulnerable to the disaster. Flooding is considered to cause the most damage to infrastructure and buildings.

To discuss the framework for assessment risk and resilience, three local government units are considered for case studies as to their experience in coping with certain risks. The case of the city of Marikina City is used to discuss how local residents managed to regain their economic viability as they struggle to compete in the globalized shoe market. On the other hand, the case of Payatas dumpsite is discussed as to its experience after a portion of the dumpsite collapsed and resulted to the death of hundreds of residents living near the dumpsite. Lastly, a former dormitory community, Taguig city emerged as an example of low-cost housing development. The parallelism of these three case studies rests on the idea of active participation of local communities and private sector in the recovery phase.

The approach in the case of Manila showed certain degree of success on local level but it does not emphasize enough the need for a comprehensive and holistic approach in developing a framework that can respond to increasing resilience of the city. The discussion of case studies is limited to one dimension of risk, although the author mentioned the interconnection of nature of dimensions of risk. It acknowledged the polycentric nature of urban development of Metropolitan Manila, which in other countries' case could have resulted to better resilience, but in the case of Manila does not really work to its advantage due to inefficient mass transport system that connects these different urban centers. An urban structure makes it more necessary to understand the dynamics of the different urban components and how strategies can be devised to manage risks and disasters.

Bankoff, Greg (2003) Constructing Vulnerability: The Historical, Natural and Social Generation of Flooding in Metropolitan Manila. *Disasters,* 27(3): 95–109, in English

In an extensive examination of flood in Manila, Bankoff emphasized that flooding is not a recent phenomenon and instead has been in existence even prior to the formation of the city. He emphasize that hazards are natural occurrences, but disasters are basically anthropogenic, meaning human organizations create unequal exposure to risk. He provided a historical, institutional and urban perspective on flooding, creating in a process a paradigm on how to approach the problem of flooding. He posited that flooding is both the result of global changes in the world temperature resulting to sea level rise and a host of socio-economic factors that increases the frequency of the occurrence of flood in Manila. The paper analyzes flooding in the following context: the generation of hazards using the historical approach, the relationship between the environment and the society that results to risk, and the innate complexity in studying vulnerability.

Flood is basically classified into three types: (1) local, inundation of 20 to 30 centimeters, which is the result of sudden and intense thunderstorms that can cause light property damage and heavy traffic congestion; (2) moderate, has flood level of more than 30 centimeters produced by intense rainfall of more than one hour causing flooding in the whole city; and (3) regional, which is a large-scale flooding of whole cities and several river basins, usually the result of typhoons that bring massive rainfall that last several days and may coincide with high tides or storm surges. This is further aggravated by subsidence of land along the Manila Bay. The intensity and magnitude of flood has been increasing over the years, causing difficulty to increasing number of residents. The worsening condition of flooding is attributed to human activities such as "deforestation, overgrazing and urbanisation (sic), resulting to more vulnerable communities. On the other hand, he correlated the existence of flood-prone areas and cities that have larger low-income residents. The high population concentration puts enormous pressure on the resources, resulting to increasing severity and period of flood.

At present Manila is considered to be a "vast urbanised (sic) drainage basin" that experiences periodic flooding due to the incapacity of existing water channels and canal constructed during the Spanish and American period. He attributed the proliferation of high-density communities along the river banks and water channels to higher flood vulnerability especially of the urban poor who constructed their shelter out of flimsy materials. The high population in the city causes Resource pressure. Another reason he states is the unmonitored urban growth that consequently resulted to paved surfaces due to more road construction and built-up spaces leading to increased incidence of flash flood. The effect of flood does not only affect the infrastructure but also lead to epidemic outbreaks such as cholera and leptospirosis, prolong power interruptions and property losses that can reach up to P900 million (USD36 million). In response to the hazard posed by flooding, the prevailing solution is to resort to technological solution, which means building pumping stations to divert outflow of stormwater. This method could actually lead to vulnerability to hazard of some segments of society.

Zoleta-Nantes, Doracie B. (2000) Flood hazards in Metro Manila: recognizing commonalities, differences, and courses of action. Social Science Diliman. Vol. 1, No.1, 60-105, in English.

In an extensive discussion on the anatomy of flooding, Zoleta-Nantes focused on the effects of flooding on sectors that are considered to be the most affected by flooding. She identified three basic sectors on which she based her comparative study on the responses and adaptation of each sector. The sectors covered in her research are the residents of wealthy subdivisions, urban poor in slums and squatter areas, and homeless street children. The approach of her research is the development of resilience strategies of each sector.

She emphasized that the issue of flooding generally occurs in urban centers that are located in low-lying area. Most countries in Southeast Asia's response to flooding is the construction of flood infrastructure which is not effective because the flood protection structures are built on floodplains that are not previously urbanized. Another governments' response to flooding is relief provision to those affected. The most affected are the residents of poor neighborhoods, whose response to the issue is to secure their personal safety that resulted to the absence of community or neighborhood-based measures. The approach to resilience is more into institutional approach, greater coordination between local and national government, provision of early warning device, improvement in the efficiency of flood control infrastructure, and community-based risk action, creation of baseline data management of those affected by flooding and their risk. it mentions about the need for site development plan and implied the need to protect upstream reservoir and more vegetation along water channels.

Literatures on flooding emphasize the importance of institutional intervention in terms of providing solution to the problem of flooding. They acknowledge the complexity of the issue such that involves multi-faceted factors that consequently results to complex problems. The approach is mostly on the provision of institutional response to the issue of flooding and how to lower the vulnerability of certain sectors to the effects of flooding. They offer insight as to what contributes to the worsening situation of flooding in Manila such as continued urbanization and lack of infrastructure to alleviate the effects of flooding but do not offer an ecological approach to the issue. Bankoff recognize the issue of informal communities and how they adapt to the realities of flooding. He also focused more on the human scale of the issue, such as the effects on the community and the residents.

Ecological planning has gradually shifted to greater integration of human and/or cultural ecosystem in their ecological planning approach. It has also placed greater emphasis on the urban environment as against the earlier bias to rural and pristine environmental planning research. Fundamentally, the concept of biodiversity remains the central theme of most ecological planning in urban areas, in which the discussion of resilience has become more relevant due to the consideration of human ecosystem in ecological planning. The following discuss the issue of biodiversity and its role in creating a more sustainable and resilient urban environments:

Tzoulas, Konstantinos, Korpela, Kalevi, Venn, Stephen, Yli-Pelkonen, Vesa, Kazmierczak, Aleksandra, Niemela, Jari, James, Philip (2007) Promoting ecosystem and human health in urban areas using Green Infrastructure: A literature review. Science Direct. No. 81. 167-178, in English.

The article focuses on the Human Ecosystem Framework in which it analyzes ecosystem and its relationship with health. It basically links the occurrence of natural ecosystem processes and functions with human health. It integrates urban systems as social, biological, and physical complexes. It discusses ecosystem health, emphasizing resilience from stress and degradation and its ability to reorganize and maintain its basic functions. It reviewed other authors who have similarly contributed to the literature including Grimm et al. (2000) who modified the framework concerning the interactions of ecological and social systems, highlighting the essential variables, interactions and feedbacks connected to land use change; and Freeman (1984) who pointed out that various urban factors have an effect on the nervous system and is manifested in mental or physical illness, linking environmental stress to chronic anxiety, chronic stress and high blood pressure, with their consequent implications on health. It also acknowledge the insights from Arch of Health (WHO, 1998) which showed the environmental, cultural, socio-economic, working and living conditions, community, lifestyle and hereditary factors' effect on public health.

Green structure or, as used in the article, green infrastructure refers to be composed of natural, semi-natural, and artificial networks having multitude of functions found in urban areas in different spatial scale. It is important in the following aspects: it has the potential to serve as guide in urban development by serving as a framework for economic growth and conservation; it provides an opportunity to integrate urban development, nature conservation, and promotion of public health: the benefits derived from green structure helps in maintaining the ecosystem health and public health; and a well-formed green structure has a potential in improving the health of the residents of urban areas. It also links green structure with the ecosystem health in the following aspects: conservation of biodiversity, maintenance of ecological integrity and could serve as a physical framework for ecological networks, improvement in the condition of habitat fragmentation, which is an important dimension in sustainable landscape, preservation of biodiversity in terms of habitats, species, and genes. It considers biodiversity as important indicators of ecosystem health, taking into account species-rich habitat as more resilient having "higher productivity, or vigor" compared to homogenous habitat.

Cieszewska, Agata. Comparative landscape structure studies for land use planning: Przedborski landscape park case study. www.paek.ukw.edu.pl/wydaw/vol6/7_cieszewska.pdf. 54-62. Accessed 2012 June 14, in English.

The concept of the geographical and ecological structures has been explored by Cieszewska, in which the author determined the relationship of the two different landscape structures. The objective of the article is to determine the landscape structure using comparative studies. The paper is divided into three parts: the first part describes the foundation of the two approaches used in clarifying landscape structure; the second part focuses on Przedborski Landscape park as a case study using both approaches; and the third and last part forms the conclusion, which sums up the strong and weak points of both approaches.

The two approaches used in describing the landscape structure are the geographical approach and the ecological approach. The geographical approach considers individual unit of landscape elements as geocomplexes, which are non-biological in origin. On the other hand, the ecological approach utilizes the conventional ecological structure model, the patch-corridor-matrix model, which emphasizes the biological component of the environment. The basic differesces between the approaches lies on (1) the spatial units used and (2) focus of the geographical approach on the relatiosn between elements, while the ecological approach on the distribution of spaces within the defined space. On the other hand, both approaches are similar in terms of their holistic approach and in placing importance on water as the basic skeleton that forms the landscape structure.

Metro Manila Greenprint Team. Metro Manila Greenprint 2030: Workshop 3: Formulating a draft vision. 19 pages, in English.

Greenprint 2030 is a workshop document prepared by its team in preparation for a comprehensive plan for Metropolitan Manila under the leadership of the Metropolitan Manila Development Authority. The final plan is expected to be completed by June 2013. The document develops a development framework for the metropolitan region that is "inclusive and green" taking into consideration the interest of the stakeholders. It acknowledges the need of the stakeholders for livelihood, transportation network and overall better urban environment. Its main thrusts are centered on the three c's: "connectivity, catalytic infrastructure and cosmetic".

It takes several assumptions about the metropolis, one of which is the polycentric character of urban centers, which is the result of private sector-led development initiative. The framework aims to take advantage of this situation by "enhancing connectivity" among these urban centers through better transportation network. It also espouses compact city concept by increasing urban density from the urban center.

Acknowledging the metropolis' vulnerability to flood, the framework aims to focus on "investing in flood control infrastructure, utilizing and implementing risk-sensitive land use planning, updating and enforcement of Building Codes, supporting community adaptation, and organizing warning and emergency response system". The approach to finding solution on the issue of flood is by resorting to engineering technology, improving community resilience and enforcing disaster warning system.

The document basically outlines the different approaches to be used and in this stage, has not discussed these approaches in detail. However, it is apparent that it will take a quite conservative stance in terms of proposing a comprehensive framework for the metropolitan region. It takes a very conventional or social position in which it places great importance on the stakeholders. However, it does not mention how it considers the environment despite the "green" approach as indicated by its title and its primary concept. The idea of a comprehensive plan seems to be confined to the geo-political definition but does not address the interconnectedness of the different issues and how a comprehensive plan can address the challenges faced by the metropolis.

Pickett, Steward T.A., Burch, William Jr., R. Dalton, Shawn E. and Foresman, Timothy W., Grove, J. Morgan, Rowntree, Rowan (1997) A conceptual framework for the study of human ecosystems in urban areas. Urban Ecosystems, No. 1, 185-199, in English.

The article is an elaboration on the ramification of defining ecosystem that is being highly influenced by human activities. This is particularly striking in the case of urban ecosystem in which human activities dominate most of the spatial units, which represents an interplay of "stresses, disturbances, structures, and functions in ecological systems". These environmental stimuli lead to heterogeneity that influences structure and processes in the ecosystem. Of particular importance is the soil which directly affect the structure and function as reflected in the kinds of patch that is formed. In terms of humans' influence on the ecosystem, they are the main agent in the propagation of heterogeneity because of their extensive influence in their exploitation of resources, introduction of new organisms, alteration of landforms which consequently change the drainage pattern, being the prime influence behind "natural disturbance agent" and more importantly, the creation of built structures.

The authors contend that even in the highly modified environment in urban areas, the watershed structure remains, thereby providing a framework for comparison with other less physically modified areas. It plays integral part in creating a systematic organization of human ecosystem, in which, as a basis of comparison, can be used in situation with similar social features and causal relationship regarding the watershed function. It also can accommodate the study of the flow of energy and interrelationships of patches within the ecosystem. Lastly, it can be used to understand the relationship "contrasting catchments with estuaries and coastal waters".

The research is an important contribution to the increasing literature on the integration of human influence on ecosystem study. Aside from discussing the tendency of ecological study on the biotic components of the ecosystem, it reinforces the role of the non-biological physical structure, in this case, the watershed component. The difficulty in studying ecosystems is the apparent lack of common basis on which to compare different systems that will lead to more objective assessment of different ecosystems. Although the idea of contextual idea of studying ecosystem has been the practice and certainly provides merit in terms of responding to the uniqueness of the existing system, finding a common ground among the different ecosystems can lead to more scientific exchanges and a ready framework for "similar" systems. Hence, the proposed idea of integrating watershed as a basis, in which similar characterization of the basins can be found in different watershed-defined spatial units. It provides a main structure to analyze the ecosystem, which profoundly affects the biological component of the ecosystem.

Secretariat of the Convention on Biological Diversity (2009) *Biodiversity, Development and Poverty Alleviation: Recognizing the role of biodiversity for human well-being*. Montreal, 52 pages, in English.

The main emphasis of the booklet is the primacy of biodiversity in analyzing the ecosystem that is dominated by human activities. It identified the main threats to biodiversity, which include: large-scale conversion of land in agricultural and urban centers, the introduction of alien species, over exploitation of natural resources, and pollution. It also identified the marginalized urban poor as the most vulnerable to the decline of biodiversity since they directly depend on biodiversity for their everyday survival and do not have the privilege to afford substitutes. It outlines strategies that need to develop to make communities resilient by conserving biodiversity to achieve sustainable development and to minimize poverty. It reiterates that improving biodiversity is important in striking a balance between development and biodiversity protection.

The global scope of the study is evident in which it emphasized that biodiversity is not included in the economic analysis. It similarly emphasized the importance of varied ecosystems which is essential in maintaining human health. In terms of the role of biodiversity to resilience, it posits that biodiversity "improves the capacity of social-ecological system both to withstand perturbations and to rebuild and renew itseld afterwards". It emphasized the importance of investing in biodiversity conservation to achieve long-term development and in reducing poverty and that it should be part of the government's planning and financial agenda.

Cook, Edward A. (2013) Urban ecosystems and the sustainable metropolis. Remaking Metropolis: Global Challenges of the Urban Landscape. Cook and Lara (eds) Oxon: Routledge. 248 – 268, in English.

Cook discussed the significance of conservation measures in promoting urban ecosystem. He placed importance on the creation of green networks to interconnect related patches and corridors to provide and sustain long-term ecological values in urban environment. This interconnection facilitates flows in the landscape in the transfer of nutrients, energy and genetic materials. It also prevents landscape fragmentation and the resulting isolation of patch. He clarified the key concepts in realizing the functional urban ecosystems. They include (1) extent or the place of the urban ecosystem being an integral part of larger system; (2) context, or the influence of adjacent land uses on the function of urban ecosystem; and (3) content, or the constitution of the urban ecosystem.

An important concept presented by the author is the memory of the landscape, or the built-in ecological integrity of a place in which the natural processes have been embedded in the landscape. This serve as important factor in determining the future use of the place and how this landscape will accommodate the possible modification. This is important in restoring ecological network, in which he proposed several measures to restore the function. The measures include the resulting typologies or urban ecosystem: (1) preserved ecosystem, or the natural or almost natural condition with functional system; (2) restored ecosystem, or that has been re-established with similar structure and function as to the original system; (3) hybrid ecosystem, or that landscape which has a combination of restored original ecological functions while allowing other landscape context; (4) synthetic ecosystem, or the establishment of ecosystem function that does not exist previously; and (5) regenerated ecosystem, or a landscape that allows natural recovery of an ecosystem that has been previously been disturbed. The overarching goal is to optimize biodiversity and ecological processes while accommodating compatible use in the urban environment.

De Jong, Taeke M. Urban ecology, scale and identity. Sustainable Urban Environments: An Ecosystem Approach. Ellen van Bueren, Hein van Bohemen, Laure Itard, Henk Visscher (ed) New York: Springer, 71-89, in English.

In a compilation on the different concepts about urban environments, De Jong elaborated on the role of humans in shaping the urban ecology. He posits that since humans dominate the urban environment, the discussion of urban ecology should be centered on the distribution of humans and their modification in the environment. These modifications or what he termed as "artefacts" have profound impact not only in terms of the adaptation of humans but also to other species in the environment. He uses the Netherlands as the area of study due to the following reasons: (1) the abundance of boundary as a result of human activities, (2) the availability of data, and (3) the country being heavily impacted by global changes in diversity. He also discussed the different classification of ecosystems based on different scales based on the system devised by Westhoff (1956), Yeang (1999) and Haber (1990). Westhoff's classification is based on the naturalness of the landscapes. Yaeng's system of classification, on the other hand, is based on the ability of the vegetation system to develop naturally or through human intervention. Haber's classification similar to Yaeng's system of classification but has simplified the classification into bio-ecosystem and techno-ecosystem. Bio-ecosystem is ecosystem that is dominated by natural processes, while techno-ecosystem is determined by human technical systems which is intended for and controlled by human. The three systems of classification emphasize the relevance of including human-dominated and controlled ecosystems in studying urban environment.

De Jong's research on urban ecosystem is focused on vegetation, in which he considered as the foundation of food pyramid. Studying the boundaries created as a result of human activities, he sees fragmentation of urban areas into smaller patches as a reflection of poor environmental condition. The boundary serves to differentiate one patch from the other. He related the ability of vegetation to recover from disturbance as a form of resilience in the face of changes in global biodiversity. In the process of recovery, intrinsic character of the vegetation system is retained. In the context of resilience of urban environment, vegetation patches have capacity to absorb the changes in the internal and external environment and regenerate to continue.

Jarvis, Peter J., Young, Christopher H. (2005) The Mapping of urban habitat and its evaluation. Discussion paper prepared for the Urban Forum of the United Kingdom Man and Biosphere Programme, 1-9, in English.

The purpose of the paper is to develop a spatial framework using the green environment for planning decisions, and in turn use the planning process to enhance the green environment. The green environment is considered in the context of biodiversity, biotope, habitat quality and the landscape structure and pattern. This structure provides link between fragmented habitats in the movement of plants and non-flying fauna, and in facilitating movement between compatible habitats for many birds and insects. It also placed importance on core areas, or greenspaces with significant ecological values that require protection and management to maintain biodiversity and recreational and cultural values. Buffer zones, or the spatial units surrounding the sore areas and corridors, are similarly considered as important components in negotiating with urban development to support biotopes and biodiversity. These, core areas, corridor and buffer zone, constitute the green development areas, or space with high ecological potential where the protection of existing biotopes is a priority.

Ge Zhang, Linying Wu, Gang Dai, Susannah Su-Ling Lee, Lijao Yan (2013) Landscape ecological approach to the ecological significance of cultural heritage sites. Life Sciences Journal 10 (2) 1982-1992, In English.

Using Hebei province in northern China as case study, Zhang et al explored the relationship between cultural heritage sites and patterns of land use. Utilizing different quantitative metrics to measure changes in the surrounding land use of cultural heritage sites. The different metrics used are the Shannon's diversity (SHDI), Shannon's evenness (SHEI), edge density (ED), the largest patch index (LPI), patch size standard deviation (PSSD), patch density (PD), and mean patch size (MPS), area-weighted mean shape index (AWMPSI), mean patch shape index (MPSI), contagion (CONTAG), area-weighted mean fractal dimension (MPFD), and landscape shape index (LSI). It was found that land use tends to be "fragmented, complex and irregular" and land use pattern has the tendency to increase near these sites. This is due to the intensity of effects around cultural heritage sites based on human activities.

3 THE ECOLOGICAL STRUCTURE

The present structure and relationships of green spaces are manifested in the ecological structure of Metropolitan Manila. It shows existing green spaces that still function as response to the biodiversity and flood condition of the metropolis, provides ecosystem services, and disruption on the system and the consequent potential for connectivity and linkages. The ecological structure is determined using biotope map in which bio-physical features are analyzed to form the biotope typologies.

3.1 Methodology of Ecological Structure Planning

The Biotope Map is an important tool in ecological study in which important physical and biological characters are combined to produce a map that effectively describes the present condition of the environment. Several attributes can be combined to reflect how the relationships of these attributes that would result to the present condition. The importance of biotope map are: (1) it describes the present bio-physical condition of the environment, (2) it indicates the relationships of different spaces based on ecological relations, (3) it provides spatial units based on ecological relationships, (4) it is useful in creating strategies to improve the ecological relationship and condition of the given environment.

In the case of Metropolitan Manila, the bio-physical attributes used in the creation of biotope map are: (1) Landform Map, (2) Soil Map, and (3) Landcover Map. These information are vital in the creation of Metropolitan Manila Biotope Map because of the following reasons: (1) the hydro-geographical features are closely linked to the character that corresponds to particular habitats such as their proximity to the coastal zone and their exposure to regular inundation; (2) soil characteristics serve as major determinant in plant diversity[28], and (3) landcover reflects the highly urbanized condition of Metropolitan Manila and at the same time indicates the remaining and existing greenspaces.

The landforms are clarified by classifying the existing physical character of the area. Since the area covered by the macro-scale has been highly urbanized, some prevailing patterns commonly observable in the physical characters of the region are absent, thus parameters are set to establish the basis for classification. Attributes usually associated with coastal environment are difficult to ascertain since the urban environment of Metro Manila has been highly modified. To establish the basis, a 1.2 meters elevation above sea level is set as the inter-tidal zone since the mean average high tide level is set at that level. The low lying area has been observed to be highly-influenced by the tidal movement. Areas that are higher than 1.2 meters to 10 Meters above sea level are considered as lowland. Any areas higher than 10 meters and have slope greater than four percent are considered as upland. On the hand, flat areas having zero to four percent slope along the main rivers are considered as riverbank.

[28] Cilliers, Sarel S. and Siebert Stefan J. (2011) Urban flora and vegetation: patterns and processes. Urban Ecology: Patterns, Processes, and Applications. Oxford University Press.: Oxford, 148 -158, in English

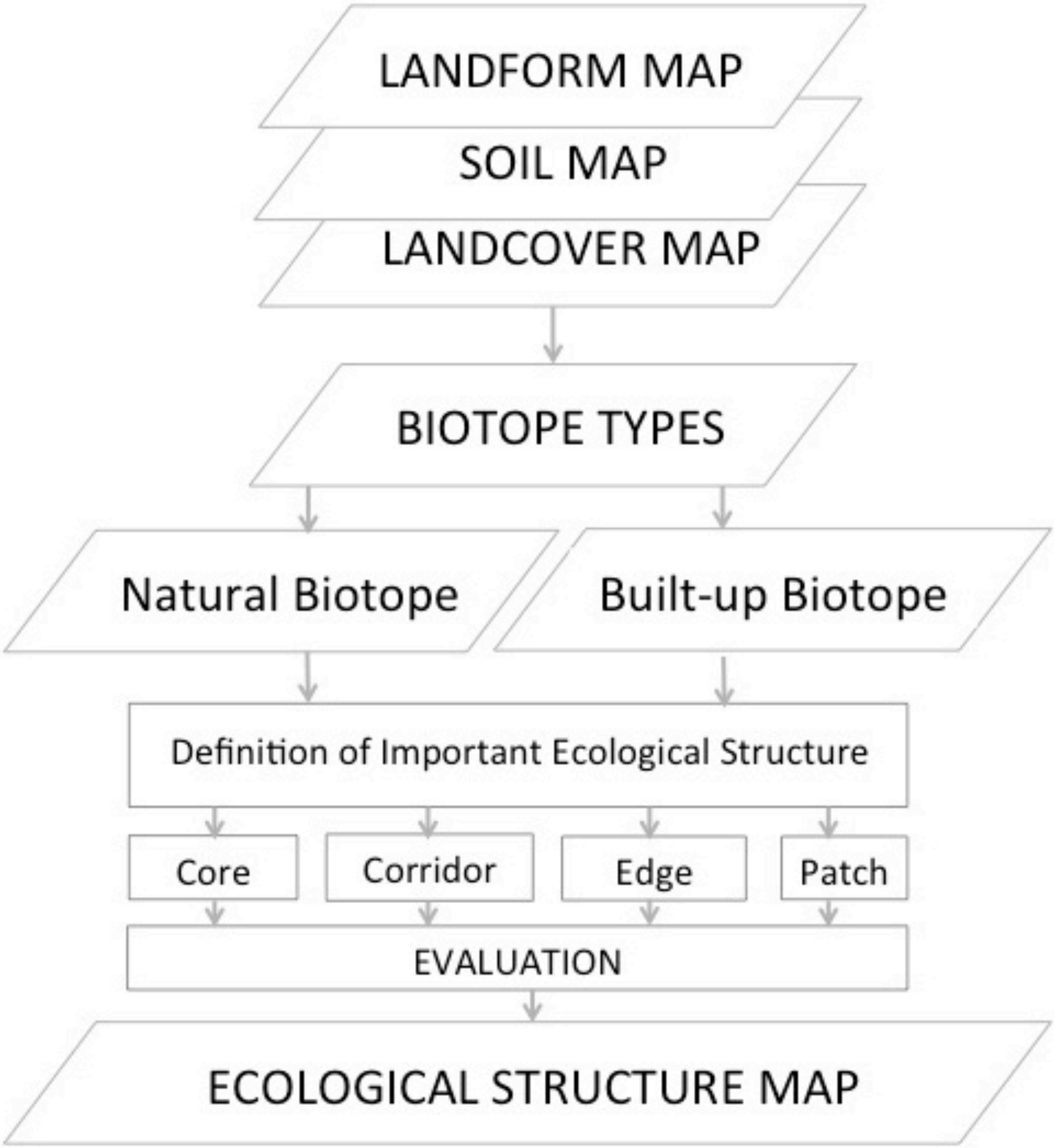


Figure 6: Flow Chart of Ecological Structure Planning

Other areas on the other hand, some areas that have lower elevation are not included since these areas are more influenced by the changes in the river water elevation, resulting to the formation of flood plains. Other landforms found in the metropolitan watershed region are: valley bottom, valley slope, and top of the valley, which are all classified under the "upland".

The soil map is based is the classification by the Department of Environment and Natural Resources in which it classified the major soil types that are found within Metropolitan Manila. Since the soil map indicates more detailed classification of soil types, the biotope map uses the major classification, resulting to four major types. Sandy loam are those that are found along the coastal edge, mostly has been influenced by the accretion of organic particles thus the presence of loam in what should be mostly sandy soil regime. Hydrosol is a type of soil that is perpetually or periodically submerged underwater. This can be found mostly in fishponds and regularly flooded areas. The practice of reclaiming and introducing foreign soil material to previously sea-covered area or to increase the elevation of low-lying areas, have resulted to the introduction of foreign soil which is unclassified in terms of based on particle size and other usual measures of determining soil type due to heterogeneity of foreign soil material. Due to this, this type of soil used for landfill and reclamation is generally classified as filled soil. Clay, which is the dominant soil type in the macro-scale, is a small particle soil type characterized by their plasticity and ability to absorb water between particles and to expand. This soil type is found mostly in the upland.

The Landcover map is generated by identifying the different physical attributes found within the identified macro-scale area. To identify the different landcover of Metropolitan Manila, a satellite map of the area that covers the macro-scale boundary of Metropolitan Manila was georeferenced with the Metropolitan Manila watershed map to get a clearer view on how spaces are being utilized. Recognizing the effect of urbanization in the Metropolitan Manila, the landcover map presents another dimension to the determining the biotope typology in providing macro-scale biological character to the region. Special attention is exerted in locating and qualifying the different non-built-up spaces, or in this respect, the different green spaces, which present the scenario and potential of the current state of the green structure of the urban region.

The inclusion of green spaces in the analysis of present situation demonstrates the extent of how much nature is still in existence and how urbanization has altered the natural conditions. Limited presence of nature in urban areas and neighborhoods are continuously being threatened by continuous conversion into more human-oriented uses. Thus, the protection of biotic components is a necessity to ensure ecological balance.[29] The urban ecosystem should be considered a region in which watershed, floodplains expansive natural areas, sustainable water management facilities, and recreational greens are considered as patches that need to be planned and implemented as it changes and grows.[30]

On the other hand, human or cultural components need to be integrated in ecological planning and biotope mapping. Humans have extensive effect on the biosphere[ii] since urban environment has been greatly modified. The effects of human habitation and processes have altered vegetation composition and condition, drainage patterns, and distribution of ecological actors. Cultural biotope components such as residential, industrial, institutional, informal settlements, and urban, have been included so as to demonstrate how extensive human influence has in shaping the current environmental condition of Metro Manila.

[29] Pickett, S. A., Burch Jr., W.R., Dalton, S.E., Foresman, T.W., Grove, J.M., Rowntree, R (1997) A conceptual framework for the study of human ecosystems in urban areas. Urban Ecosystems, 1, 185-199.

[30] Pickett, S.TA., Cadenasso, M.L. (2006) Advancing urban ecological studies: Frameworks, concepts, and results from the Baltimore Ecosystem Study. Annual Ecology, 31, pp 114-125, in English.

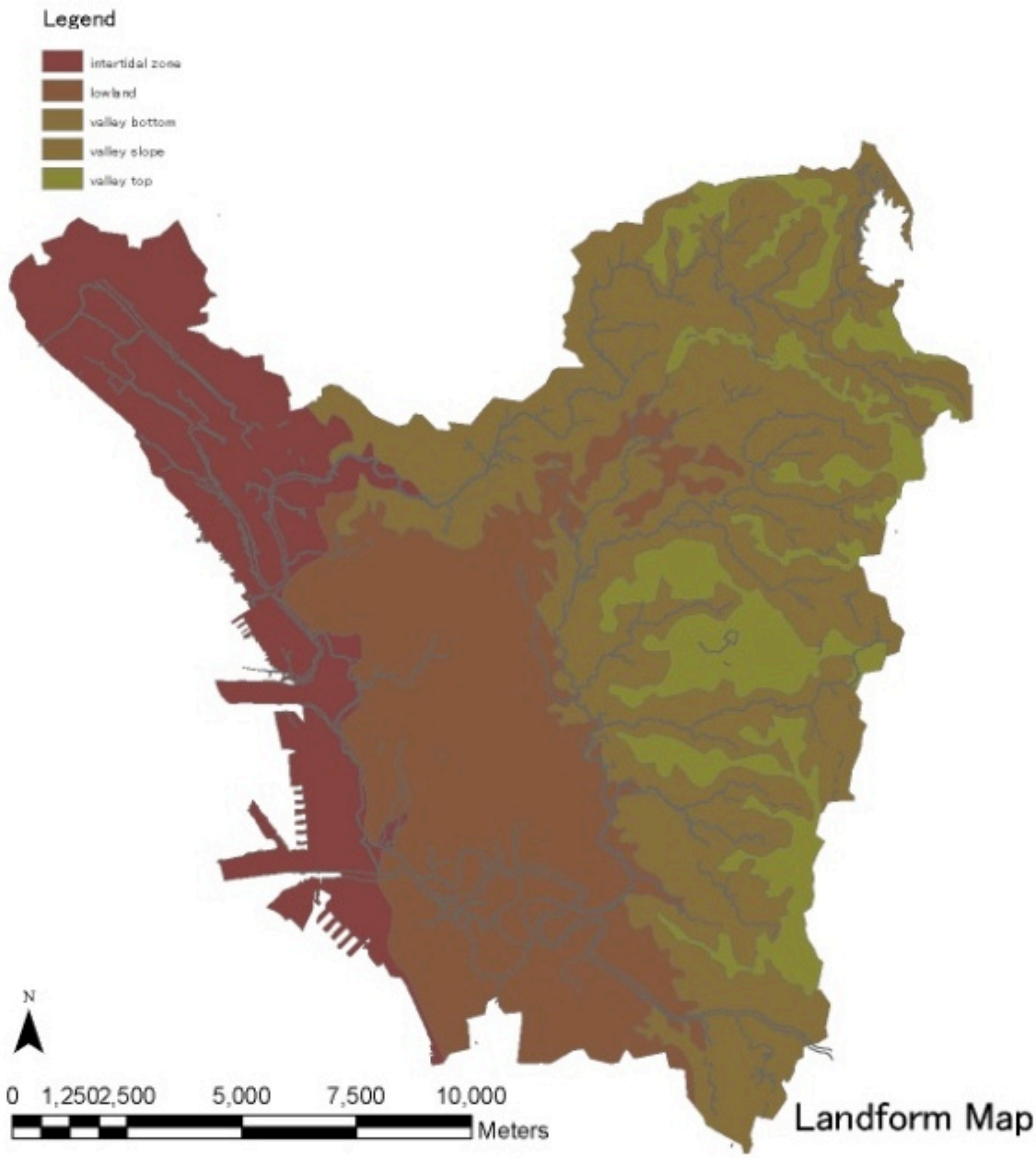


Figure 7: Landform Map of Metropolitan Manila

The regional biotope of Metropolitan Manila is characterized by mostly urban features, in which green spaces are limited to fishponds, watershed forest, and some urban parks. The rest of spaces are occupied by urban spaces, which could be further classified in finer scale as residential commercial, institutional, and industrial. Aside from urban areas, another human dominated biotope that figures prominently in the regional biotope map is the informal communities.

The basic structure of the regional watershed region is formed by the three major rivers: the Pasig River, Tulahan River and San Juan River. These major streams are connected by their tributaries and streams which connect the different biotopes. The edge of the watershed region is the coastal environment close to the Manila Bay. This zone has a biological biotope mainly consist of mangroves and fishponds. This zone still has urban components such as the port area.

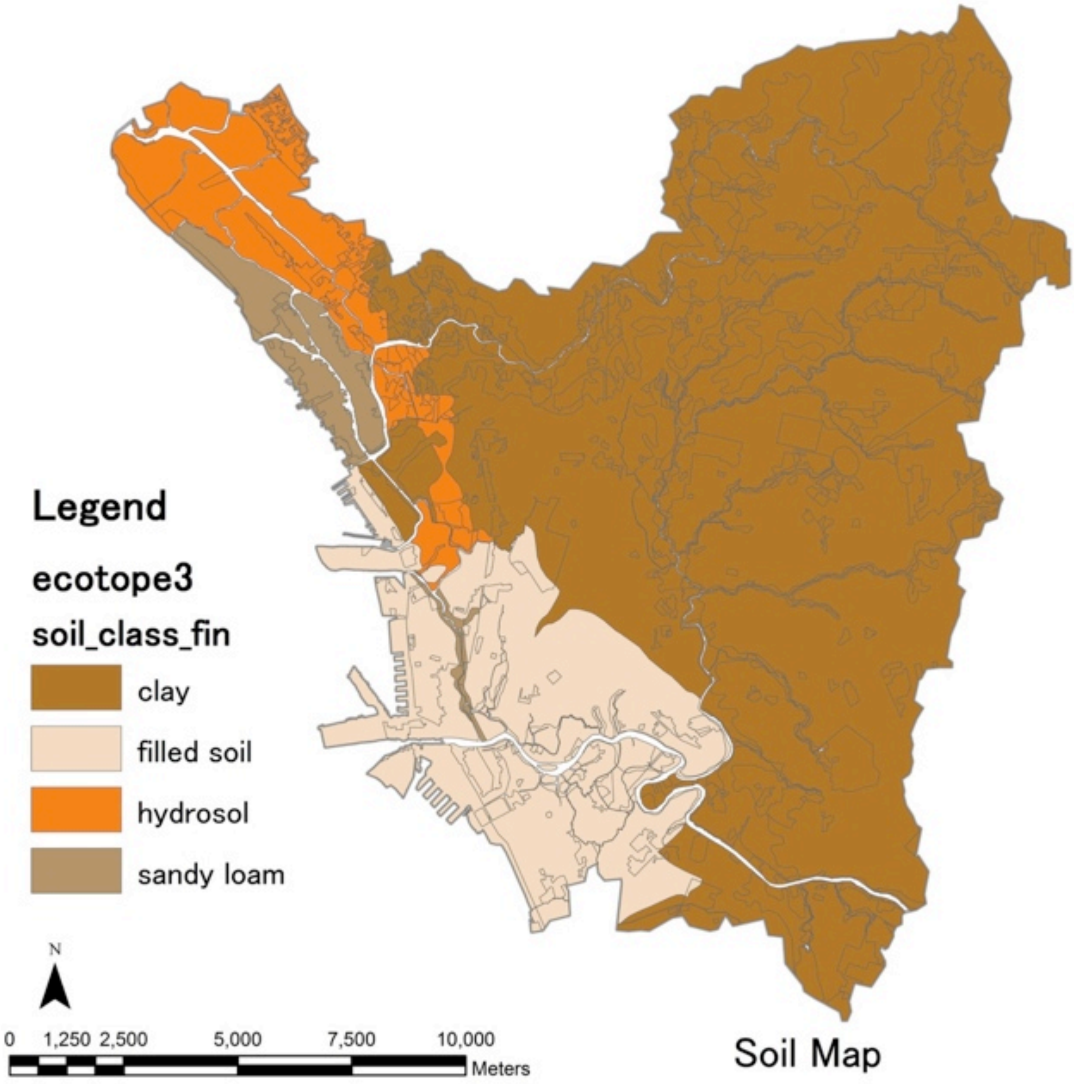


Figure 8: Soil Map of Metropolitan Manila

Metropolitan Manila's regional environment is composed of different spatial units that are defined using hydro-geological and biological factors. On aerial level, the metropolitan region is overwhelmingly urbanized with small patches of green areas.

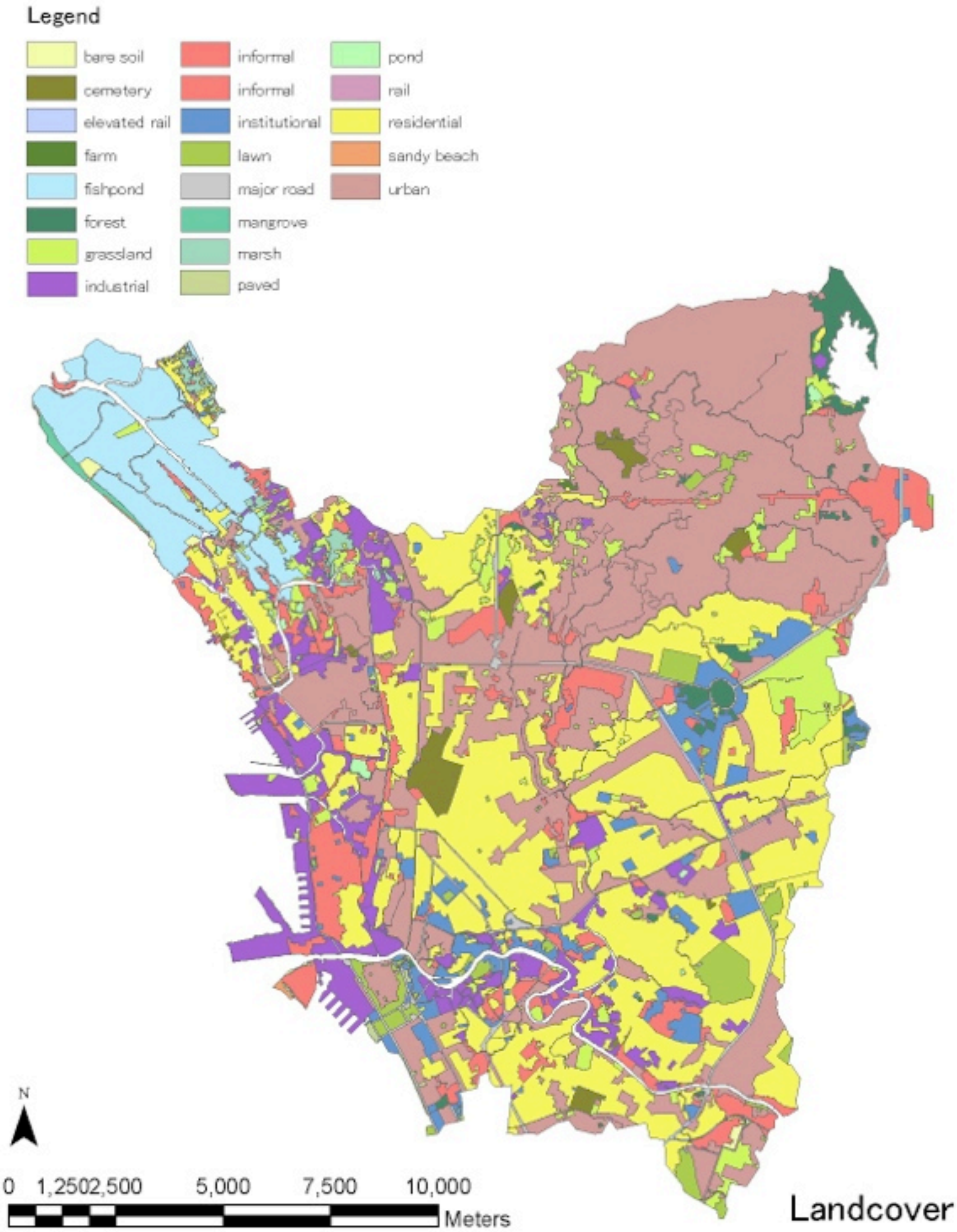


Figure 9: Landcover Map of Metropolitan Manila

Quite pronounced are the major roads and elevated rail lines that traverse the city, as they connect different urban modes. Boundaries between different urban spaces are not recognizable as paved and built-up spaces dominate the landcover. Commercial areas are distinguishable by the presence of high-rise buildings highly concentrated along major roads. Most of the commercial spaces are found in Makati City, Malate district of Manila, Ortigas in Mandaluyong, and Cubao and development along Epifanio Delos Santos Avenue (EDSA) in Quezon City. Institutional areas are characterized by bigger plot areas with occasional green spaces that serve as civic space. Institutional areas are mostly

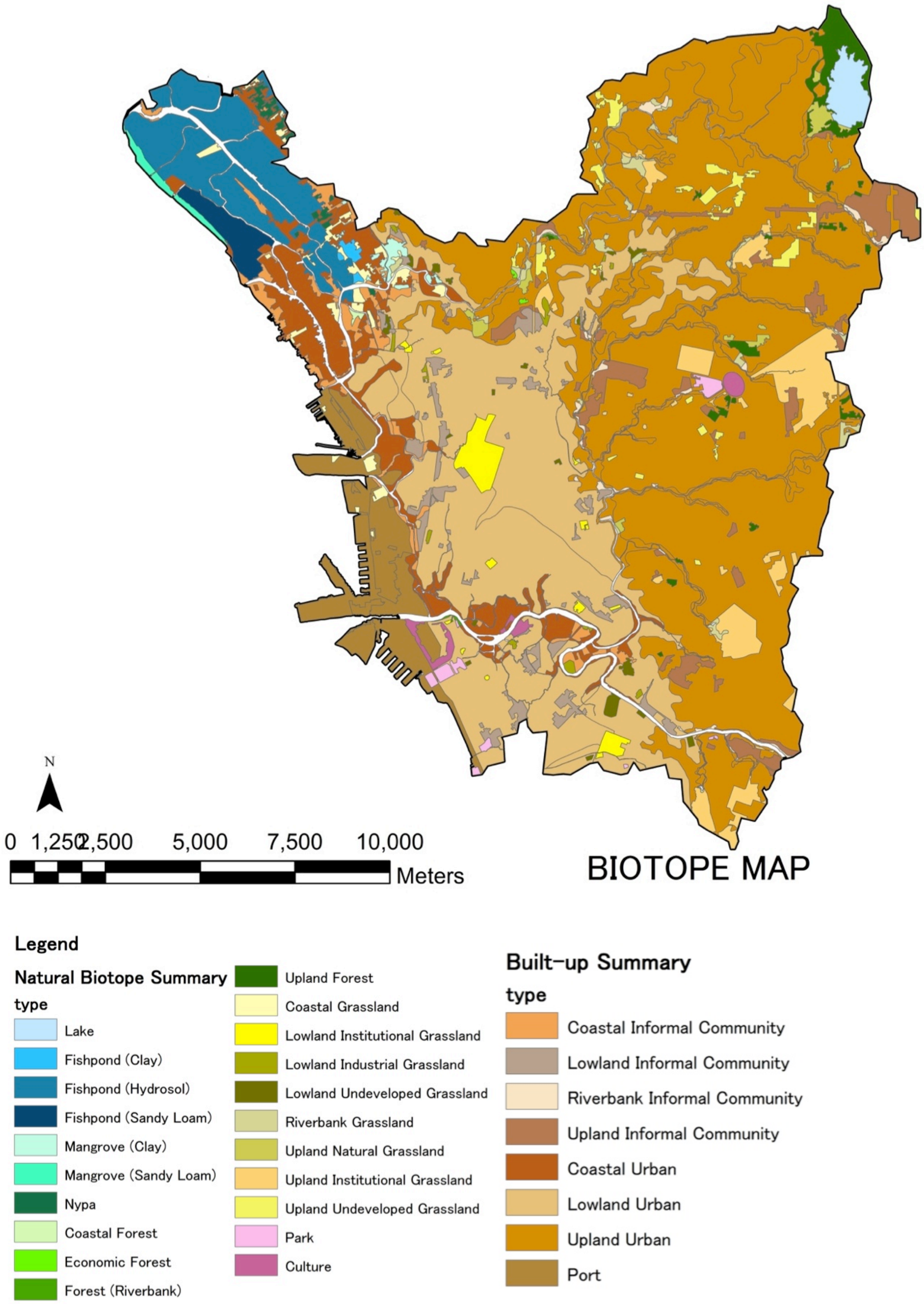


Figure 10: Biotope Map of Metropolitan Manila

found in around the elliptical road in Quezon City, the University of the Philippines and Ateneo de Manila University campuses, the university belt area in Manila, the surrounding structures around Rizal Park, and the military camp in Cubao/Santolan in Quezon City. Industrial areas are mostly along the banks of Pasig River in Manila, in the

Balintawak area of Quezon City, and in Caloocan and Malabon Area. Formal residential areas have relatively smaller plot area with well-organized street system, and low-rise to medium-rise buildings often arranged in gridiron fashion. They are concentrated in Quezon City's triangles, subdivision developments along Commonwealth Avenue and old capitol site, and the gated communities along EDSA and Katipunan Avenue. Green spaces are usually found as open spaces in residential developments and in commercial areas. Significant green spaces are found in the La Mesa Eco-park and watershed reserve, the campuses of the universities in Quezon City, the Quezon Memorial Circle-Ninoy Aquino Parks and Wildlife-Veterans' Memorial Medical Center triangle, different memorial parks, the Rizal Park in Manila, and the fishponds in Navotas-Malabon-Obando area.

One particular urban issue that has been considered a serious problem in Metropolitan Manila is the informal communities. They are found in all of the component cities, mostly in Quezon City. They are equally present along the banks of major river networks of Pasig River, Tullahan River and San Juan River. They can be seen also along the coastal area of Manila Bay, mainly in Navotas and Malabon. They can be seen close to the industrial zones in Pandacan, Manila and in Balintawak area in Quezon City. They can be characterized by their irregular/organic spatial layout, high-density, and small and overlapping plots. Those that are found along water channels show no defined boundary between the water and the occupied land and in most instances blur the land-water interface.

Different ecological network components are hardly visible in the case of Metropolitan Manila. With the river system serving as the main arteries of the network, significant spatial units are identified and evaluated to form the basic network of ecological cores that are connected by corridors. Major patches that have small patches are considered as matrices. The ecological network forms the basic green structure of the metropolitan region.

To analyze further the ecological structure based on the biotope map of Metropolitan Manila. The different biotope types are classified into two major types: the natural biotope and the built-up biotope types. These biotope types represent the particular characteristics of each typology that comprise the major classification.

3.2 Biotope Analysis

3.2.1 Natural Biotope

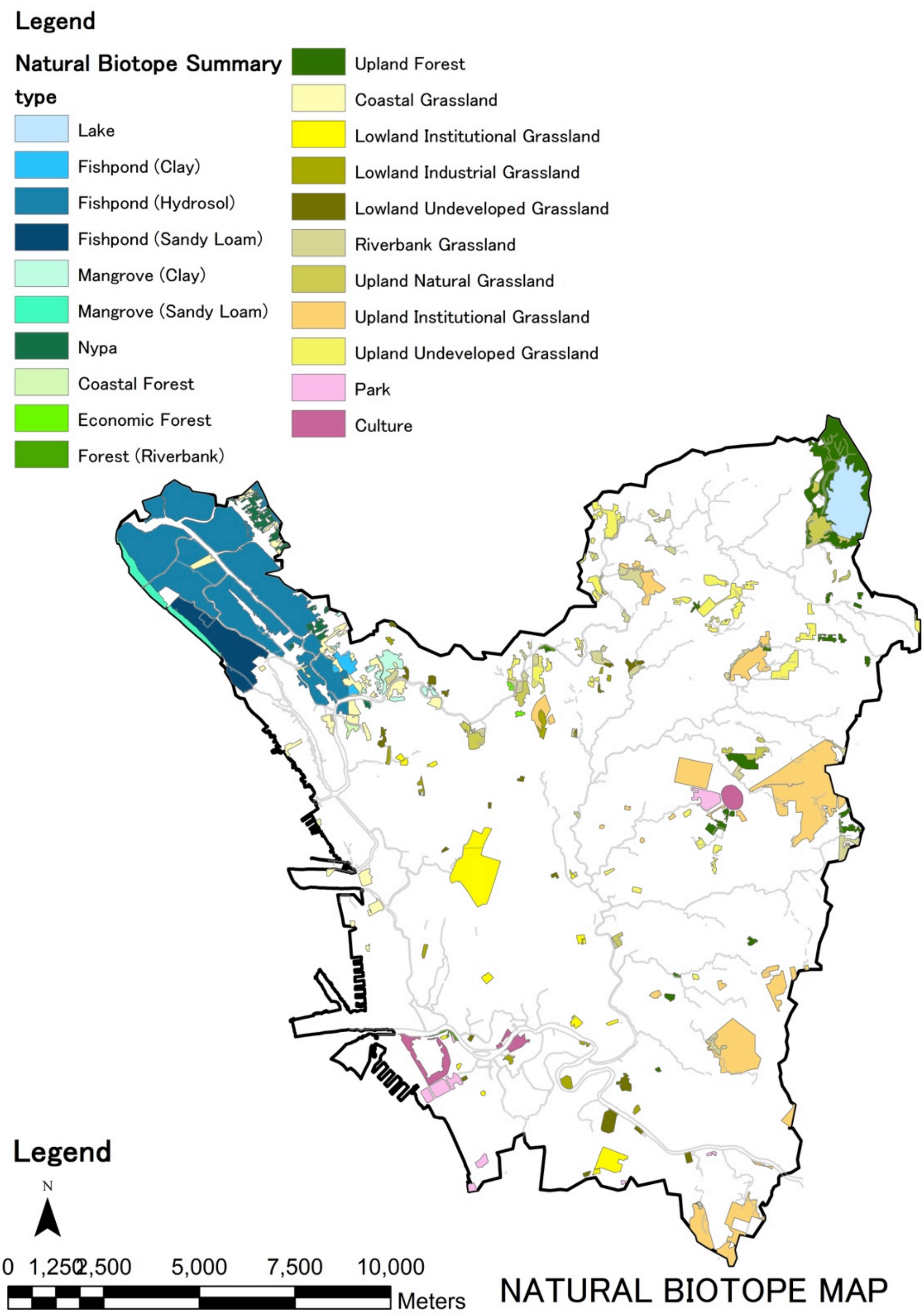
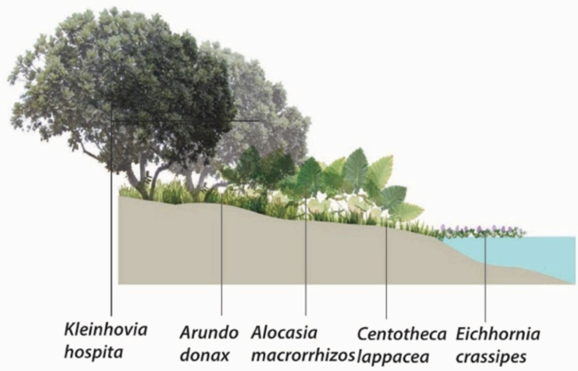


Figure 11: Natural Biotope Map

NATURAL BIOTOPE 1: Lake

GEOGRAPHY	Gentle Sloping
SOIL TYPE	Clay
LANDCOVER	Lake

CHARACTERISTIC



DESCRIPTION

- Lake formed by dam
- Serves as reservoir for the water needs of Metropolitan Manila
- Lake is not accessible to the public and perimeter is fenced

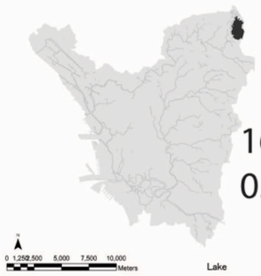
SPECIES **Tree**
Kleinhovia hospital

Groundcover
Arundo donax
Alocasia macrorrhizos
Centotheca lappcea

Aquatic Plant
Eichornia crassipes

WILDLIFE **Bird**
Columba livia
Harpactes ardens

DISTRIBUTION



166.96 Ha
0.71%

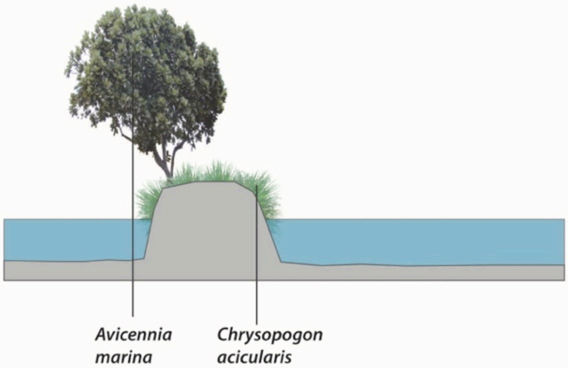
FUNCTION	BIODIVERSITY	FLOODING	CULTURE	POVERTY	AMENITY	PRODUCTIVITY
	High	High	Low	_	High	_

Figure 12: Natural Biotope 1

NATURAL BIOTOPE 2: Fishpond (Clay)

GEOGRAPHY	Coastal Inland
SOIL TYPE	Clay
LANDCOVER	Fishpond

CHARACTERISTIC



DESCRIPTION

- Vegetation can be found on dikes
- Trees present are mangrove species or those adapted to coastal conditions
- Trees appear to have grown spontaneously

SPECIES **Tree**
Avicennia marina

Tree
Chrysopogon acicularis

WILDLIFE **Birds**
Halcyon smyrnensis
Sterna fuscata

DISTRIBUTION

28.59 Ha
0.12%

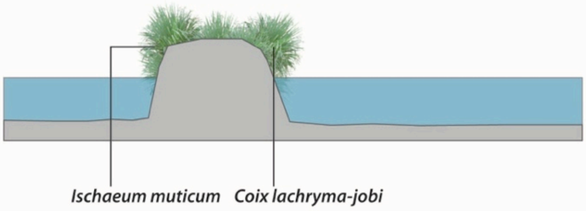
FUNCTION	BIODIVERSITY	FLOODING	CULTURE	POVERTY	AMENITY	PRODUCTIVITY
	Low	High	_	_	_	Low

Figure 13: Natural Biotope 2

NATURAL BIOTOPE 3: Fishpond (Hydrosol)

GEOGRAPHY	Coastal Inland
SOIL TYPE	Hydrosol
LANDCOVER	Fishpond

CHARACTERISTIC



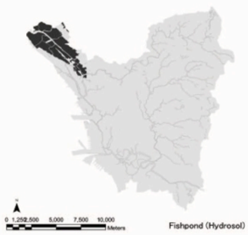
DESCRIPTION

- Vegetation is limited to grass species
- Soil material is too thin to support complex vegetation
- Grasses are periodically disturbed due to maintenance of dikes, tidal and monsoon floods, or burning

SPECIES **Groundcover**
Ischaeum muticum
Coix lachryma-jobi

WILDLIFE **Birds**
Halcyon smyrnensis
Sterna fuscata
Egretta garzetta

DISTRIBUTION



1,163.73 Ha
4.92%

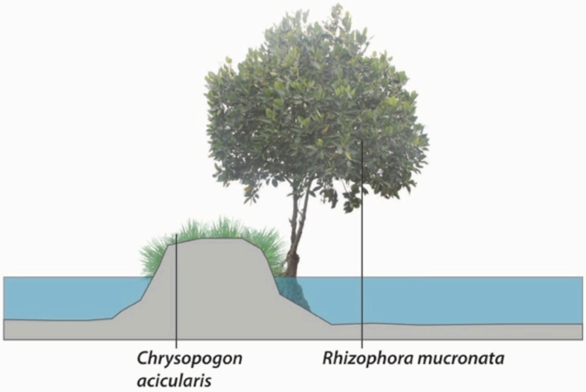
FUNCTION	BIODIVERSITY	FLOODING	CULTURE	POVERTY	AMENITY	PRODUCTIVITY
	Low	High	_	_	_	High

Figure 14: Natural Biotope 3

NATURAL BIOTOPE 4: Fishpond (Sandy Loam)

GEOGRAPHY	Coatsal Inland
SOIL TYPE	Sandy LOam
LANDCOVER	Fishpond

CHARACTERISTIC



DESCRIPTION

- Spontaneous generation of mangrove tree species
- Location is close to mangrove colony along the coastline
- Fishpond is protected from storm surge by mangroves
- Fishpond remains productive compared to other fishponds

SPECIES

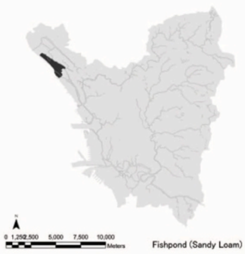
Tree
Rhizophora mucronata

Groundcover
Chrysopogon acicularis

WILDLIFE

Birds
Halcyon smyrnensis
Sterna fuscata
Egretta garzetta

DISTRIBUTION



190.62 Ha
0.81%

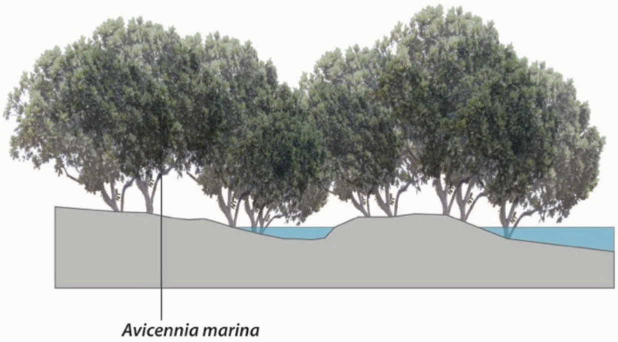
FUNCTION	BIODIVERSITY	FLOODING	CULTURE	POVERTY	AMENITY	PRODUCTIVITY
	Moderate	High	_	_	_	_

Figure 15: Natural Biotope 4

NATURAL BIOTOPE 5: Mangrove (Clay)

GEOGRAPHY	Coastal Inland
SOIL TYPE	Clay
LANDCOVER	Mangrove

CHARACTERISTIC



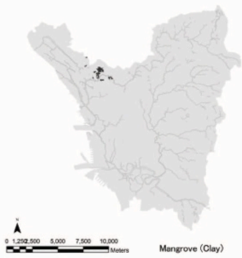
DESCRIPTION

- Naturally-grown mangroves
- Fragmented small patches of magroves surrounded by informal communities and urban areas
- Mangroves harvested for firewood and charcoal
- Under threat of conversion to development

SPECIES **Tree**
Avicennia marina

WILDLIFE **Birds**
Halcyon smyrnensis
Sterna fuscata
Egretta garzetta

DISTRIBUTION



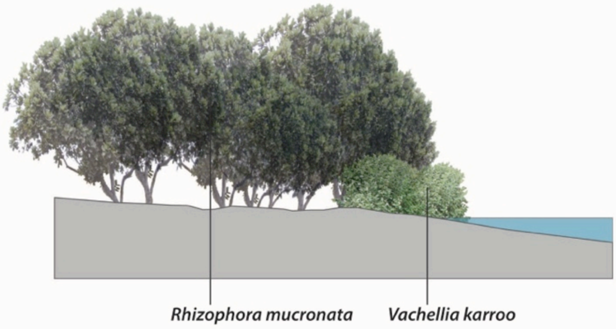
51.99 Ha
0.22%

FUNCTION	BIODIVERSITY	FLOODING	CULTURE	POVERTY	AMENITY	PRODUCTIVITY
	Moderate	High	Low	Moderate	Low	Low

Figure 16: Natural Biotope 5

NATURAL BIOTOPE 6: Mangrove (Sandy Loam)		
	GEOGRAPHY	Coastal Inland
	SOIL TYPE	Sandy Loam
	LANDCOVER	Mangrove

CHARACTERISTIC



DESCRIPTION

- Combination of natural and reforested mangrove forest
- mangrove protected the fishponds from storm surge
- Organized field trip and mangrove tree planting has been organized
- Being promoted as eco-tourism site
- Under threat of conversion to landfill and dumpsite

SPECIES

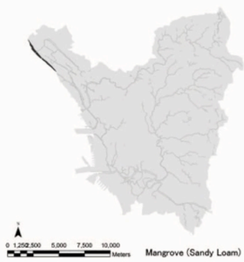
Tree
Rhizophora mucronata

Groundcover
Vachellia karroo

WILDLIFE

Birds
Halcyon smyrnensis
Sterna fuscata
Egretta garzetta

DISTRIBUTION



56.59 Ha
0.24%

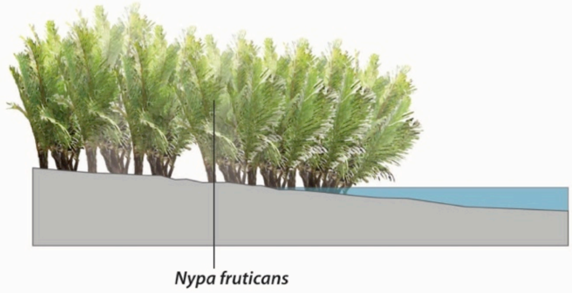
FUNCTION	BIODIVERSITY	FLOODING	CULTURE	POVERTY	AMENITY	PRODUCTIVITY
	Moderate	High	_	_	Moderate	Low

Figure 17: Natural Biotope 6

NATURAL BIOTOPE 7: Nypa

GEOGRAPHY	Coastal Inland
SOIL TYPE	Hydrosol
LANDCOVER	Mangrove

CHARACTERISTIC



DESCRIPTION

- Spontaneous growth after disappearance of mangrove species due to development and excessive harvesting
- Sedimentation and more organic nutrients led to condition ideal for Nypa

Presence is tolerated because of its importance for roofing

SPECIES **Tree**

Nypa fruticans

WILDLIFE **Birds**

Halcyon smyrnensis
Sterna fuscata
Egretta garzetta

DISTRIBUTION

62.16 Ha
0.26%

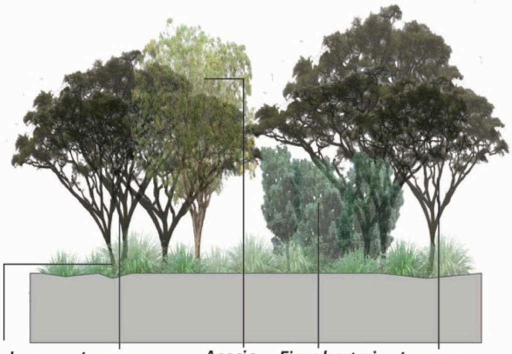
FUNCTION	BIODIVERSITY	FLOODING	CULTURE	POVERTY	AMENITY	PRODUCTIVITY
	Low	High	–	Moderate	–	Moderate

Figure 18: Natural Biotope 7

NATURAL BIOTOPE 8: Coastal Forest

GEOGRAPHY	Coastal Inland
SOIL TYPE	Filled Soil
LANDCOVER	Forest

CHARACTERISTIC



DESCRIPTION

- Natural forest growth
- Surrounded by informal communities
- Trees are mostly pioneer species and adapted to coastal condition
- Periodically affected by flooding

SPECIES

Tree
Leucaena leucocephala
Acacia auriculiformis
Ficus barteri

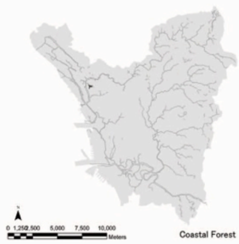
Groundcover
Saccharum spontaneum

WILDLIFE

Birds
Ardea cinerea
Egretta garzetta
Sterna fuscata

Vertebrate Fauna
Phyton reticulatus
Naja philippensis

DISTRIBUTION



6.20 Ha
0.03 %

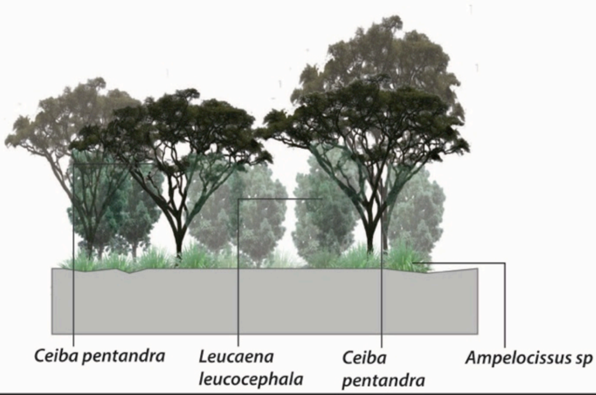
FUNCTION	BIODIVERSITY	FLOODING	CULTURE	POVERTY	AMENITY	PRODUCTIVITY
	High	High	_	High	Moderate	_

Figure 19: Natural Biotope 8

NATURAL BIOTOPE 9: Economic Forest

GEOGRAPHY	Lowland
SOIL TYPE	Clay
LANDCOVER	Forest

CHARACTERISTIC



DESCRIPTION

- Planted forest with mixture of naturally growing pioneer tree species
- Tree species used have economic importance
- Tree species can be harvested for furniture and other household use

SPECIES

Tree
Ceiba pentandra
Leucaena leucocephala

Groundcover
Ampelocissus sp

WILDLIFE

Bird
Passer montanus
Pycnonotus goiavier
Gerygone sulphura
Rhipidura javanica
Lanius cristata

DISTRIBUTION

4.78 Ha
0.020%

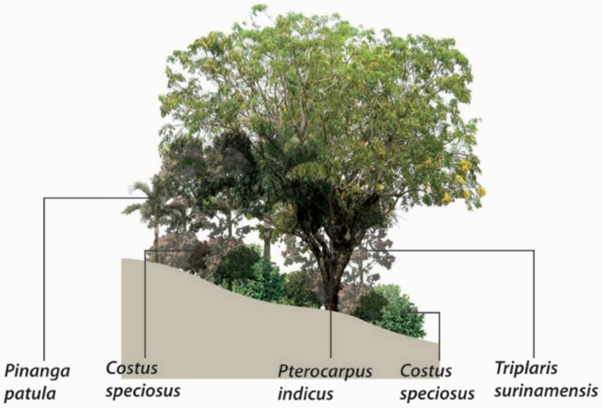
FUNCTION	BIODIVERSITY	FLOODING	CULTURE	POVERTY	AMENITY	PRODUCTIVITY
	Moderate	_	_	_	Low	High

Figure 20: Natural Biotope 9

NATURAL BIOTOPE 10: Upland Forest

GEOGRAPHY	Gentle Slope
SOIL TYPE	Clay
LANDCOVER	Forest

CHARACTERISTIC



DESCRIPTION

- Mix forest of natural and reforested forests
- Comnination of pioneer tree species and ornamental species
- Presently used as recreational space
- Under management of environmental organization

SPECIES

Tree
Pterocarpus indicus
Triplaris surinamensis

Groundcover
Pinanga patula
Costus speciosus

WILDLIFE

Bird
Passer montanus
Pycnonotus goiavier
Gerygone sulphura
Rhipidura javanica
Lanius cristata

DISTRIBUTION

270.36. Ha
1.14%

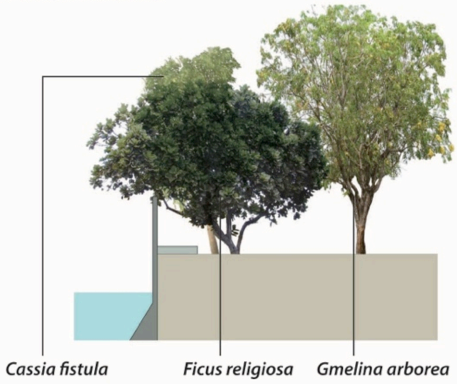
FUNCTION	BIODIVERSITY	FLOODING	CULTURE	POVERTY	AMENITY	PRODUCTIVITY
	High	High	_	_	High	Moderate

Figure 21: Natural Biotope 10

NATURAL BIOTOPE 11: Riverbank Forest

GEOGRAPHY	Riverbank
SOIL TYPE	Clay
LANDCOVER	Forest

CHARACTERISTIC



DESCRIPTION

- Reforested forest
- Mostly composed of ornamental trees
- Groundcover is absent due to dense foliage canopy
- Majority of trees planted throug tree planting efforts of environmental groups

SPECIES **Tree**

Ficus religiosa
Gmelina arborea
Cassia fistula

WILDLIFE

Birds

Sterna fuscata
Chlidonias hybrida
Hirundo sp

Vertebrate Fauna

Platymanthis sp
Rana cancrivora
Varanus salvatori
Dogania subplana
Naja philippensis
Phyton reticulatus

DISTRIBUTION

6.31Ha
0.027%

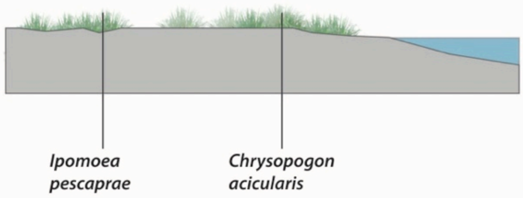
FUNCTION	BIODIVERSITY	FLOODING	CULTURE	POVERTY	AMENITY	PRODUCTIVITY
	Moderate	Moderate	Moderate	_	High	_

Figure 22: Natural Biotope 11

BIOTOPE 12: Coastal Grassland

GEOGRAPHY	Coasta; Inland, Reclaimed Land
SOIL TYPE	Clay, Filled Soil, Hydrosol, Sandy Loam
LANDCOVER	Grassland

CHARACTERISTIC



DESCRIPTION

- Natural growth
- Usually single-layer cover of vegetation
- Very thin soil cover to support complex vegetation
- Grasses growing are adapted to strong wind, saline condition, and intermittent extreme dry and wet conditions

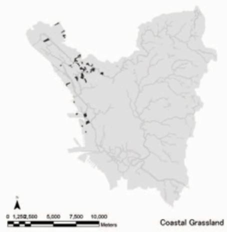
SPECIES **Groundcover**
Ipomoea pescaprae
Chrysopogon acicularis

WILDLIFE

Birds
Sterna fuscata
Chlidonias hybrida
Hirundo sp

Vertebrate Fauna
Platymanthis sp
Rana cancrivora
Varanus salvatori
Dogania subplana
Naja philippensis
Phyton reticulatus

DISTRIBUTION



163.74 Ha
0.69%

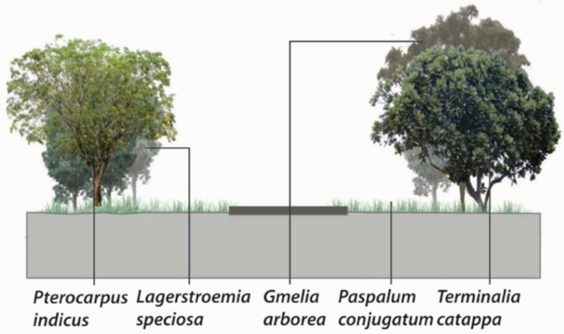
FUNCTION	BIODIVERSITY	FLOODING	CULTURE	POVERTY	AMENITY	PRODUCTIVITY
	Low	High	_	Low	Low	_

Figure 23: Natural Biotope 12

NATURAL BIOTOPE 13: Lowland Institutional Grassland

GEOGRAPHY	Lowland
SOIL TYPE	Clay, Filled Soil
LANDCOVER	Grassland

CHARACTERISTIC



DESCRIPTION

- Composed of lawn with occasional planted ornamental trees
- Lawns are maintained by regular mowing and used for social and sports activities

SPECIES

Tree

Pterocarpus indicus
Lagerstroemia speciosa
Terminalia catappa
Gmelina arborea

Groundcover

Paspalum conjugatum

WILDLIFE

Bird

Passer montanus
Pycnonotus goiavier
Gerygone sulphura
Rhipidura javanica
Lanius cristata

DISTRIBUTION

207.20 Ha
0.88%

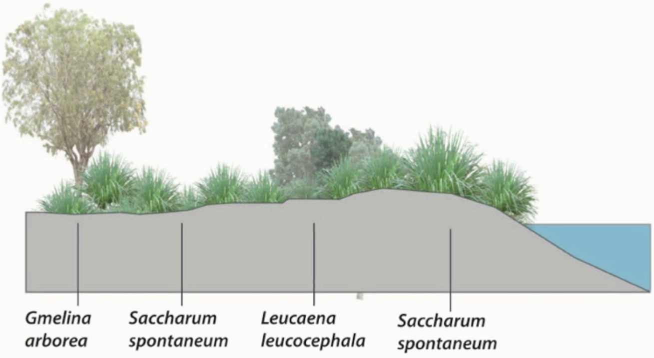
FUNCTION	BIODIVERSITY	FLOODING	CULTURE	POVERTY	AMENITY	PRODUCTIVITY
	Moderate	Moderate	High	_	High	_

Figure 24: Natural Biotope 13

NATURAL BIOTOPE 14: Lowland Industrial Grassland

GEOGRAPHY	Lowland
SOIL TYPE	Clay, Filled Soil
LANDCOVER	Grassland

CHARACTERISTIC



DESCRIPTION

- Grassland adjacent to factories and other brownfields
- Grasses and trees emerged spontaneously
- Access is restricted

SPECIES

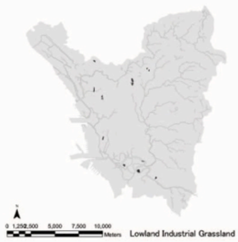
Groundcover
Gmelina arborea
Leucaena leucocephala (sapling)

Groundcover
Saccharum spontaneum

WILDLIFE

Bird
Passer montanus
Pycnonotus goiavier
Gerygone sulphura
Rhipidura javanica
Lanius cristata

DISTRIBUTION



42.64 Ha
0.18%

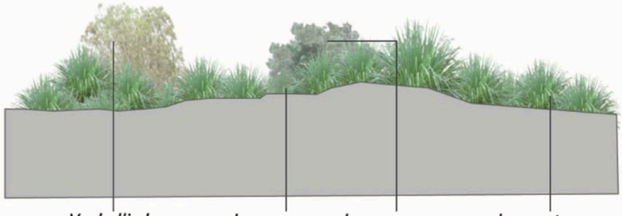
FUNCTION	BIODIVERSITY	FLOODING	CULTURE	POVERTY	AMENITY	PRODUCTIVITY
	Moderate	Moderate	Low	_	Low	_

Figure 25: Natural Biotope 14

NATURAL BIOTOPE 15:
Lowland Undeveloped Grassland

GEOGRAPHY	Lowland
SOIL TYPE	Clay, Filled Soil
LANDCOVER	Grassland

CHARACTERISTIC



DESCRIPTION

- Found in emtry lots and or in the process of being devel-oped
- Grasses emerged spontane-ously
- Being used as nesting grounds of birds

SPECIES

Groundcover

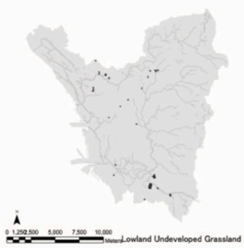
Vachellia karroo
Leucaena leucocephala (sapling)
Ipomoea pescaprae
Imperata cylindrica

WILDLIFE

Bird

Passer montanus
Pycnonotus goiavier
Gerygone sulphura
Rhipidura javanica
Lanius cristata

DISTRIBUTION



75.76 Ha
0.32%

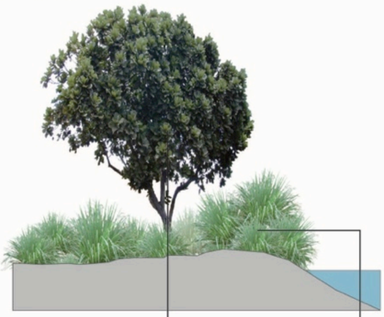
FUNCTION	BIODIVERSITY	FLOODING	CULTURE	POVERTY	AMENITY	PRODUCTIVITY
	Moderate	Moderate	_	Moderate	Low	_

Figure 26: Natural Biotope 15

NATURAL BIOTOPE 16: Riverbank Grassland

GEOGRAPHY	Riverbank
SOIL TYPE	Clay
LANDCOVER	Grassland

CHARACTERISTIC



DESCRIPTION

- Spontaneous growth of wild grassses
- Usually becomes flooded during rainy season
- Plants present are adapated to periodic flooding

SPECIES

Tree
Neolamarckia cadamba

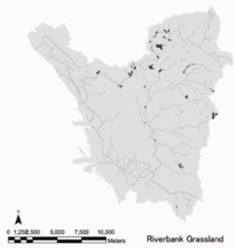
Groundcover
Arundo donax

WILDLIFE

Birds
Sterna fuscata
Chlidonias hybrida
Hirundo sp

Vertebrate Fauna
Platymanthis sp
Rana cancrivora
Varanus salvatori
Dogania subplana
Naja philippensis
Phyton reticulatus

DISTRIBUTION



146.84 Ha
0.62%

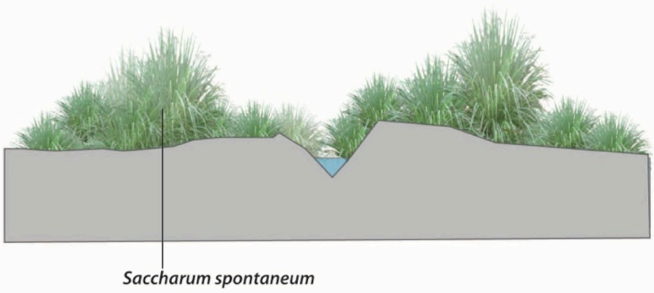
FUNCTION	BIODIVERSITY	FLOODING	CULTURE	POVERTY	AMENITY	PRODUCTIVITY
	Moderate	High	_	_	Moderate	_

Figure 27: Natural Biotope 16

NATURAL BIOTOPE 17: Upland Natural Grassland

GEOGRAPHY	Gentle Slope
SOIL TYPE	Clay
LANDCOVER	Grassland

CHARACTERISTIC



DESCRIPTION

- Natural colony of grass
- Sustained by small streams but dries up during long period of summer
- Serve as nesting grounds of birds

SPECIES

Groundcover

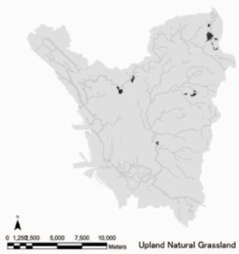
Saccharum spontaneum

WILDLIFE

Bird

Passer montanus
Pycnonotus goiavier
Gerygone sulphura
Rhipidura javanica
Lanius cristata

DISTRIBUTION



103.50 Ha
0.44%

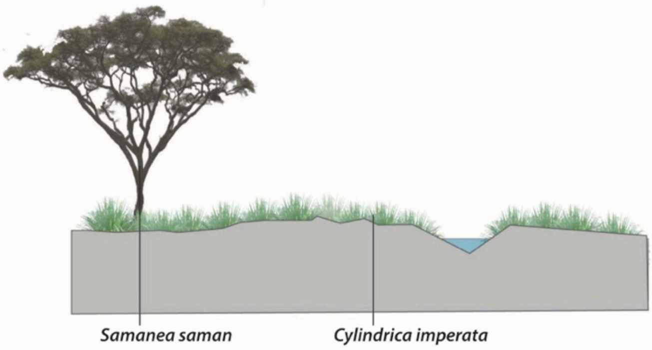
FUNCTION	BIODIVERSITY	FLOODING	CULTURE	POVERTY	AMENITY	PRODUCTIVITY
	Moderate	High	_	_	Low	_

Figure 28: Natural Biotope 17

NATURAL BIOTOPE 18: Upland Institutional Grassland

GEOGRAPHY	Gentle Slope
SOIL TYPE	Clay
LANDCOVER	Grassland

CHARACTERISTIC



DESCRIPTION

- Combination of natural grass and lawn
- Maintained by regular mowing
- Being used for recreational, sports and social purposes
- Artificial irrigation is sometimes provided

SPECIES

Tree
Samanea saman

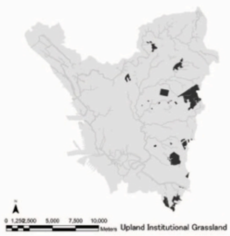
Groundcover
Cylindrica imperata

WILDLIFE

Bird
Passer monatus
Pycnonotus goiavier
Lanius tahitica

Vertebrate Fauna
Gekko gecko
Mabuya mutifasciata
Naja philippinensis
Rhabdophis spilogaster
Bufo marinus
Rana erytraea

DISTRIBUTION



747.18 Ha
3.16%

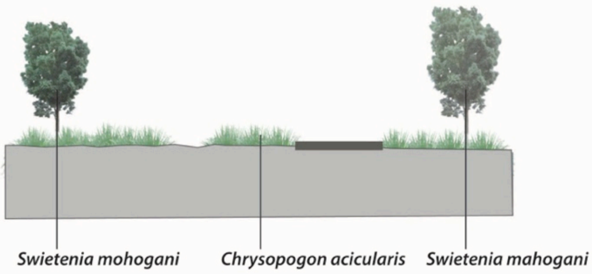
FUNCTION	BIODIVERSITY	FLOODING	CULTURE	POVERTY	AMENITY	PRODUCTIVITY
	Moderate	–	High	–	High	–

Figure 29: Natural Biotope 18

NATURAL BIOTOPE 19: Upland Undeveloped Grassland

GEOGRAPHY	Gentle Slope
SOIL TYPE	Clay
LANDCOVER	Grassland

CHARACTERISTIC



DESCRIPTION

- Grass naturally regenerated
- Usually found in vacant lots or spaces to be developed
- Mostly fenced and access is prohbited
- Tree species are remnants of previous use

SPECIES

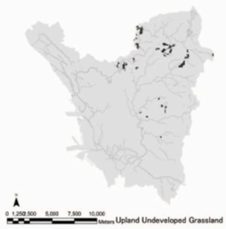
Tree
Swietenia mahogani

Groundcover
Chrysopogon acicularis

WILDLIFE

Bird
Passer montanus
Pycnonotus goiavier
Gerygone sulphura
Rhipidura javanica
Lanius cristata

DISTRIBUTION



208.40Ha
0.88%

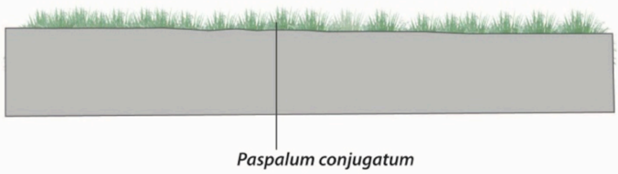
FUNCTION	BIODIVERSITY	FLOODING	CULTURE	POVERTY	AMENITY	PRODUCTIVITY
	Moderate	_	_	Moderate	Low	Low

Figure 30: Natural Biotope 19

NATURAL BIOTOPE 20: Park

GEOGRAPHY	Lowland, Gentle
SOIL TYPE	Filled Soil, Clay
LANDCOVER	Grassland

CHARACTERISTIC



DESCRIPTION

- Artificially created and maintained
- Subject to regular moving and irrigation
- Being used for social events and recreational purposes
- High human traffic

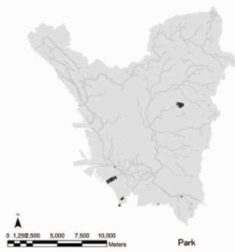
SPECIES

Groundcover
Paspalum conjugatum

WILDLIFE

Bird
Passer montanus
Pycnonotus goiavier
Gerygone sulphura
Rhipidura javanica
Lanius cristata

DISTRIBUTION



74.92 Ha
0.32%

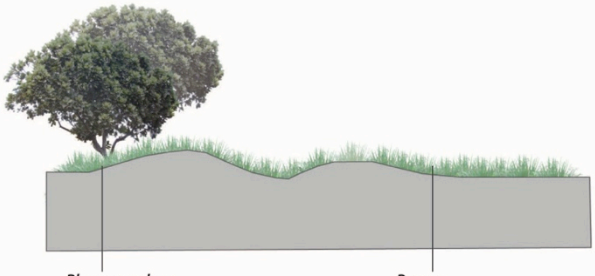
FUNCTION	BIODIVERSITY	FLOODING	CULTURE	POVERTY	AMENITY	PRODUCTIVITY
	Moderate	Low	High	_	High	_

Figure 31: Natural Biotope 20

NATURAL BIOTOPE 21: Culture

GEOGRAPHY	Lowland, Gentle
SOIL TYPE	Filled Soil, Clay
LANDCOVER	Grassland

CHARACTERISTIC



DESCRIPTION

- Artificially created and maintained
- Composed of lawn used for recreational, golf, and social purposes
- Under regular mowing and irrigation maintenance
- Public access is restricted

SPECIES

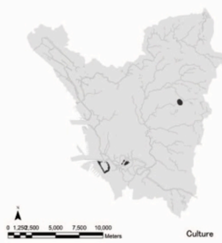
Tree
Plumeria rubra

Tree
Poa sp.

WILDLIFE

Bird
Passer montanus
Pycnonotus goiavier
Gerygone sulphura
Rhipidura javanica
Lanius cristata

DISTRIBUTION



88.52 Ha
0.37%

FUNCTION	BIODIVERSITY	FLOODING	CULTURE	POVERTY	AMENITY	PRODUCTIVITY
	Moderate	Moderate	High	_	High	_

Figure 32: Natural Biotope 21

Table 1: Natural Biotope Summary

Biotope number	Biotope	Area (Ha)	Coverage (%)
NB1	Lake	166.94	0.0071
NB2	Fishpond (Clay)	28.59	0.0012
NB3	Fishpond (Hydrosol)	1,163.73	0.0492
NB4	Fishpond (Sandy Loam)	190.62	0.0081
NB5	Mangrove (Clay)	51.99	0.0022
NB6	Mangrove (Sandy Loam)	56.59	0.0024
NB7	Nypa	62.16	0.0026
NB8	Coastal Forest	6.20	0.000 3
NB9	Economic Forest	4.78	0.0002
NB10	Upland Forest	270.36	0.0114
NB11	Forest (Riverbank)	6.31	0.0003
NB12	Coastal Grassland	163.74	0.0069
NB13	Lowland Institutional Grassland	207.20	0.0088
NB14	Lowland Industrial Grassland	42.64	0.0018
NB15	Lowland Undeveloped Grassland	75.76	0.0032
NB16	Riverbank Grassland	146.84	0.0062
NB17	Upland Natural Grassland	103.50	0.0044
NB18	Upland Institutional Grassland	747.18	0.0316
NB19	Upland Undeveloped Grassland	208.40	0.0088
NB20	Park	74.92	0.0032
NB21	Culture	88.52	0.0037
Total		**3,866.97 Ha.**	**18.84%**

A total of 21 natural biotope types are found in Metropolitan Manila. They are a combination of water and vegetation dominated biotope types, which are found in different areas of the metropolitan region. The different biotope types range from water bodies to aquaculture ponds and mangroves to forests and grasslands. Other classification included parks and culture, which represent a still predominantly-natural biotope types but have been largely influenced by human activities and urban development. The largest of which is Fishpond (Hydrosol) while the smallest of the natural biotopes is Economic Forest. The natural biotope types are numbered based on their location, starting with those found coastal and lowland.

Natural biotope 1 or the Lake is found in the higher elevation of the La Mesa Dam. It is surrounded by multi-tiered vegetation which benefits from being a protected area and the micro-climate provided by the presence of the lake. The lake is formed by retaining the water that serves as reservoir that supplies the water needs of some parts of Metropolitan Manila. Being a crucial resource, public accessibility is limited, thus possible intrusion of informal communities is averted. Surrounding the lake is a forest and an eco-park, which provides amenity value to the biotope type. It is considered as the headwater for the Tullahan Corridor.

Natural biotope 2 is Fishpond (Clay) found along the coastal zone of the metropolis. Being previously extensively used for aquaculture, vegetation is limited to those that thrive along the dikes of the fishpond, composed mostly of grass species and the scattering of trees adapted to saline environment and extreme condition. The vegetation pattern appeared spontaneously. This fishpond are not as extensively used for aquaculture because of several important dikes that protect the fishponds were destroyed during the recent typhoons. Many operations of the fishponds have been halted while some areas are still awaiting repair of the dikes.

Natural biotope 3 or Fishpond (Hydrosol) is found in hydrosol soil which is characterized of long exposure of being submerged underwater resulting to low oxygen in the soil. This condition results to very thin layer of vegetation that grows on the dike. Since many of the fishponds in this biotope type remain operational, the grasses are often removed or trimmed to prevent hosting possible pests that could affect the fishpond operation. Exposure to natural conditions such as strong wind, storms and saline condition and occasional burning has also kept the vegetation limited.

Natural biotope 4 is Fishpond (Sandy Loam), found close to the coast of Manila Bay. The presence of adjacent strips of mangrove have protected the fishpond from damages brought by typhoon and storm surges, unlike those that are found in Fishpond (Clay). It also remains productive and has remained operational. The proximity of mangroves may also aided in the dispersion of mangrove species along the dikes of the fishpond. Mangrove trees found along the dikes appeared to have thrived spontaneously because of the pattern of distribution.

Natural biotope 5 is Mangrove (Clay). It is found in several patches, mainly remnants of naturally mangroves that grow in the coastal zone. It is continuously being threated by urbanization with the presence of informal communities that surround it. The mangrove trees found in this biotope are harvested and mainly used for firewood and charcoal.

Natural biotope 6 or Mangrove (Sandy Loam) is a combination of naturally growing mangrove species and the efforts for reforestation of the mangrove areas along the coastal zone. This biotope has been important barrier in protecting the adjacent fishpond from strong waves and rising water during typhoons and storm surge. Because of this, measures have been taken by the local government to protect this biotope. Educational field trips have been organized to raise the awareness of the residents and visitors of the importance of mangroves. Further, guests are enjoined to mangrove reforestation by participating in the tree-planting activity as part of the experience. On the other hand, some portions of the mangroves are being threatened as some fishponds near the mangroves are being converted into landfill and dumpsite.

Natural biotope 7 is composed of *Nypa fruticans*, the only palm species that thrive in mangrove environment. Nypa has spontaneously grown in this environ which appears to have been previously grown by mangrove trees. The presence of communities around it has resulted to shallower water and deposition of sediments and organic nutirents, altering the environ conducive for the growth of Nypa. Nypa is being used as roofing materials by the communities that surround it.

Natural biotope 8 is Coastal Forest, which has very small distribution in the coastal zone. It developed naturally with trees mostly associated with pioneer species. There is also pressure from the surrounding informal communities as well as periodic exposure to flooding.

Natural biotope 9 or Economic Forest is privately-owned forest in which the owner benefits economically from the forest products. It is a mixture of naturally growing vegetation, mainly pioneer species, and tree species with economic benefits. The trees are mainly used for furniture, while twigs and smaller branches are used for firewood. Because it is privately-owned, access is limited to the owners and caretakers of the forest.

Natural biotope 10 or Upland Forest is the forest that surrounds the Lake. It is a mixture of natural-growing trees and reforested trees. Massive reforestation program was undertaken to reforest this area which serves as watershed protection area. Tree species include pioneer tree species and ornamental trees. It was revealed by the management of the forest that they will eventually shift to planting endemic species once the pioneer species has established suitable forest condition. The management has also converted some portions of the forest into a park that serves as recreational amenity and environmental educational venue for the visitors and guests. The forest is part of the larger protected watershed area in which water resource is closely linked to the adjacent spaces. Forests and grasslands are being encouraged while built-up spaces are limited to the minimum.

Natural biotope 11 is Riverbank Forest or forests found along the river. The forests are restored or reforested forest along the major river, Pasig River. The tree composition is mostly ornamental trees while understory is devoid of any vegetation because of the dense canopy of trees. Most of the efforts of reforestation is attributed to the environmental groups that have advocated keeping the city green, in which many schools have been involved in the effort.

Natural biotope 12 or Coastal Grassland have naturally generated from lots and vacant spaces found in the coastal zone. The vegetation structure is a simple cover of grasses that thrive in coastal and extreme conditions. Aside from this, the soil cover is thin so as not to be able to support complex vegetation structure. Even with this condition, a number of bird species has been observed in the area.

Natural biotope 13 or Lowland Institutional Grassland is composed mainly of lawns with occasional ornamental trees planted in between. This biotope can be found in government complexes, small public parks and playgrounds, church grounds and cemetery, and school compounds and athletic fields. It is used mostly for recreational, sports and social events. Many of these institutions have significant historical and cultural value. The demand and use of this biotope require it to be maintained regularly, thus the necessity for mowing and trimming.

Natural biotope 14 is Lowland Industrial Grassland, which can be found adjacent to the factories and industrial plants. Some areas are abandoned industrial lots or empty lots that surround the industrial area. Vegetation has naturally generated, with some pioneer trees growing along with tall grasses and reeds. It is presumed that some of these areas have polluted soil and can be considered as brownfield. A host of birds have been observed to be present at the location of these sites.

Natural biotope 15 or Lowland Undeveloped Grassland can be found in vacant lots or spaces that are currently being developed. Grasses have emerged spontaneously with saplings of pioneer tree species. The thick carpet of grasses and reeds have become an ideal nesting ground for some birds observed in the area aside from the limited disturbance from human activities because of the limited access to the site.

Natural biotope 16 or Riverbank Grassland is natural grassland found along riverbanks. Because of its exposure to periodic flooding, vegetation has adapted to frequent inundation, mainly composed of reeds and occasional trees. They are mostly found along the Tullahan River in which some areas along the river have not been encroached by development or informal communities.

Natural biotope 17 is Upland Natural Grassland that has served as nesting ground for bird species. This biotope type thrives with the presence of small streams or tributaries that sustain the grasses even during long spell of dry season. It is an important space for absorbing runoff and excess rain, making it an important infiltration zone in the upstream.

Natural biotope 18 or Upland Institutional Grassland is found in academic institutions and government grounds. It is a combination of natural grasslands, which is the original landcover of the upland, and lawn areas, which have been cultivated for the social and recreational purposes. The biotope requires regular maintenance such as mowing and trimming, and artificial irrigation.

Natural biotope 19 or Upland Undeveloped Grassland has naturally regenerated from previous land clearing or is being prepared for future development. Occasional impervious surfaces are found along with condemned structures. Grass species have overran the area with remnant trees that dot the biotope. Access to the biotope is limited because of being fenced and prohibition against trespassing.

Natural biotope 20 is composed of Parks, which are significantly larger than the small parks and community parks. These parks are large spaces intended for park purposes, which involve recreational and social uses. Vegetation includes lawns and landscaped areas, mostly with ornamental plants and trees. The high pedestrian traffic in this biotope has resulted to open vegetation with expansive lawns serving as important social and recreational spaces, while trees serve ornamental and shading purposes with shrub as groundcover. In terms of management, these parks are managed by the national government in contrast with the other parks that are managed by local governments. It is intensively managed by means of mowing and irrigation.

Natural biotope 21 includes Culture or areas that have been recognized for their historical and cultural values. This biotope includes golf courses in the former moat around the historic wall of Intramuros, parks dedicated in memory of a national hero, and the presidential palace grounds. These spaces have wide lawns dotted with ornamental trees. These are artificially created and maintained through mowing and artificial irrigation. Access is limited from the public, allowing more frequent maintenance and less stress on the environ. The biotopes are managed by the national government, except for the Quezon Memorial Circle which has been turned over to the local government.

3.2.2 Built-up Biotope

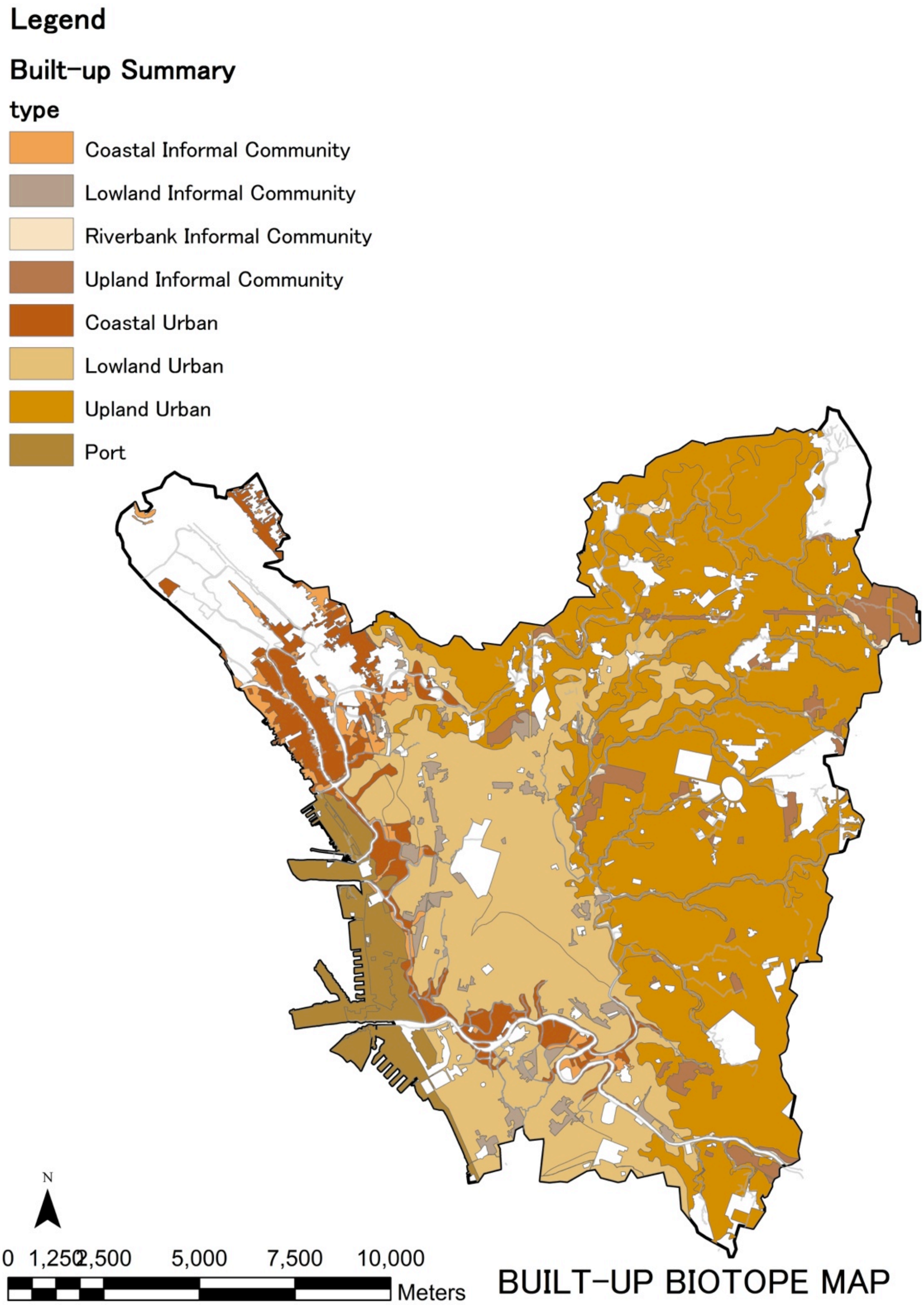
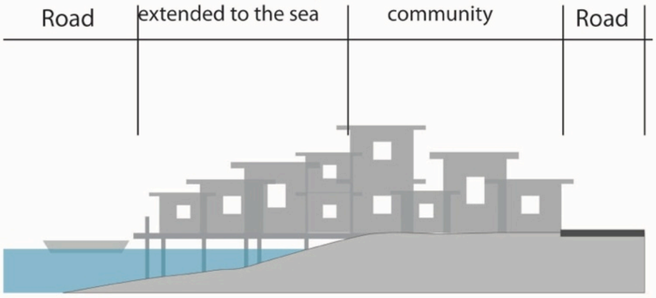


Figure 33: Built-up Biotope Map

BUILT-UP BIOTOPE 1: Coastal Informal Community

GEOGRAPHY	Coastal Inland
SOIL TYPE	Sandy Loam, Clay, Hydrosol
LANDCOVER	Informal Community

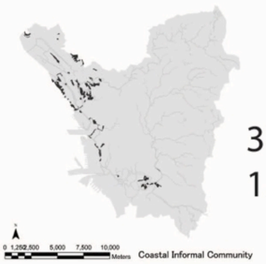
CHARACTERISTIC



DESCRIPTION

- Development is linear following the coastal line
- Life is dependent on coastal activities
- Houses are linked by bridges, serving as connectors and common/social area
- Houses are built with stilts to elevate above average high tide level

DISTRIBUTION



370.09 Ha
1.57%

FORM

FUNCTION	BIODIVERSITY	FLOODING	CULTURE	POVERTY	AMENITY	PRODUCTIVITY
	Low	- High	–	- High	- High	Moderate

Figure 34: Built-up Biotope 1

BUILT-UP BIOTOPE 2: Lowland Informal Community

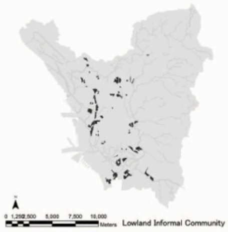
GEOGRAPHY	Lowland
SOIL TYPE	Sandy Loam, Clay, Hydrosol
LANDCOVER	Informal Community

CHARACTERISTIC

DESCRIPTION

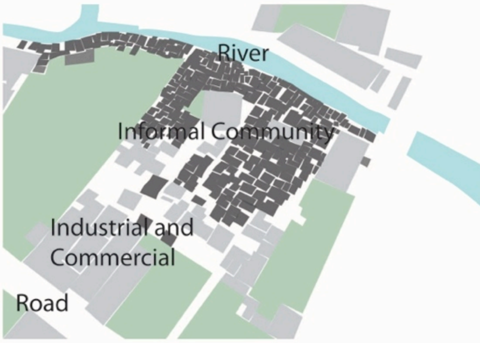
- Development in mass having its own center
- Church plays important role in forming community identity
- Community sustains itself by having facilities within
- Needs to be linked to formal urban activities

DISTRIBUTION



428.16 Ha
1.81%

FORM



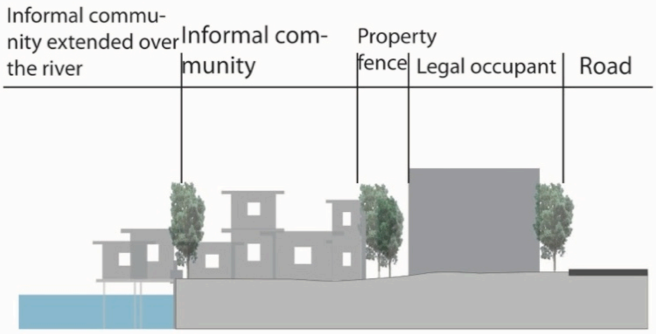
FUNCTION	BIODIVERSITY	FLOODING	CULTURE	POVERTY	AMENITY	PRODUCTIVITY
	Low	- Moderate	Low	- High	- Moderate	_

Figure 35: Built-up Biotope 2

BUILT-UP BIOTOPE 3:
Riverbank Informal Community

GEOGRAPHY	Riverbank
SOIL TYPE	Filled Soil
LANDCOVER	Informal Community

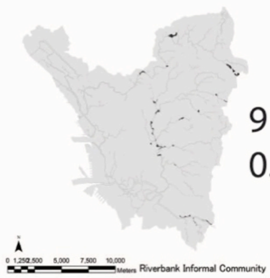
CHARACTERISTIC



DESCRIPTION

- Development is linear within the setback area along the river
- Strip of area is limited resulting to construction over the water area
- Community needs to be linked to formal amenities and activities to sustain

DISTRIBUTION



91.98 Ha
0.39%

FORM

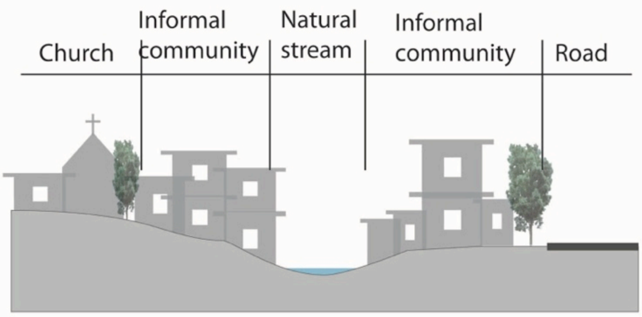
FUNCTION	BIODIVERSITY	FLOODING	CULTURE	POVERTY	AMENITY	PRODUCTIVITY
	- Moderate	- High	–	- High	- High	–

Figure 36: Built-up Biotope 3

BUILT-UP BIOTOPE 4: Upland Informal Community

GEOGRAPHY	Gentle Slope
SOIL TYPE	Clay
LANDCOVER	Informal Community

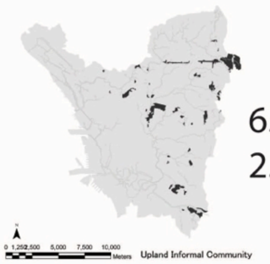
CHARACTERISTIC



DESCRIPTION

- Community has access to main road
- Community sustains itself by having amenities within
- Emerges in easements and setbacks, non-buildable zones (under trasmission lines, over water pipes, along water channels

DISTRIBUTION



654.76 Ha
2.77%

FORM

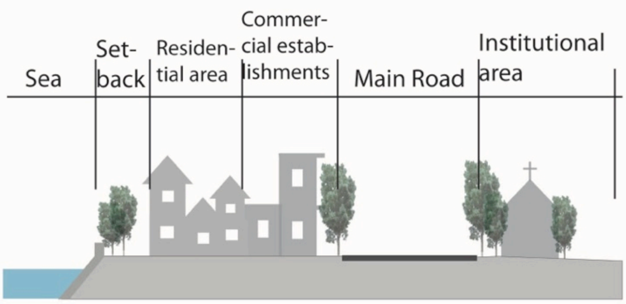
FUNCTION	BIODIVERSITY	FLOODING	CULTURE	POVERTY	AMENITY	PRODUCTIVITY
	- Low	–	Low	- High	- Low	–

Figure 37: Built-up Biotope 4

BUILT-UP BIOTOPE 5: Coastal Urban

GEOGRAPHY	Coatsal Inland
SOIL TYPE	Sandy Loam, Clay, Hydrosol
LANDCOVER	Urban

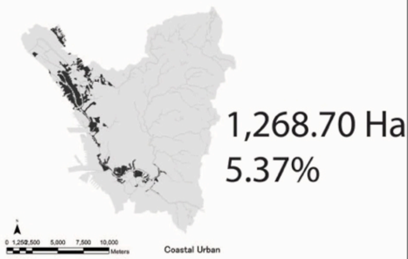
CHARACTERISTIC



DESCRIPTION

- Linear development along the coast
- Building height is limited to mid-rise but houses close to sea have two-storeys as form of adaptation to periodic flood
- Urban activities influenced by coastal factors

DISTRIBUTION



FORM

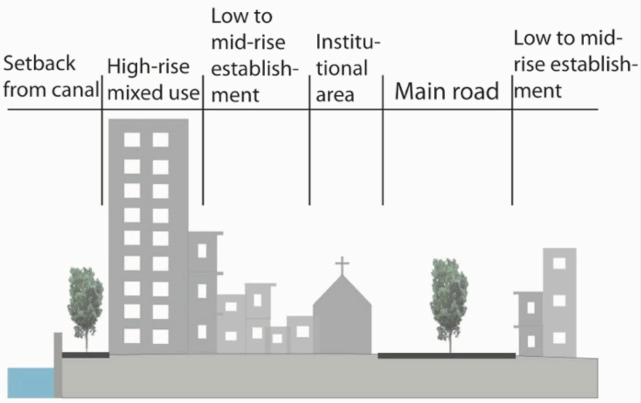
FUNCTION	BIODIVERSITY	FLOODING	CULTURE	POVERTY	AMENITY	PRODUCTIVITY
	Low	- High	Moderate	- Low	Low	Low

Figure 38: Built-up Biotope 5

BUILT-UP BIOTOPE 6: Lowland Urban

GEOGRAPHY	Lowland
SOIL TYPE	Clay, Hydrosol, Filled Soil
LANDCOVER	Urban

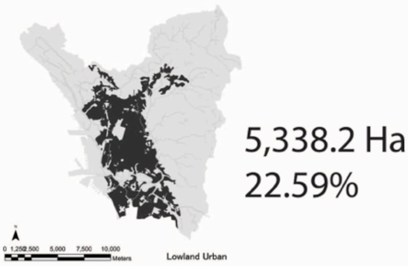
CHARACTERISTIC



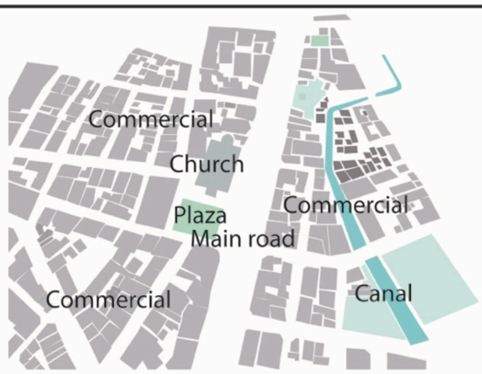
DESCRIPTION

- Older urban center (downtown)
- Has numerous cultural herit-age sites and buildings
- Building heights were lim-ited due to soil condition
- Interconnected canals
- Vegetation limited to street-scapes and plazas

DISTRIBUTION



FORM



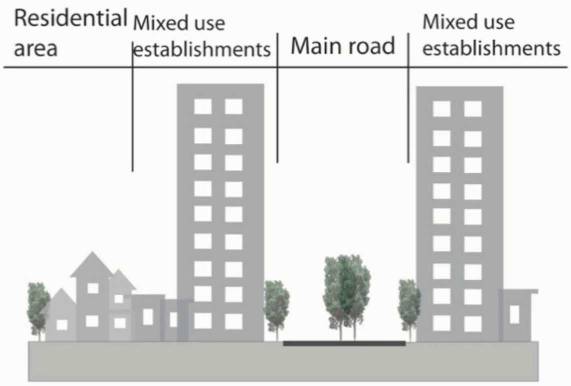
FUNCTION	BIODIVERSITY	FLOODING	CULTURE	POVERTY	AMENITY	PRODUCTIVITY
	Low	Moderate	High	Low	Moderate	High

Figure 39: Built-up Biotope 6

BUILT-UP BIOTOPE 7: Upland Urban

GEOGRAPHY	Gentle Slope
SOIL TYPE	Clay
LANDCOVER	Urban

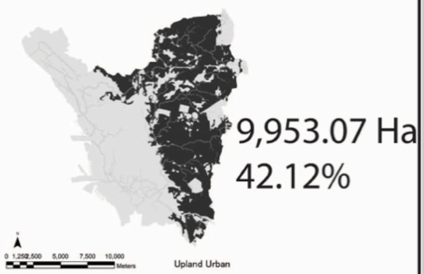
CHARACTERISTIC



DESCRIPTION

- Serves as one of the polyc-entric centers
- Development follows road and major commenrcial center
- High-rise establishments emerge due to limited land
- Vegetation is confined in roads and small patches of parks

DISTRIBUTION



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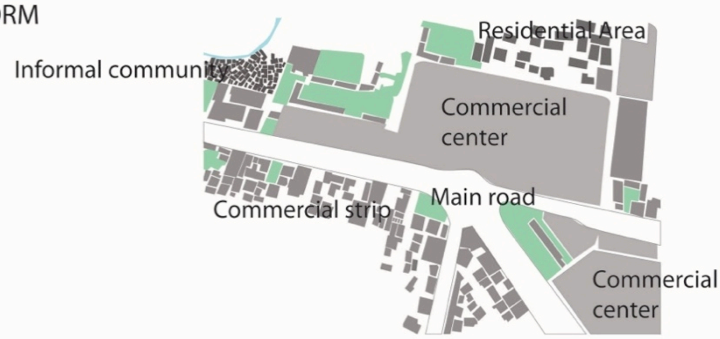


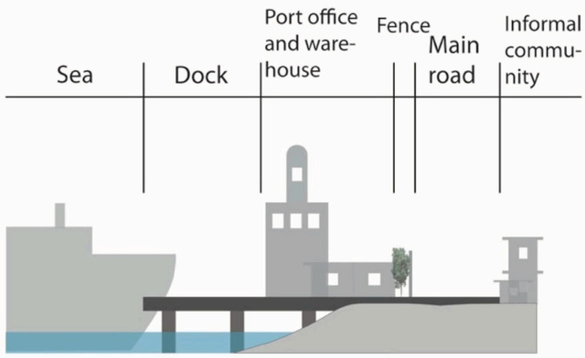
FUNCTION	BIODIVERSITY	FLOODING	CULTURE	POVERTY	AMENITY	PRODUCTIVITY
	Low	- High	Moderate	- Low	Low	Low

Figure 40: Built-up Biotope 7

BUILT-UP BIOTOPE 8: Port

GEOGRAPHY	Reclaimed Land
SOIL TYPE	Filled Soil
LANDCOVER	Urban, Informal Community

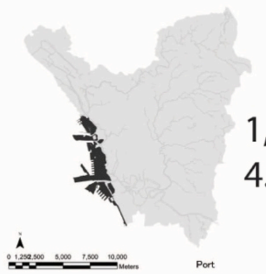
CHARACTERISTIC



DESCRIPTION

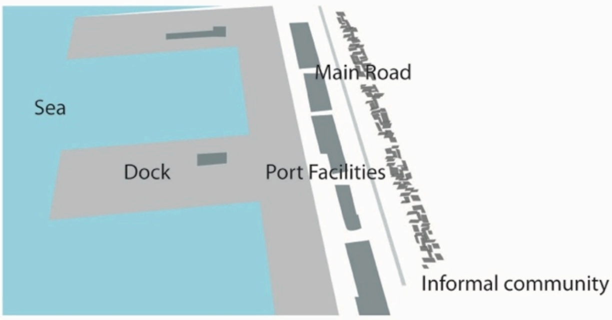
- Port developed in reclaimed area
- Port activities attracted informal settlers
- Linear development and intensive port activities leave very little space for vegeta-tion
- Port accessibility is limited and connected to main road

DISTRIBUTION



1,073.2 Ha
4.54%

FORM



FUNCTION	BIODIVERSITY	FLOODING	CULTURE	POVERTY	AMENITY	PRODUCTIVITY
	Low	- High	Moderate	- High	High	High

Figure 41: Built-up Biotope 8

Table 2: Built-up Biotope Summary

Biotope Number	Biotope	Area (Ha)	Coverage (%)
BB1	Coastal Informal Community	370.09	1.57
BB2	Lowland Informal Community	428.16	1.81
BB3	River Bank Informal Community	91.98	0.39
BB4	Upland Informal Community	654.76	2.77
BB5	Coastal Urban	1,268.70	5.37
BB6	Lowland Urban	5,338.23	22.59
BB7	Upland Urban	9,953.07	42.12
BB8	Port	1,073.27	4.54
Total		**19,178.26 Ha**	**81.16%**

There are eight built-up biotope types. Four of the built-up biotope types are a form of informal communities, while three are urban-related. The informal communities are dominated by a mass of built-up spaces having developed organically and bereft of planning that is apparent in urban biotope types. Urban biotope types are formally planned spaces composed of residential, industrial, institutional, commercial and mixed-use. The eighth type is port, which is differentiated from the rest because of its unique function as compared to urban biotope types. The intensive industrial and transportation function that occurs in the port area sees transient and continuous movement of people. Unlike in informal community and urban biotope types, the population is continuously changing with the configuration of spaces changing daily with the movement of containers, goods, and passengers. Its location along the coastal zone makes it also in a very ecologically sensitive space, which contribute to the total urban form of the city.

Built-up biotope 1 is Coastal Informal Community, which is composed of clusters of residential spaces built along the coastal zone. The lives of the residents are closely tied with the coastal processes, with many of households depend on fishing for their diet and livelihood. The community overflows to the sea zone with structures built with stilts to elevate the houses above the highest tide level. These structures are connected with interconnected bridges, which serve as a common space among the residents where they interact socially with the rest of the community. This community is at great risk during typhoons, floods and storm surges.

Built-up biotope 2 or Lowland Informal Community is more nuclear and multi-layered community with the church and local government playing an important role in keeping community cohesion. The community has most of its important community components, such as community center, church, and local shops offering basic services. In a way, it is self-sustaining in which all the necessary components of the community are present. However, it still needs to be connected to the formal urban network since most of the residents work outside of the community.

Built-up biotope 3 is Riverbank Informal Community, a linear form of residential structures built along the banks of the river. The width of the community is limited because it is commonly based on the easement provided for the river. The community requires to be connected to the formal urban activities since other components needed by the community have to be sourced outside of the community, such as school, church, and market. Most of the structures are built with stilts encroaching the edge of the river, or even covering the total width of the river in some areas.

Built-up biotope 4 is Upland Informal Community which needs to be connected to main road. Similar to the lowland informal community, this biotope has, to a certain point, capacity to be self-sustaining with the presence of components vital for the community, such as schools, church, playground, and local government. Aside from existing in vacant or undeveloped lots, this biotope develops in public easements and setbacks, and non-buildable zones, such as under transmission lines, on pipe lines and along minor water channels.

Built-up biotope 5 or Coastal Urban develops as linear strips along major road that traverse the coastal zone. The low elevation and constant threat of flooding because of the location and influence of tidal movement are the common problems of this biotope. Structural heights are limited because of the lack of load-bearing capacity of the soil. On the other hand, residential buildings are often built with second-storey as a form of adaptation to the periodic flood experienced by this biotope. The biotope is composed of institutional buildings and spaces, a large residential community, industries and factories and warehouses, informal community, and cultural buildings. The biotope is closely linked to the coastal activities, with many of the residents involved in fisheries and aquaculture production.

Built-up biotope 6 or Lowland Urban is where the early Manila developed as an urban center. Many of the older buildings are found in the downtown, hence the presence of a number of structures with cultural and historical values. The lowland is characterized by the presence of canals or "esteros" which helped shaped the present form of lowland urban, with streets and buildings oriented along these canals. The presence of vegetation is limited to the streetscapes and small gardens, rotundas, pocket parks and memorial parks.

Built-up biotope 7 is Upland Urban with its dense building and population concentration. It forms the urban centers in which development follows the road and commercial centers. Prices of land are also high, resulting to construction of high-rise developments for commercial, residential and mixed use. Vegetation is limited to road streetscapes and patches of parks.

Built-up biotope 8 or Port is nestled in a very sensitive ecological zone which connects the coastal zone with the rest of the metropolitan region. The port is built on reclaimed area with facilities that include warehouses, cargo and passenger terminals, and navigational facilities. The intensive activities within this biotope has attracted immigrants thus the development of informal communities near the port. Many of the residents of the informal communities near the port depend their livelihood in the port. The intensive and high traffic of both heavy equipment and pedestrians have left very little space for vegetation.

3.3 Biotope Evaluation

3.3.1 Natural Biotope

Table 3: Natural Biotope Evaluation

		Function							Strategy			
Biotope number	Type	Biodiversity	Flood	Culture	Poverty	Amenity	Productivity	Total	Preservation	Conservation	Improvement	Creation
NB1	Lake	3	3	1		3	1	11	*			
NB2	Fishpond (Clay)	1	3				1	5			*	
NB3	Fishpond (Hydrosol)	1	3				3	7			*	
NB4	Fishpond (Sandy Loam)	2	3				3	8		*		
NB5	Mangrove (Clay)	2	3	1	-1		1	6			*	
NB6	Mangrove (Sandy Loam)	2	3			2	1	8		*		
NB7	Nypa	2	3		-2		2	5			*	
NB8	Coastal Forest	3	3		-3	2	2	7				
NB9	Economic Forest	2				1	3	6			*	
NB10	Upland Forest	3	3			3	2	11	*			
NB11	Forest (Riverbank)	2	2	2	-3	3		6			*	
NB12	Coastal Grassland	1	3		-3	2		3				*
NB13	Lowland Institutional Grassland	2	2	3		3		10		*		
NB14	Lowland Industrial Grassland	2	2	1		1		8		*		
NB15	Lowland Undeveloped Grassland	2	2		-2	1		3				*
NB16	Riverbank Grassland	2	3			2		7			*	
NB17	Upland Natural Grassland	3	3			1		7			*	
NB18	Upland Institutional Grassland	2		3		3		8		*		
NB19	Upland Undeveloped Grassland	2	2		-2	1		3				*
NB20	Park	2	1	3		3		9		*		
NB21	Culture	3	2	3		3		11	*			

The different natural biotope types are evaluated based on their function that correspond to how they relate to the major issues faced by Metropolitan Manila, namely: Biodiversity, Flooding, Poverty and Culture. Aside from these, additional parameters are also added to evaluate their value as amenity and how they contribute to the productivity. The rating of value ranges from the highest possible value of three (3) to minus five (-3), in which a value of five (3) is given to the parameter in which a specific biotope optimizes its function. For instance, a multi-tiered and complex vegetation structure of a forest provides a host of benefits to maintain and preserve the biodiversity, thus optimizing the biodiversity function for that biotope type. On the other hand, when the biotope has an inverse relation with the parameter, the value given is below zero (0) or negative value. In this case, a grassland that experiences constant flooding and suffers the consequence of the disaster without providing any measure of mitigating flood is given a negative value. However, a fishpond that experiences flood but serves as an important area for exfiltration of runoff and absorbing the effects of flood is given a positive value, depending on their effectivity in responding to the parameter. On the other hand, when the parameter does not correspond to the specific biotope, a null value is given for that parameter. A forest that does not have any encroachment of informal communities is receives a null value since poverty does not exist within the specific biotope. The total value of the biotope type is summarized by adding all the values in which appropriate strategy is proposed to optimize the function of the biotope. With the six parameters included for the natural biotope type, the highest possible total value for a biotope type is 18 points, and the lowest is -18. Biotope type that receives a total of at least 11 points is considered for preservation. Biotope type that receives a total value of eight (8) to 10 is considered for conservation, while those with five (5) to seven (7) points are proposed to be improved, and any total value lower than that need to be change to create new greenspace.

Different strategies are proposed for biotope depending on their total value, these are Preservation, Conservation, Improvement, and Creation. Preservation pertains to the strict protection of the biotope type in which any human activities that have could affect the function of the biotope type is prohibited while vegetation structure and composition need to be maintained as status quo. On the other hand, conservation leans on optimizing the function of the biotope while providing its benefits to the residents and urban condition. Improvement implies facilitating connectivity and strengthening the complexity of the vegetation structure. On the other hand, creation means shifting the use of some present built-up biotopes into green space to increase the percentage of green spaces within the matrix.

Among the different natural biotope types, the Lake, Upland Forest and Culture generated the highest total value, necessitating preservation for these biotope types. These spaces require that the boundaries are protected and buffered so as to prevent encroachment and possible changes in the land use. Further, these biotope types should be considered as ecological cores that can serve as ecological anchors to maintain stability of biodiversity of the region. Biotope types Fishpond (Sandy Loam), Mangrove (Sandy Loam), Lowland Institutional Grassland, Lowland Industrial Grassland, Upland Institutional Grassland, and Parks are utilized for human benefits in which measures should be taken to maintain the biodiversity while keeping the productivity and amenity. These biotopes types have also positive relationship with flooding, meaning they serve to avert the effects of flooding, implying the need to keep them as greenspaces and preventing further changes in the land use into built-up areas. On the other hand, Fishpond (Clay), Fishpond

(Hydrosol), Mangrove (Clay), Nypa, Economic Forest, Riverbank Forest, Riverbank Grassland, and Upland Natural Grassland are presently stable as natural biotopes but will stand to benefit if they are connected with other natural biotopes and strengthening exchanges between them. The rest of the biotope types, Coastal Grassland, Lowland Undeveloped Grasslands, and Upland Undeveloped Grassland, can achieve ecological stability by shifting their uses into more ecological-oriented function, such as changing the Coastal Grassland into bird watching site by minimizing disturbance to the site and allowing natural vegetation regeneration or supporting the present vegetation regime by encouraging growth of beneficial species. Lowland Undeveloped Grassland and Upland Undeveloped Grassland can also be changed into reserved sites in which integrated parkland can take their place while allowing the wildlife to flourish.

3.3.2 Built-up Biotope

Table 4: Built-up Biotope Evaluation

		Function							Strategy		
Biotope number	Type	Biodiversity	Flood	Culture	Poverty	Amenity	Productivity	Total	Conversion	Redevelopment	Improvement
BB1	Coastal Informal Community	1	-3		-3	-3	2	-6	*		
BB2	Lowland Informal Community	1	-2	1	-3	-2		-5		*	
BB3	River Bank Informal Community	1	-3		-3	-3		-8	*		
BB4	Upland Informal Community	1	-3	2	-3	1		-2		*	
BB5	Coastal Urban	1	-3	2	-1	1	1	1			*
BB6	Lowland Urban	1	-2	3	-1	2	3	6			*
BB7	Upland Urban	1	-3	2	-1	1	1	1			*
BB8	Port	1	-3	2	-3	3	3	3			*

Similar to the Natural Biotope, the Built-up biotope types are similarly evaluated using the six parameters: Biodiversity, Flood, Culture, Poverty, Amenity, and Productivity. A range of values from three (3) to minus three (-3) is given for each parameter to determine their total value in which a strategy can be proposed. The different strategies are different compared with the natural biotope evaluation, with strategies that include Conversion, Redevelopment, and Improvement. Conversion necessitates shifting of use into more natural biotope function of some spaces because of threats these spaces face, particularly against flood and poverty. These biotope types face the higher threats and immediate steps need to be taken address their most urgent issues. Total value of these biotope types should be greater than minus six (-6). Redevelopment implies changing policies to improve the condition, such as reducing the issues of poverty and coming up with proposal to adapt present threats. For these biotope types, total value should be from zero (0) to minus five (-5). On the other hand improvement can be instituted to biotope types that receive positive total values in which threats is not as great as those compared with other biotope types but altering some spaces can improve the overall condition of the biotope, such as adding more greenspaces in heavily built-up biotopes.

Built-up biotope types Coastal Informal Community and Riverbank Informal Community face the highest threat, particularly from flood and poverty, thus conversion of these biotope types is necessary to prevent residents from further exposure to risk and disasters. The community structure is not resilient enough to withstand disturbance since the community components are not complete to absorb the effects of disturbance and they have to rely from the support of the formal urban system to be able to overcome the threats. On the other hand, Lowland Informal Community and Upland Informal Community have well developed community system that although they also face high risk of threats from flood and poverty, they can weather these challenges, thus redevelopment in certain aspects of the community is necessary to enhance the community, particularly in the area of amenity and productivity. The rest of the built-up biotopes, the urban spaces and port can improve the overall resilience of the metropolitan region by improvement, in which they scored low in biodiversity and poverty. Measures to address these main issues need to be implemented such as better housing for the informal communities and strengthening biodiversity by means emphasizing the micro-green spaces or patches to improve the matrix of green spaces within the urban environment.

3.4 Existing Ecological Structure

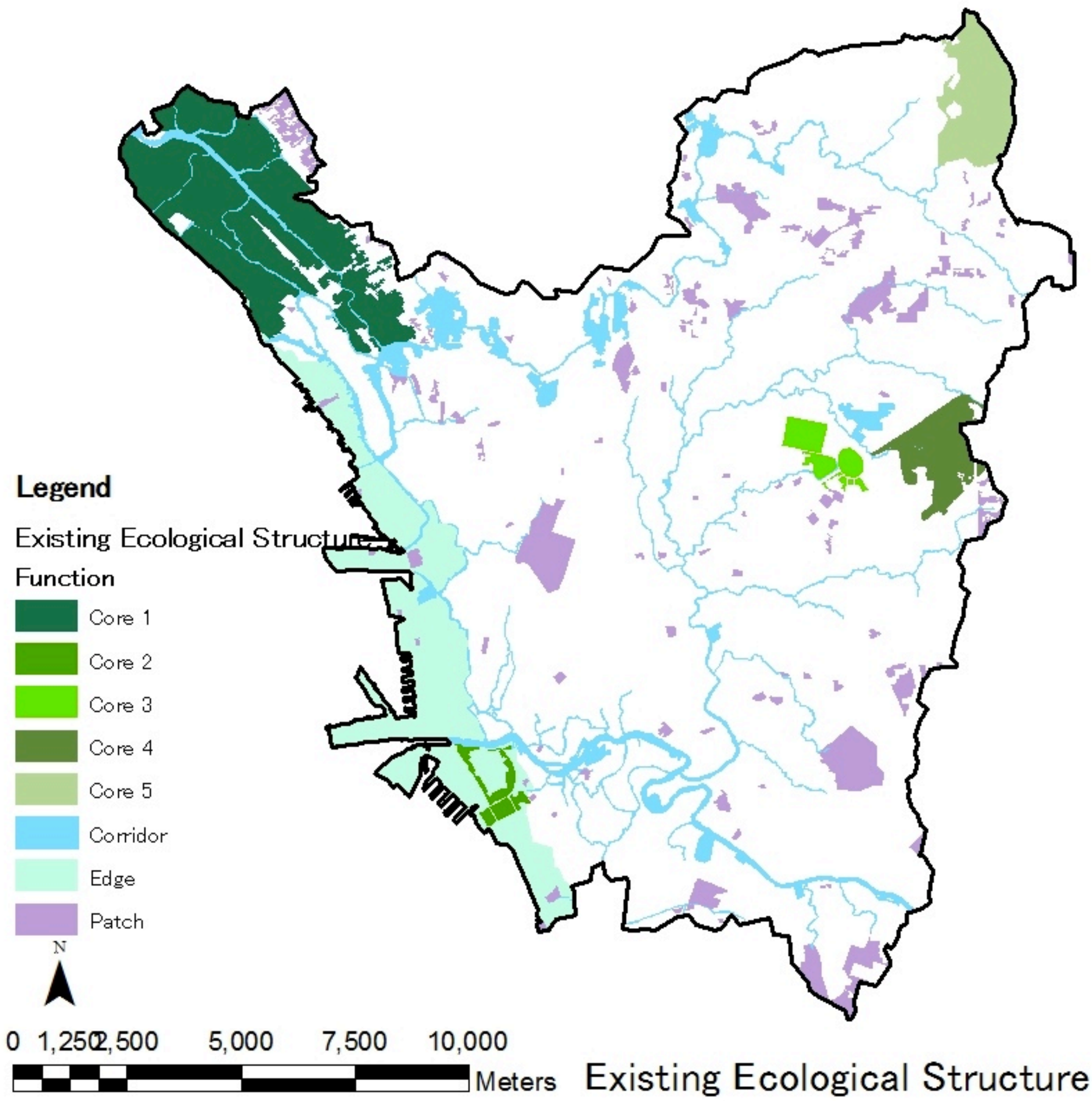


Figure 42: Existing Ecological Structure of Metropolitan Manila

Based on the biotope map, important ecological structure is determined based on their function. The different functions in the ecological structure are: (1) core, (2) corridor, (3) edge, and patch. Cores are major green spaces composed of a singular patch or a cluster of patch having (combined) area for each core of 100 hectares, possess complex or multiple vegetation structure, and present potential for connectivity and linkages by being connected to a water channels. Corridors include both the water body and the linear patches along water channels. Edge is the area between the land and sea, having coastal characteristics. The edge is differentiated by the river or road parallel to the sea, being in the coastal inland or lowland landform. The patches are isolated green spaces, generally having area smaller than 100 hectares and isolated from other green spaces.

3.4.1 Core

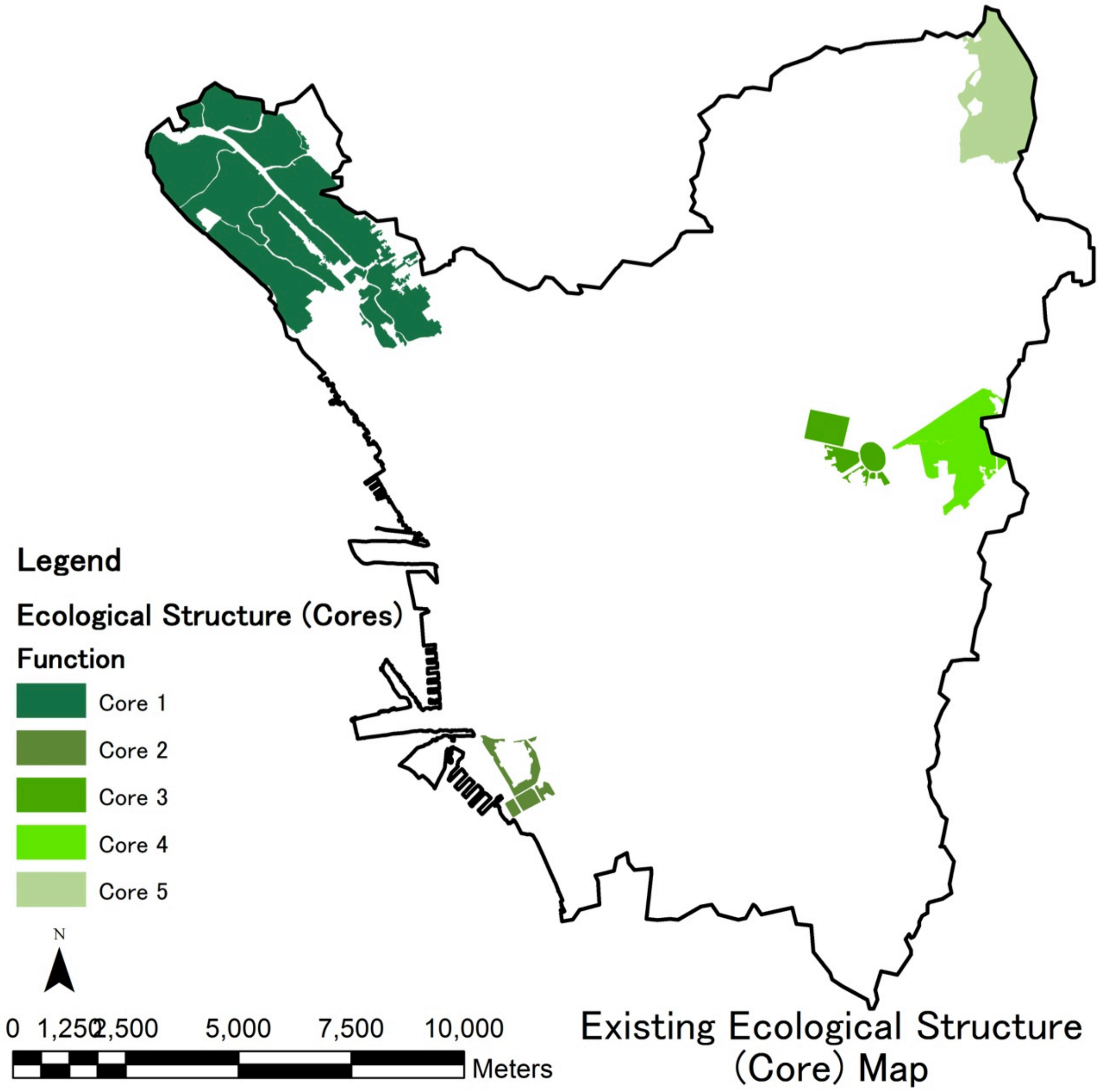


Figure 43: Existing Ecological Structure (Core)

Ecological cores are composed of biotopes or agglomeration of biotopes that are similar in terms of landcover composition and/or connected in such a manner that biological exchanges can transpire. They serve as important spatial units particularly in the field of biodiversity conservation and as genetic stock. They also serve certain ecosystem benefits such as water retention, deceleration of runoff rate, natural water filter, carbon storage, among others. They also serve as important amenity area, serving as recreational space and breathing space in a highly congested and urbanized region of Metropolitan Manila.

Table 5: Core Planning Strategy

Function	Biotope Number	Biotope Type	Area	Patch Count	PROPOSED MANAGEMENT	Action
Core 1	NB2	Fishpond (Clay)	28.59	1	Improvement	Coastal Resource Management
	NB3	Fishpond (Hydrosol)	1,144.31	14	Improvement	Coastal Resource Management
	NB4	Fishpond (Sandy Loam)	190.62	1	Conservation	Coastal Resource Management
	NB5	Mangrove (Clay)	2.98	2	Improvement	Coastal Resource Management
	NB6	Mangrove (Sandy Loam)	56.59	1	Conservation	Coastal Resource Management
	NB7	Nypa	17.40	4	Conservation	Coastal Resource Management
	NB12	Coastal Grassland	49.93	6	Creation	Coastal Resource Management
Total			**1,924.37 Ha**			
Core 2	NB13	Lowland Institutional Grassland	1.19	1	Conservation	
	NB20	Park	32.89	3	Conservation	National Park Management
	NB21	Culture	42.17	1	Preservation	Preservation Law
Total			**142.18 Ha**			
Core 3	NB10	Upland Forest	4.60	2	Preservation	Watershed Management
	NB18	Upland Institutional Grassland	64.92	3	Conservation	
	NB20	Park	27.40	1	Conservation	National Park Management
	NB21	Culture	28.26	1	Preservation	Preservation Law
			585.61			
Core 4	NB16	Riverbank Grassland	3.49	1	Improvement	Linear Park
	NB18	Upland Institutional Grassland	283.92	2	Conservation	
Total			**523.11 Ha**			
Core 5	NB1	Lake	66.94	1	Conservation	Watershed Management
	NB10	Upland Forest	188.30	4	Preservation	Watershed Management
	NB17	Upland Natural Grassland	44.12	3	Conservation	Watershed Management
Total			**1,453.05 Ha**			

Core 1
Core 1 is composed of the forest that surround the La Mesa Lake. The forest is part of the forest reserve for the La Mesa Watershed. The area is divided into two major areas: the La Mesa Eco-park and the La Mesa Watershed Forest Reserve. The La Mesa Eco-park is open to the public except for some facilities that charge entrance fees. Access to the La Mesa Watershed Forest Reserve is restricted/limited. The forest has been severely denuded before but has been restored through reforestation efforts.

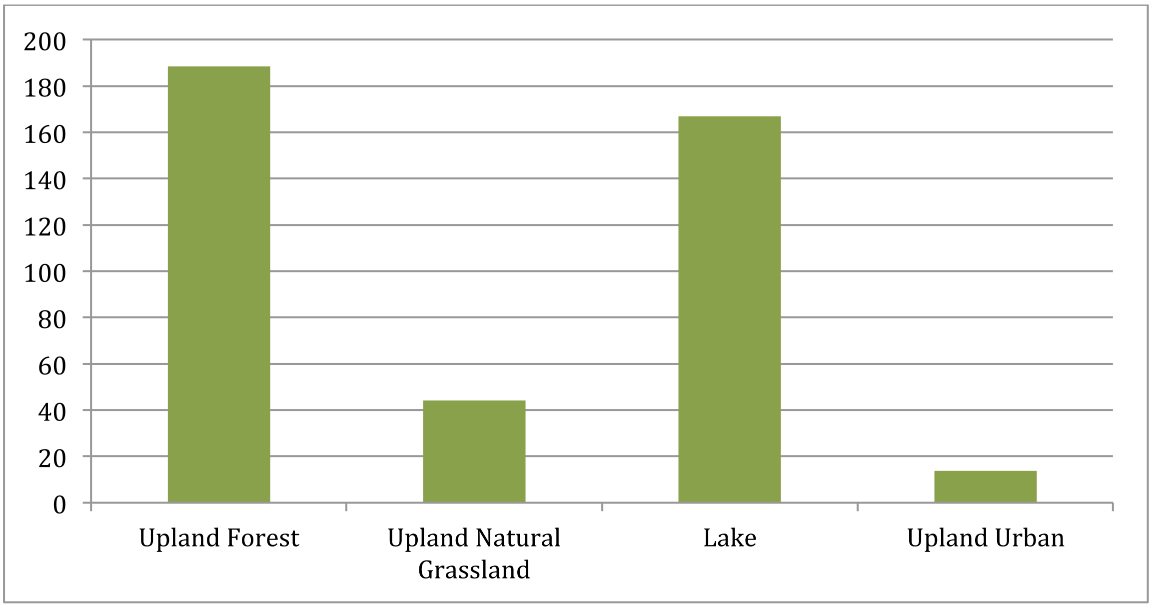


Figure 44: Biotope Distribution in Core 1

Core 2: The University of the Philippines Campus Greens
Core 2 is an academic ground where the campus of the University of the Philippines can be found. The sprawling grounds are mainly composed of lawns, naturally- vegetated meadows, groves of ornamental trees, orchard plantation and ornamental gardens. Quite prominent of the vegetated area in the campus is the canopied academic oval by mature *Samanea saman*, creating an envelope of green around the center of the academic life. The urbanized biotopes include paved surfaces of roads and pathwalks and built-up structures. The university campus is open to the public, allowing people to enjoy the benefits of having a major green space within the vicinity of mostly institutional and residential areas.

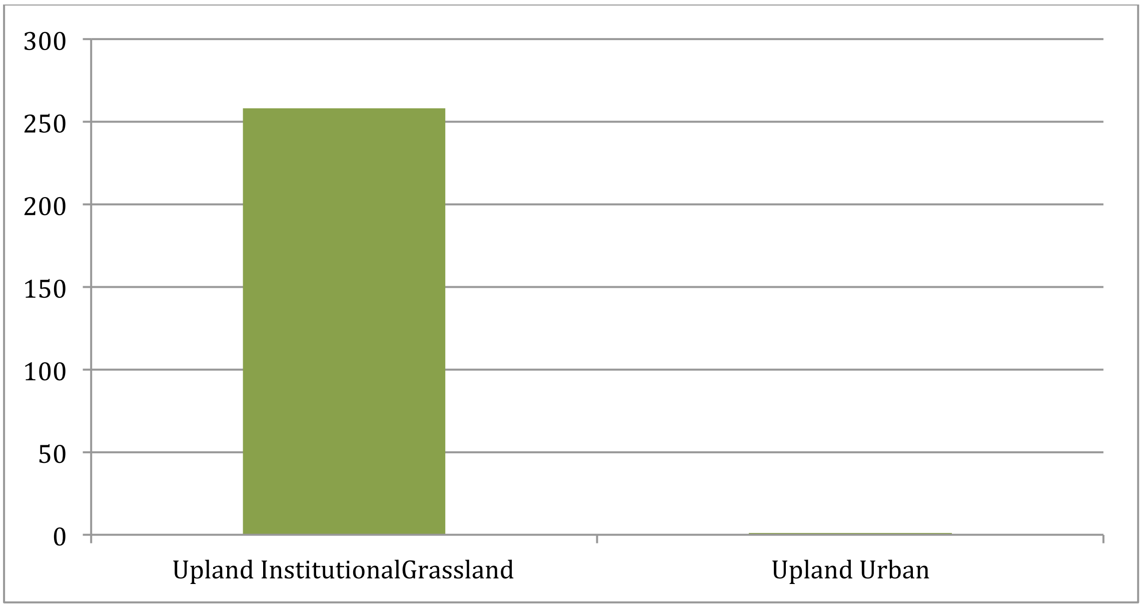


Figure 45: Biotope Distribution in Core 2

Core 3: Core 3: Civic Greens of Quezon City

Core 3 is composed of three major green spaces: the Quezon Memorial Circle (QCMC), the Ninoy Aquino Parks and Wildlife Center (NAPWC) and the Veterans Memorial Medical Center (VMMC). The QMC is an open public park with various recreational amenities amid the lush greenery. Mature ornamental trees frame the park in which playgrounds, gazebos and picnic grounds can be found. The NAPWC has limited access due to entrance fee. It contains an artificially constructed lake surrounded by urban forest. It also houses a wildlife rescue center, which also serves as a zoological center. The VMMC is a golf course that surrounds the hospital facility. Rows of ornamental trees serve as space delineation that divides the lawn areas into that serve various recreational purposes

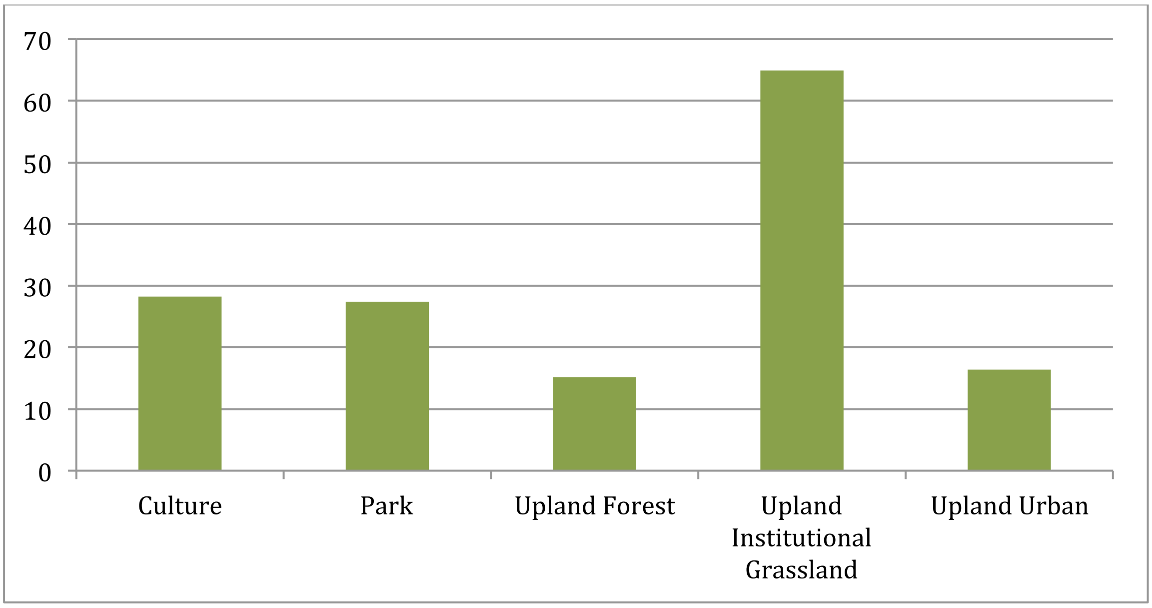


Figure 46: Biotope Distribution in Core 3

Core 4: Civic Greens of Manila

Core 4 is composed of several public open spaces (POS) that is part of the implemented portion of the proposed Burnham Plan. The POS that compose Core 4 are: the Rizal Park, the Intramuros Golf Course, and the Quirino Grandstand grounds. Rizal Park is national park consist mostly of a central civic space of lawn and avenue of palms, an artificial lagoon and themed gardens. Themed gardens include a Japanese garden, Chinese garden, orchid garden, and children's paradise or tot lot. The themed gardens have variety of vegetation, particularly ornamental trees species, providing a thick green around the main civic center. The Intramuros Golf Course used to be a moat that surrounds the walled city of Intramuros. The moats have since been reclaimed and filled to create the present golf course. The lawn areas are bordered by groves of *Cocos nucifera*, *Gliricidia sepium*, and *Plumeria obtuse-alba*. The golf course also has numerous ponds and land mounds that serve as hazards for those playing golf. The Quirino Grandstand ground is a lawn area fronting the grandstand. Shade trees such as *Pterocarpus indicus* and *Syzygium cuminii* border the grandstand area and grounds.

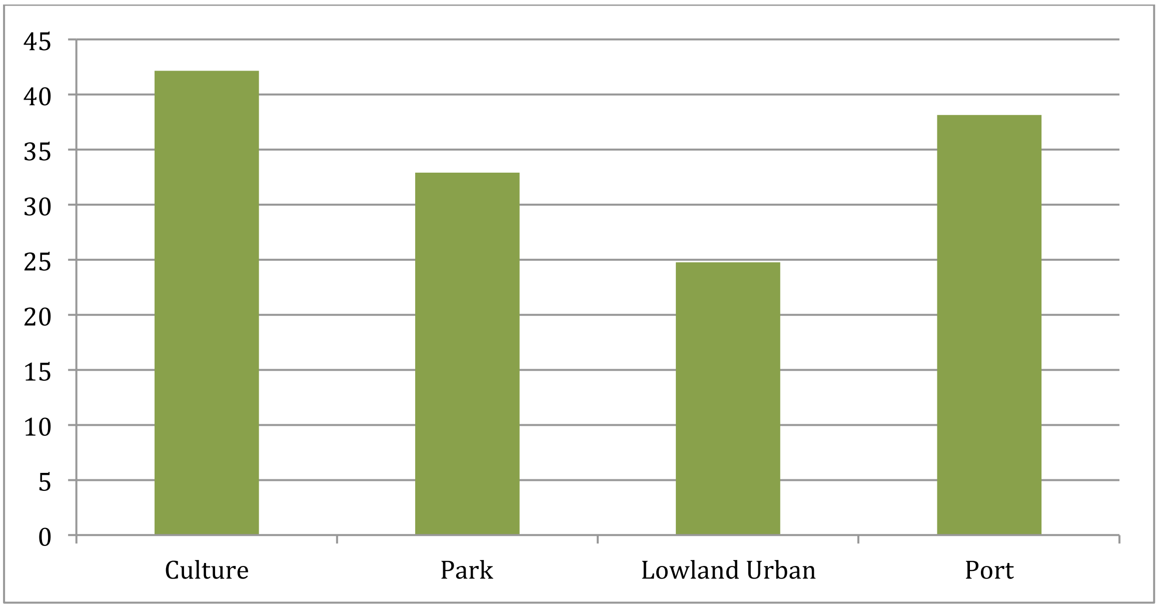


Figure 47: Biotope Distribution in Core 4

Core 5: Fishpond

Core 5 is a primarily a mosaic of fishpond, some of them have not been operational since the major typhoon occurred. The fishponds are defined by earth dikes on which sparse vegetation grown, mostly grass and some isolated mangrove trees or coastal-tolerant trees. Vegetation structure is simple since the purpose of the area is mainly for aquaculture, while some huts on stilts can be found at the edge of the fishpond. Some community settlement has emerged in certain points, particularly in areas which used to be the center of the aquaculture operation. Operation of most fishponds have ceased since the major dike that prevents storm surges was destroyed during Typhoon Ondoy (Ketsana). Since then, most of the fishponds have been unutilized while some of the earth dikes have remained unrepaired, thereby causing some concerns of the hazard of storm surge in the town of Obando, Bulacan.

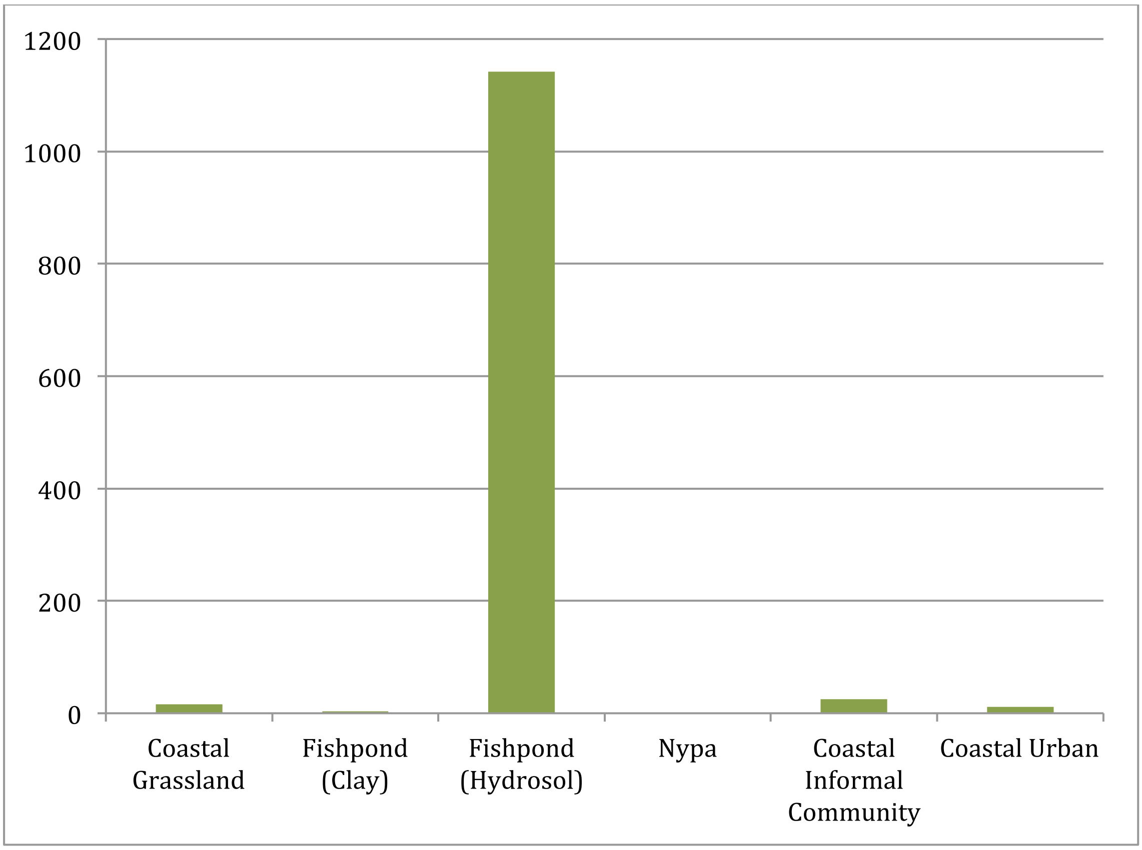


Figure 48: Biotope Distribution in Core 5

Significant biotope types have been assessed to determine the vegetation composition and structure to have a basis for assessing the ecological condition of each of the important spatial units. The different ecological cores have been evaluated based on the representative species. The representative species serve as indicator as to the dominant species, the native and exotic distribution of main species in the biotope and the function that the representative species in the context of their habitat.

The different representative species of each ecological core represents the character of the habitat. The computation of Species Importance Values is limited to the upper story tree species, which in this case reflects the condition of the different habitats. Core 1 is characterized by species that are mainly used for reforestation. These species are introduced species and are fast-growing. They easily thrive in most soil conditions and can tolerate various environmental situations, even the polluted urban conditions. These species have been chosen in the succession of species from a denuded forest that was overran by grass species to develop into a forest cover in a short span of time.

Table 6: Core Dominant Species

Ecological Core	Species	Use
Core 1	*Parkia javanica*	Reforestation
	Acacia auriculiformis	Reforestation, Street tree
	Leucaena leucocephala	Reforestation, Recolonization
Core 2	*Veitchia merillii*	Ornamental
	Swietenia mahoganii	Reforestation
	Bauhinia purpurea	Ornamental
Core 3	*Swietenia mahoganii*	Reforestation
	Pterocarpus indicus	Reforestation, Ornamental
	Samanea saman	Ornamental
Core 4	*Pterocarpus indicus*	Reforestation, Ornamental
	Cocos nucifera	Plantation
	Eucalyptus deglupta Blume	Reforestation, Ornamental
Core 5	*Sonneratia sp*	Mangrove

The university campus habitat of Core 2 is dominated by *Veitchia merillii*, a palm species often found in ornamental gardens and urban parks. They are used to provide structural plants along roadways or as accent in a landscape with lush understories. On the other hand, *Swietenia mahoganii* is a species used for reforestation and street trees because of its fast development and durability to withstand typhoons, while *Bauhinia purpurea* is a medium tree often used to add colors in the garden. Core 3's main tree species are often used for reforestation and are considered as introduced tree species. Being tree species used for reforestation, they are fast growing and are easily propagated. They can also tolerate occasional dry seasons and drought, making them resilient to extreme conditions. Except for *Samanea saman,* the other dominant species can withstand strong winds because of their deep root network. Representative species of Core 4 represents tree species that present the imagery associated with the vegetation in tropical landscapes. The propagation of *Pterocarpus indicus*, to a certain extent, has been encouraged due to its being the nation's national tree, while the *Cocos nucifera* has been considered as an important resource due to the multitude of human benefits derived from it. Their presence in the traditional urban core of Manila's POS is part of the effort to nationalize the primary civic spaces in the country. On the other hand, *Eucalyptus deglupta Blume* is a Philippine species that have been introduced in ornamental gardens as collectors' tree because of its unique tree architecture and feature. All of the species found in Core 4 are durable species that can survive drought, periodic flooding and strong winds.

Species found in Core 5 is limited due to its condition that is brackish and is more subjected to flooding. *Sonneratia sp* is a mangrove species, which can thrive in semi-salty condition, strong coastal winds, and regular inundation. Tree species in this core is limited since their medium of growth is limited on earth mounds, which does not present a lot of opportunity for propagation and growth. Further, the need to optimize sunlight in aquaculture ponds make it necessary to limit the tree coverage and species that still allow penetration of light to the bottom of the pond.

3.4.2 Corridor

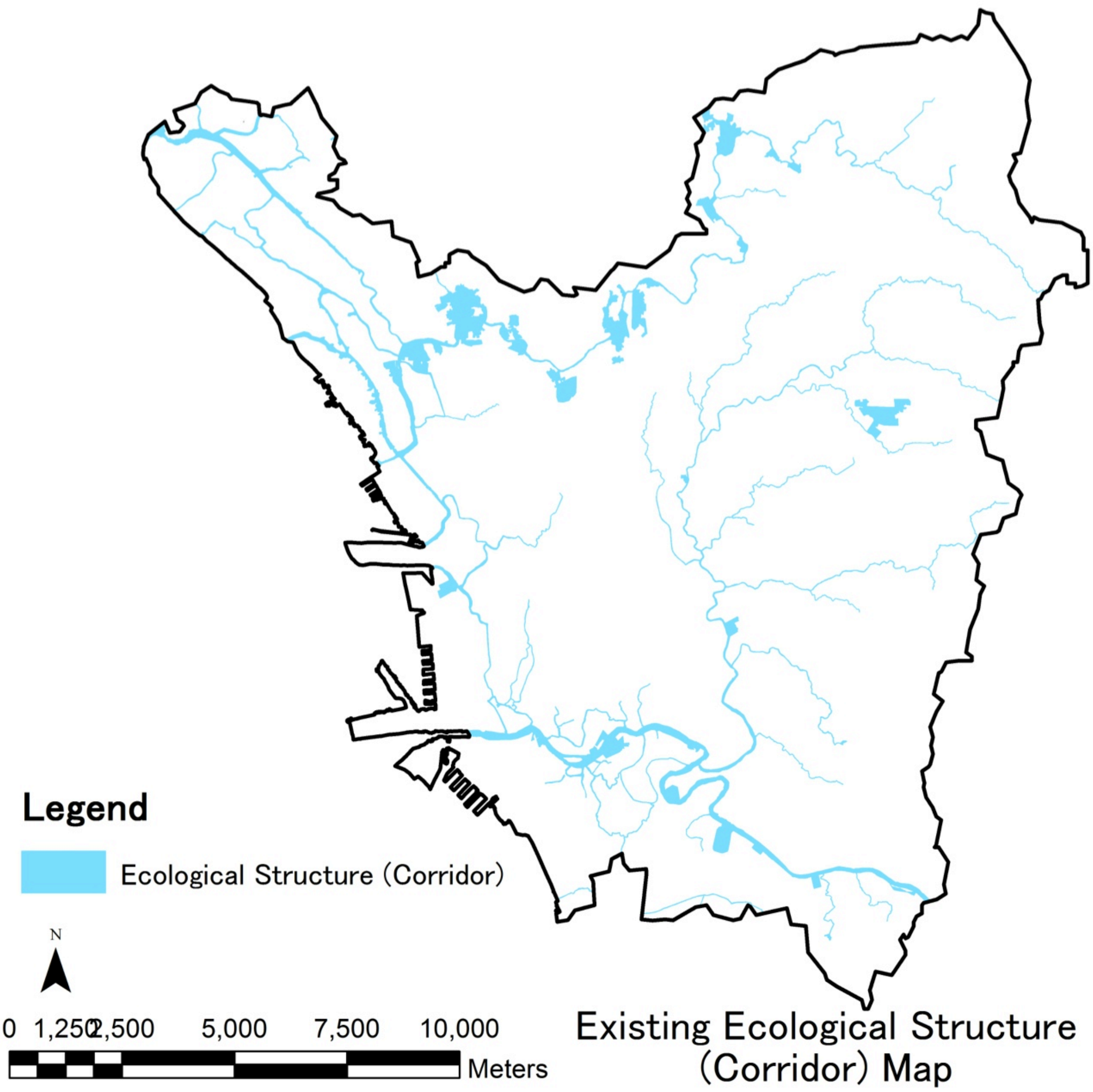


Figure 49: Existing Ecological Structure (Corridor)

Table 7: Corridor Planning Strategy

Function	Biotope Number	Biotope Type	Area (Ha.)	Patch Count	PROPOSED MANAGEMENT	Action
Corridor	NB3	Fishpond (Hydrosol)	8.12	1	Improvement	Coastal Resource Management
	NB5	Mangrove (Clay)	46.39	5	Improvement	Coastal Resource Management
	NB7	Nypa	2.87	1	Conservation	Coastal Resource Management
	NB9	Economic Forest	4.78	1	Conservation	
	NB10	Upland Forest	22.14	2	Preservation	Watershed Management
	NB11	Forest (Riverbank)	6.31	2	Creation	Linear Park
	NB12	Coastal Grassland	66.22	9	Creation	Coastal Resource Management
	NB14	Lowland Industrial Grassland	9.94	2	Creation	
	NB15	Lowland Undeveloped Grassland	33.29	5	Creation	
	NB16	Riverbank Grassland	55.38	15	Improvement	Linear Park
	NB17	Upland Natural Grassland	51.14	5	Conservation	Watershed Management
	NB18	Upland Institutional Grassland	2.03	1	Conservation	
	NB19	Upland Undeveloped Grassland	64.75	4	Improvement	
	NB20	Park	1.08	1	Conservation	National Park Management
	NB21	Culture	18.09	3	Preservation	Preservation Law
Total			**392.53 Ha**			

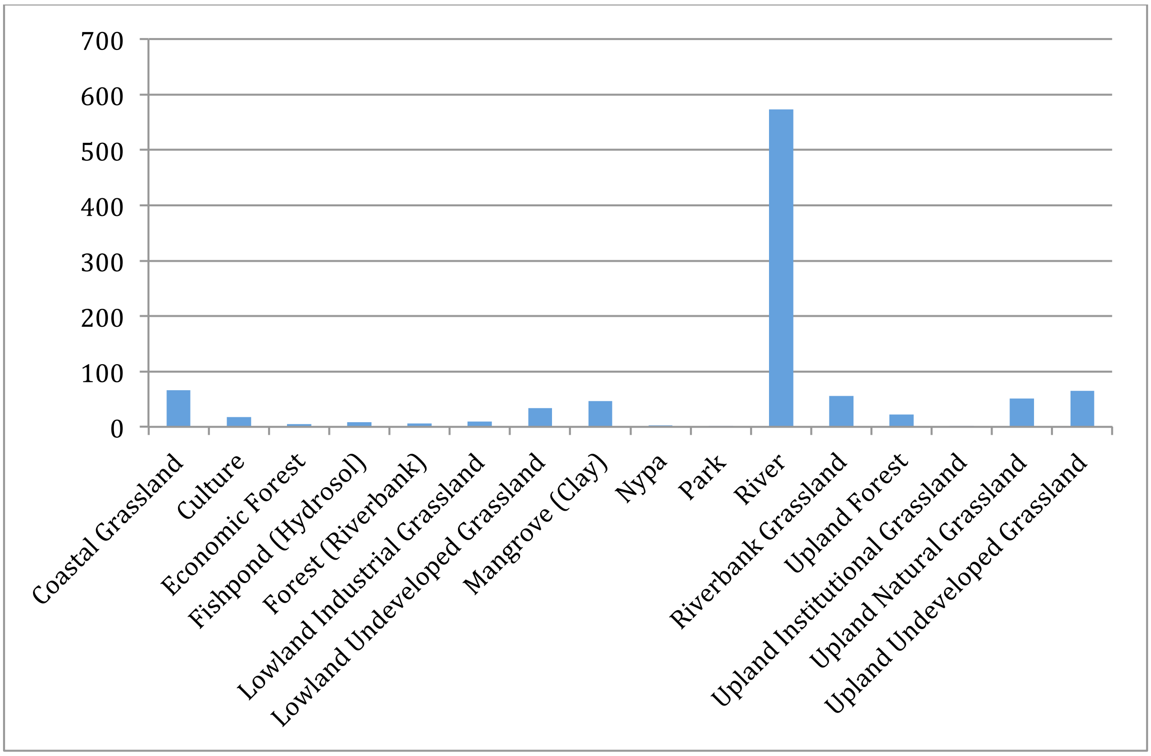


Figure 50: Biotope Distribution in Corridor

The Tullahan corridor is defined by the Tullahan River. It starts from the downstream streams from the La Mesa Lake that goes all the way to the Manila Bay. Upstream biotopes include forest and grasslands having gentle slopes while those in the downstream are mostly fishponds and mangroves in coastal inland. In between these different environs are the urban and informal community biotopes which cover the banks of the Tullahan River. The presence of informal communities along the river is attributed to the presence of industrial factories and plants at the downstream of the banks of the river. One of the most prominent area that has gained great concern among urban/environmental planners is the Smokey Mountain, which used to be an open dumpsite and has grown into a mountain of garbage. Dumping of garbage has since stopped and low-cost housing community has since been established near the site. The upstream bank, on the other hand is occupied by residential developments that have evolved as urbanization heads to the north from the central urban core of Manila and other more urbanized enclaves.

The Pasig River runs the course from the Laguna Lake to the Manila Bay. Surrounding it are the highly urbanized biotopes with some biological biotopes in the form of urban parks and green spaces. Along the river are the industrial sites which were developed using the river as the main means of transporting goods. Other major biotopes include urban areas composed of commercial establishments and institutional zones. The river has been an important channel for in the history of Manila and has played a significant role in shaping the urbanization of Metropolitan Manila. The water quality of Manila is polluted mostly due to emission from factories that edge the river and the lack of sewerage system for residential areas. The condition of the river is affected by the quality of upstream sources, particularly the Laguna Lake and the Marikina River. Downstream biotopes include port areas and informal communities that have sprouted near the river, most notable of which is the Baseco Compound.

The San Juan River serves as the major tributary of the Pasig River. It extends from the narrow creeks in Quezon City that widens into a river as it passes the cities of San Juan and Mandaluyong and finally joins the Pasig River. The upstream biotopes are mostly composed of residential areas and informal communities. It connects the Core 2 and Core 3, which both serve as public open space. The downstream biotopes are similarly urban but mostly composed of industrial areas with informal communities usually found adjacent to the factories and plants.

3.4.3 Edge

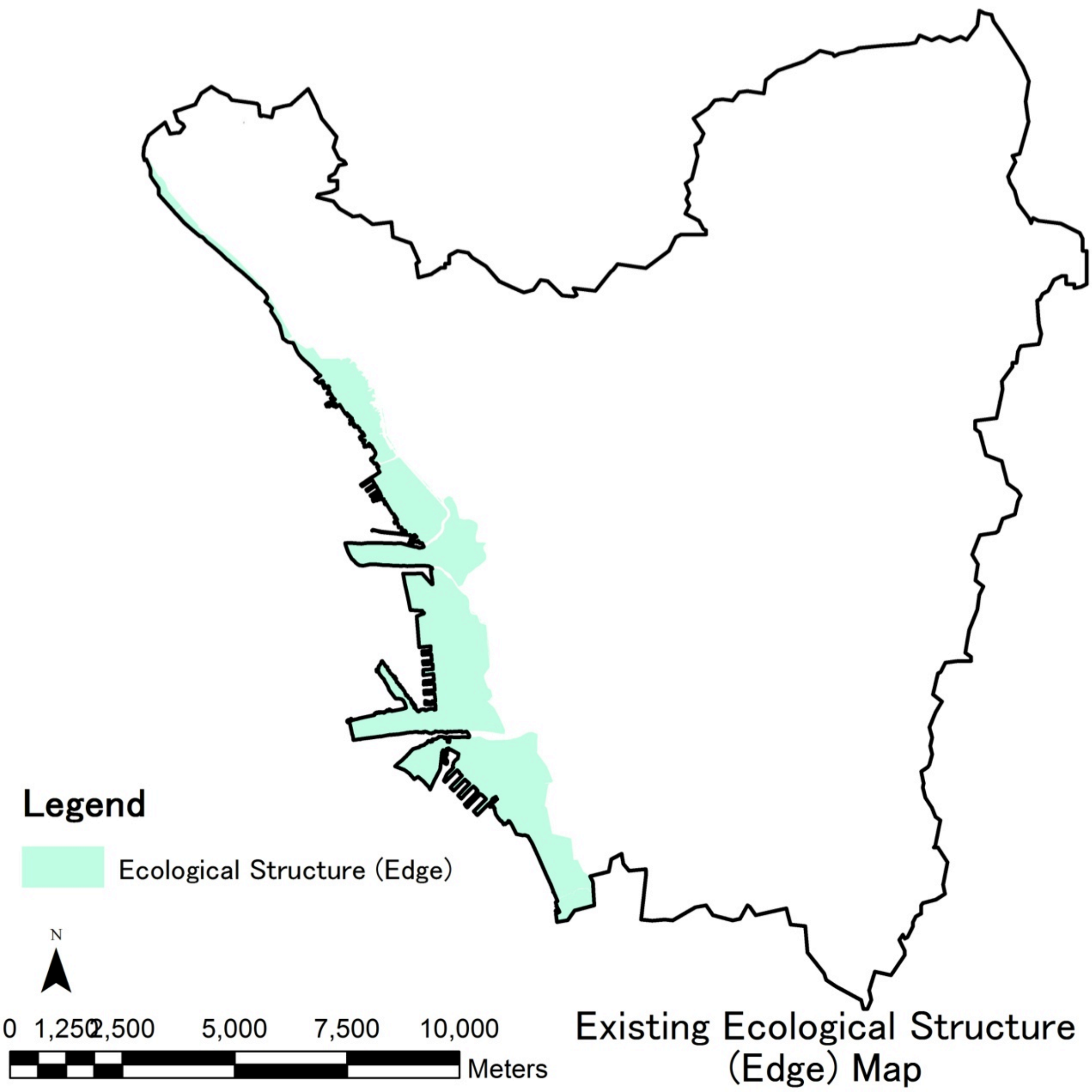


Figure 51: Existing Ecological Structure (Edge)

Table 8: Edge Planning Strategy

Function	Biotope Number	Biotope Type	Area (Ha)	Proposed Management	Action
Edge	NB3	Fishpond (Hydrosol)	0.50	Productive Management	Coastal Resource Management
	NB4	Fishpond (Sandy Loam)	6.61	Integrative Management	
	NB6	Mangrove (Sandy Loam)	55.55	Integrative Management	
	NB11	Forest (Riverbank)	2.35	Productive Management	Protected Green Spaces
	NB12	Coastal Grassland	34.24	Intensive Use Management	
	NB13	Lowland Institutional Grassland	2.44	Integrative Management	Integrated Recreational Green Spaces
	NB21	Culture	42.17	Protective Management	
	NB20	Park	42.94	Integrative Management	
	BB1	Coastal Informal Community	74.03	Intensive Use Management	Mitigation from Disasters
	BB2	Lowland Informal Community	14.34	Intensive Use Management	
	BB5	Coastal Urban	250.45	Productive Management	Improvement of Urban System
	BB6	Lowland Urban	201.40	Productive Management	
	BB8	Port	1,073.22	Productive Management	
Total			**1800.24 Ha**		

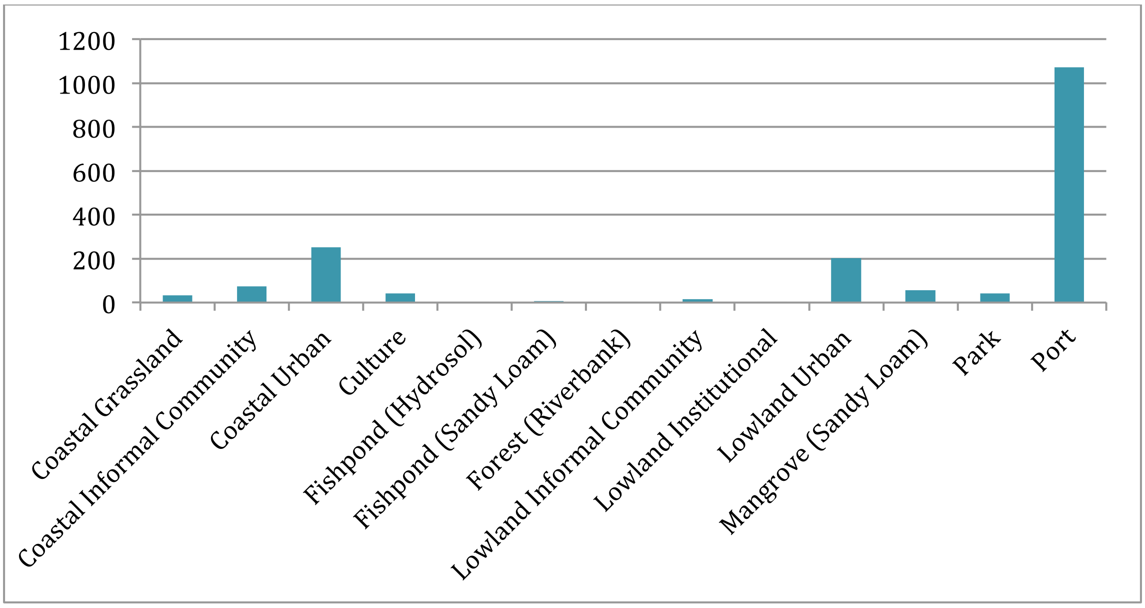


Figure 52: Biotope Distribution in Edge

The Edge of the watershed region of Metro Manila is basically composed of a strip of land that extends from the fishponds of Bulacan on the northside to the Manila Baywalk on the southside facing the Manila Bay on the west. Being the lower basin of the watershed, two main rivers drain towards the sea, the Pasig River and the Tullahan River. These water channels deposit sediments at the mouth of the river resulting to the formation of different soil types along the coastal zone. The location of the fishponds in Bulacan is comprised mostly of fine sand, while those areas near Manila, Navotas and Malabon areas are mostly silt loam. Some stretches of beach is still present while mangrove corridors, which serve as filter to sediments washed from upstream have maintained the sandy character of the northern part of the coastal area. On the other hand, the highly urbanized areas near the Navotas-Malabon and the city of Manila area have resulted to more silt-loam composition since a lot of esteros and canals have been clogged with informal settlements along the water channel, the silted rivers and canals and presence of large volume of solid waste along the water channels and the fact that a large part of the coastal zone is reclaimed land. This soil material has been introduced from other source, changing the natural soil character of this zone. The rest of the zone is composed of clay material, which is the dominant soil type for the rest of the watershed region.

In terms of composition of the landcover, the most dominant landform is fishpond which comprised 34 percent of the total area. Other significant landcover types are industrial (21percent), informal settlements (14 percent), and residential (13 percent). Semi-natural components are quite small compared to the cultural components, in which grassland covers only four percent, marsh having three percent, and mangrove and pond having one percent each. This meager distribution of semi-natural greenspaces needs to be examined and analyzed in terms of its impact to the overall environment and how sustainable this remains for the rest of the coastal zone. Similarly, amenity spaces, such as lawn and paved areas, mostly comprised of plazas, parks and playground, are very limited compared to the areas covered by residential, urban, and informal settlements. There is an apparent shortage of spaces devoted for recreation and leisure, which are important spaces for high densely populated areas such as the coastal zone.

Information found in biotope map further shows the extent of how urbanized the coastal zone is of Metro Manila. The largest biotope component is fishpond, with fishpond on fine sand with 26 percent and fishpond on clay with eight percent. This significant share of the coastal area manifests the brackish environ prevalent in the area, which makes it the ideal condition for aquaculture production. Careful management has to be employed though since these fishpond water are oftentimes loaded with organic substances that may offset the balance in the aquatic environment. Deposition of excessive nutrient has resulted to explosion of algal growth which adversely affect not only the adjacent water body but also those that are connected to the flow and fluxes of nutrient cycles. Other significant biotope types in term of distribution are: industrial area on silt loam (12 percent), residential area on fine sand (nine percent), and informal settlement on silt loam (seven percent). The large percentage of these biotope types shows that cultural biotopes dominate the coastal area. Very small portion of the area is composed of semi-natural biotopes, such as grassland on clay (three percent), mangrove on find sand (one percent), marsh on clay (one percent), grassland on silt loam (one percent), and grassland on fine sand (one percent). These important biotope types are necessary to keep the balance between urbanization and maintaining semi natural areas for the natural processes to perpetuate, such as drainage, groundwater recharge, inter-patch flora and fauna species exchange (patch dynamics), nutrient cycle, and soil erosion prevention. Meanwhile, greenspaces for amenity areas (cemetery on fine sand, lawn on clay and silt loam, paved on silt loam) are negligible in terms of distribution. These amenity spaces are important, not only in managing the well-being of the population, but also as part of the ecological network. Although their role in the ecosystem process is not as pronounced as those of semi-natural biotope types, they serve as complement to the functioning of the semi-natural patches. They can function as buffer area between intensive urban activity and natural processes, secondary habitat for species adapted to urban conditions, reserve for species bank, and drainage/retention basins.

Creating a network of patches is necessary to form connected greenspaces, putting more emphasis on semi-natural and amenity biotope types. Cultural biotope types should be examined and regulated in terms of their fit in terms of the functioning of the ecological processes. For instances, activities that can result to the obstruction of water channels, such as the presence of informal settlement and lack of easement along water channels, should be reviewed and regulated. Proximity of intensive urban activities like industrial and informal settlements to sensitive biotope types such as mangroves on fine sand should be set so as to prevent the disruption of its ecological function. Identification of critical environ, such as sandy beach, mangroves, marshes, and naturally occurring grassland should be carried out so as to avoid further encroachment of these spaces. Waterways can serve as important corridors that connect these significant patches. Canals and esteros can be re-vegetated to create greenways, optimizing ecological linkages while serving as important amenity space for the community.

On the other hand, as population continues to increase, amenity greenspaces should be given more emphasis since they are vital to keep the quality of life for the residents of the city. Aside from functioning as “ecological reserve”, they provide breathing space for the highly congested urban environment. They can also serve as possible evacuation areas in case of disasters.

The concentration of urban population on the coastal zone provides insight on the dynamics of that of urban ecosystem within the watershed. The growth of (mega)cities along the world's coastlines necessitates the balancing act that needs to be done in order to maintain the sustainability of these urban ecosystems and to leave an ecological legacy for the next generation.

Coastal ecosystem contains the biological habitat in which the habitat is considered a mosaic where different functions and processes exist. However, these relationships between components of the system need to be arranged, organized and phased to allow them to perform their function. Humans have been programmed to arrange and organize components to optimize their benefits. However, the concept of time is different in nature as the processes and function take place beyond the generational lifespan. Thus, plans and environmental management should take precedence beyond political administration or myopic planning that neglects the consideration of the overall function of the system.

3.4.4 Patches

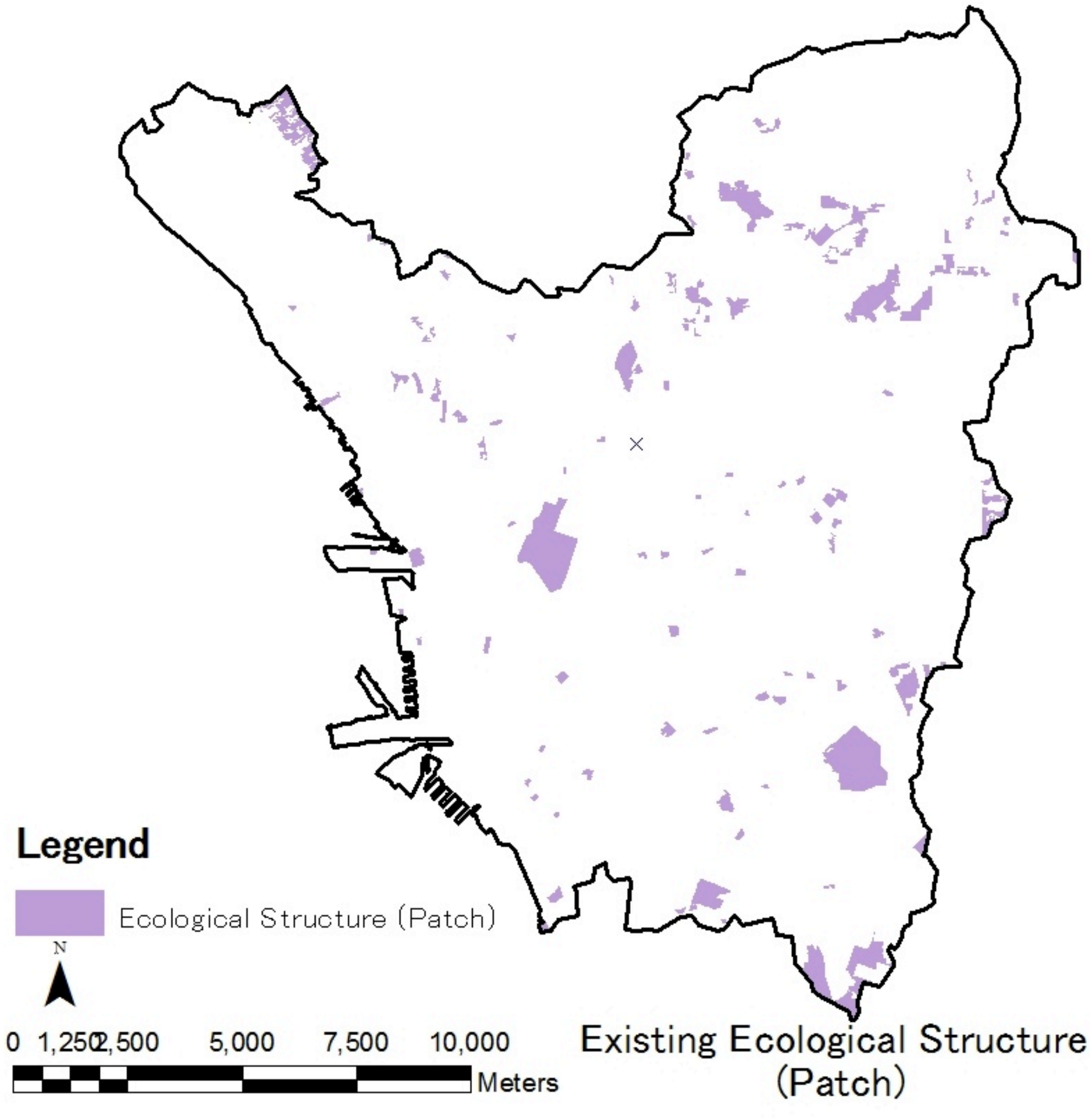


Figure 53: Existing Ecological Structure (Patch)

Table 9: Patch Planning Strategy

Function	Biotope Number	Biotope Type	Area (Ha)	Patch Count	PROPOSED MANAGEMENT	Action
Patch						
	NB18	Upland Institutional Grassland	396.30	23	Conservation	
	NB13	Lowland Institutional Grassland	206.01	13	Conservation	
	NB19	Upland Undeveloped Grassland	143.66	24	Improvement	
	NB16	Riverbank Grassland	87.97	16	Improvement	Linear Park
	NB10	Upland Forest	55.32	15	Preservation	Watershed Management
	NB12	Coastal Grassland	47.59	15	Creation	Coastal Resource Management
	NB15	Lowland Undeveloped Grassland	42.47	15	Creation	
	NB7	Nypa	41.89	5	Improvement	Coastal Resource Management
	NB14	Lowland Industrial Grassland	32.70	9	Creation	
	NB20	Park	13.56	4	Conservation	National Park Management
	NB3	Fishpond (Hydrosol)	11.30	2	Improvement	Coastal Resource Management
	NB17	Upland Natural Grassland	8.24	4	Conservation	Watershed Management
	NB8	Coastal Forest	6.20	1	Improvement	Coastal Resource Management
	NB5	Mangrove (Clay)	2.62	2	Improvement	Coastal Resource Management
Total			**1,095.83 Ha**			

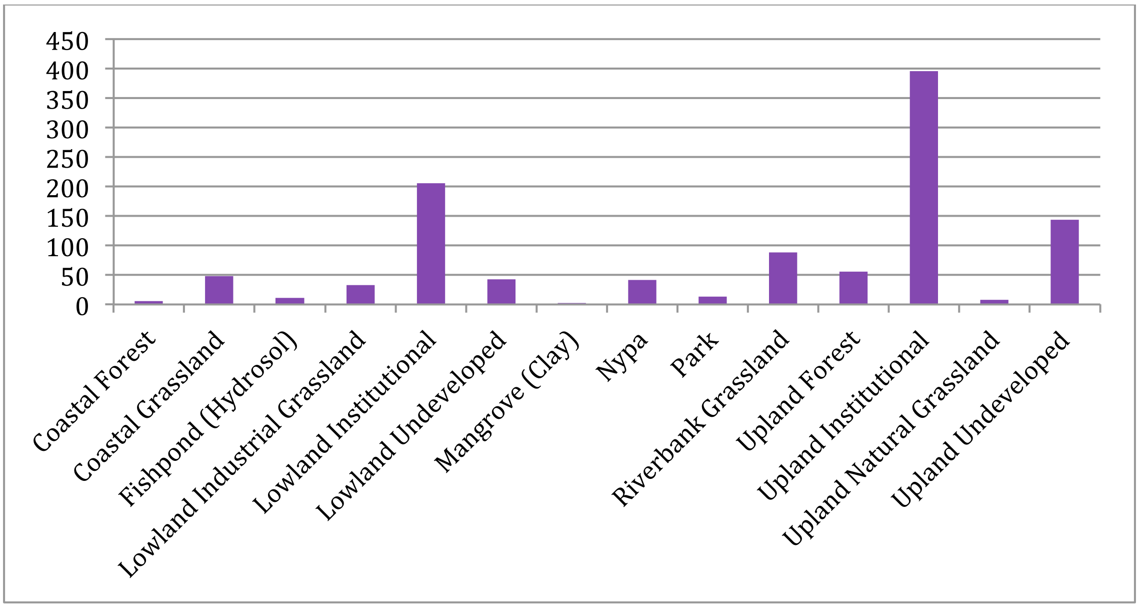


Figure 54: Biodiversity Distribution of Patch

Other natural biotopes that are not part of the core-corridor and edge function are considered as part of the matrix of the regional biotope. These patches serve as important spaces, especially in a highly urbanized city like Metropolitan Manila since these are the only remaining natural biotopes within the city. They play key role in serving as links to other natural biotopes in terms of habitat migration and species exchange to keep the ecological integrity. According to Forma, the ecological value of large patches are: (1) water quality protection for aquifer and lake, (2) connectivity with smaller streams for fish and terrestrial movement, (3) serving as habitat for populations of patch interior species, (4) escape cover for large vertebrates, (5) source of species dispersion through matrix, (6) "microhabitat proximities for multihabitat species", (7) species evolve with the disturbance that occur near the patch, and (8) serves as buffer from extinction during disturbance. On the other hand, small patches serve the following functions: (1) habitat and stepping stope in species dispersal, (2) "high species densities and high population sizes of edge species", (3) matrix heterogeneity, (4) serves as habitat for small patch-specific species, and (5) serve to protect small habitats and rare species.[31] Large patches such as Upland Institutional Grassland, Lowland Institutional Grassland, and Lowland Undeveloped Grassland can serve as important habitat for isolated species. When effectively linked to other natural biotopes through green and water corridors, ecological link can be established and linked. On the other hand, smaller patches, particularly along the coast zone need to be protected from further conversion into other uses. There has been an observed trend among fishponds which have become unproductive because of suffering from the effects of typhoons and monsoon rains that they are being converted into other uses. Using coastal resource management, better policy can be instituted to protect these spaces and keep their function as mangroves, forest and fishpond. Parks and small open spaces need to be improved by linking them with other small open spaces to create an integrated park system to optimize their function as amenity for the users and residents of Metropolitan Manila.

[31] Cook, Edward A. (2002) Landscape structure indices for assessing urban ecological networks. Landscape and Urban Planning, No. 58, 269-280, in English.

4 THE ECOLOGICAL MANAGEMENT

ECOLOGICAL MANAGEMENT

The Metro Manila watershed region is part of the major watershed region known as the Manila Bay Watershed region, comprised of streams and tributaries and distributaries that drain towards the Manila Bay. The major watershed region covers areas of Metro Manila, parts of the provinces of Bataan, Pampanga, Nueva Ecija, Bulacan, Rizal, Laguna and Cavite

4.1 Ecological Management Planning Method

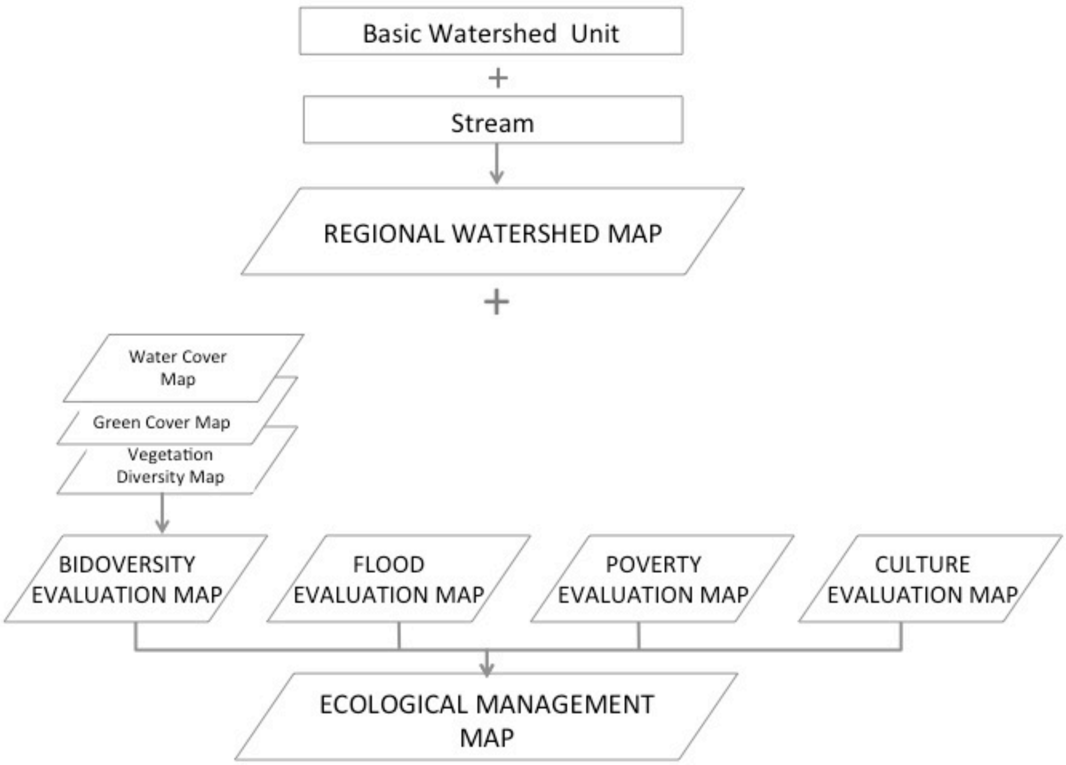


Figure 55: Flow Chart of Ecological Management Planning

The Ecological Management utilizes the watershed in defining the ecological units and boundary for evaluating the conditions of Metropolitan Manila and in providing strategies in responding to the issues. The ecological management planning starts with the determining of the basic watershed units. For this research, the basic watershed units are generated using the Geographic Information System (GIS) Hydrology function. Using streams as tool in connecting adjacent polygons, sub-watersheds are formed based on the major stream that dominates the sub-watershed. The different sub-watersheds that overlap with the Geo-referenced map of Metropolitan Manila are considered as part of the Regional Watershed Map.

To evaluate the different aspects that influence the ecological processes of the regional watershed area, which in this research is represented by the four pillars, each basic watershed unit that comprise the regional watershed is quantified to achieve the value of influence. For the issue of Biodiversity, three maps are used to measure the influence of biodiversity to the watershed. These include the Water Cover Map, Green Cover Map, and the Vertical Diversity Map. The water cover map represents the extent of influence of water bodies as habitat within the watershed. On the other hand, the green cover map represents the coverage of green space within the watershed. The assumption for green cover is that the bigger the green coverage within the watershed, the greater the ecological integrity of the spatial unit and has high potential serving as a habitat. However, green cover map implies that that measure is mainly two-dimensional aspect, necessitating the need to measure the influence in three-dimensional aspect, thus the use of Vertical Diversity Map. The vertical diversity map represents the hierarchy of vegetation within a specific area. It reflects the complexity of vegetation based on the different layers found within the green space. It is also assumed that the more complex the vegetation is the higher its ecological integrity and ecological function potential. The measure of coverage for water cover and green cover is in percentage of the total area of the basic watershed unit. On the other hand, vertical diversity value is computed by rating the vegetation in each watershed unit from zero (0) to three (3), multiplied to area covered by vegetation in relation to the watershed.

The other pillars evaluated in the ecological management are: flood, poverty, and culture. Flood is evaluated based on the intensity and frequency of flood in the watershed. The information is based on the reported flooding from the Department of Environment and Natural Resources (DENR). The assumption for flood evaluation is that the higher the coverage of flood within the watershed, the higher the probability that the ecological integrity of the area is compromised, thus those basic watershed units with lower flood incidence have higher value compared to those that have higher incidence. Poverty is represented by the presence of informal communities within the watershed. The more area the informal communities occupy within the watershed, the lower its ecological integrity. Both for flood and poverty, the evaluation is in percentage in terms of occurrence within the watershed. The last pillar, culture, is evaluated by determining the number of cultural heritage sites and monuments based on the list released by the National Commission for Culture and Arts (NCCA) for each basic watershed unit.

With the percentage, rating, and frequency of each basic watershed unit based on the four pillars, the watershed is given valuation to determine the management required. The different management interventions are: Protective Management, Integrative Management, Productive Management, and Intensive Use Management. These management interventions of each basic watershed unit comprise the Ecological Management Planning.

4.2 Regional Watershed

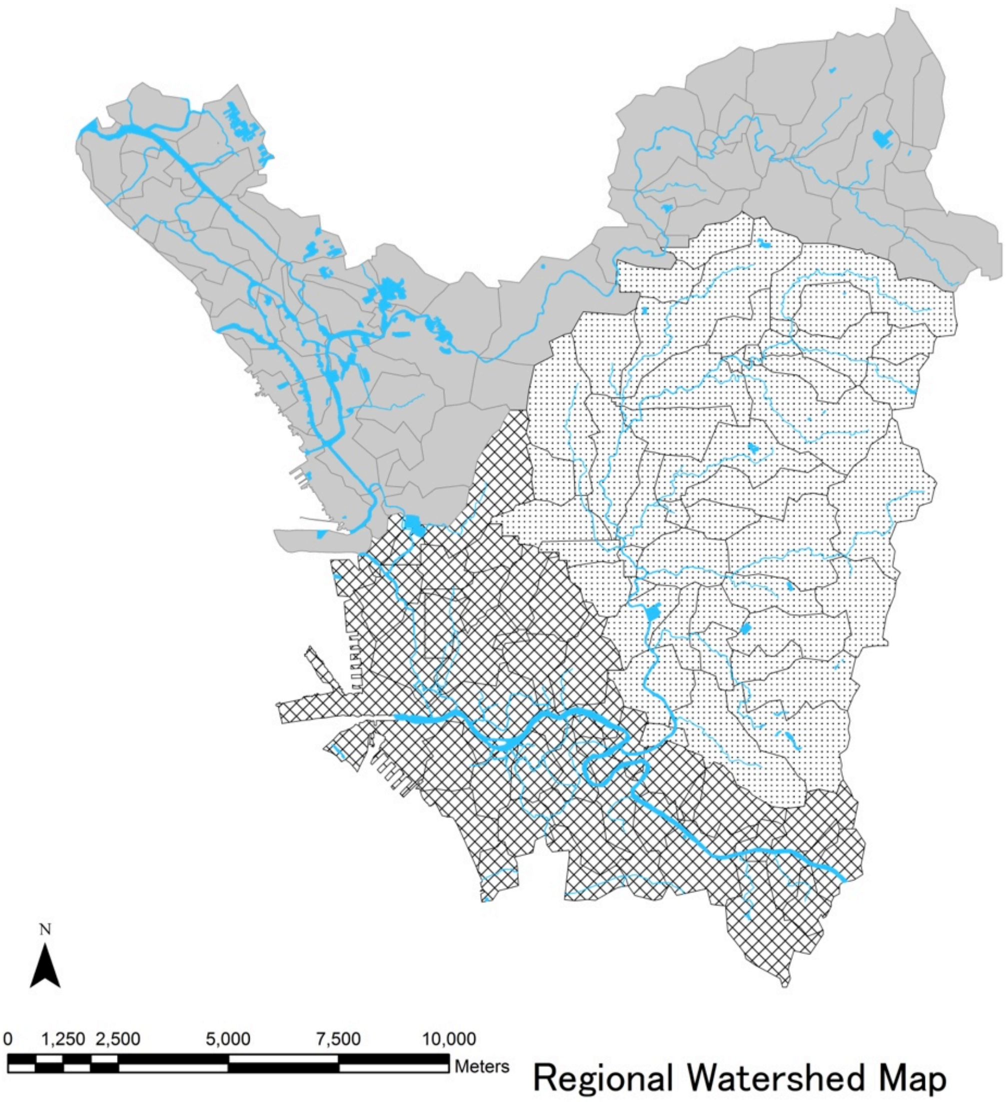


Figure 56: Regional Watershed Map of Metropolitan Manila

At the macro-scale, a watershed-based spatial analysis is used to determine the significant areas that encompass the watershed region. The watershed region is composed of 147 basic watershed units, which form the different formations based on stream regimes. It has an average elevation of 10 meters[32]. There are three sub-watershed formations that comprise the Metro Manila watershed region based on two major stream systems that drain towards the Manila Bay in which all of the lesser order streams originate, these are the Pasig River and the Tullahan River, with the La Mesa Lake forming the headwater. It has to be emphasized though that other water systems have effects on these stream systems, particularly the Laguna Lake, which can be better analyzed in a much larger scale. Laguna Lake is the other origin of the Pasig River, aside from the Marikina Basin, which affect the stream flow of Pasig River depending on the season. During rainy season

[17] Roberts, Brian (2011) Manila: Metropolitan vulnerability, local resilience. Planning Asian Cities: Risk and Resilience. Hamnett Stephen, Dean Forbes (ed). Routledge, New York. 287-321. In English.

when the water level is higher in Laguna Lake because of inflow of water from other tributaries, water flows from the lake to Pasig River, which eventually flushes to Manila Bay. On the other hand, during summer season when water level is lower in the lake, the Pasig River reverses its water flow towards the lake, resulting to the inflow of saltwater to more inland areas. This phenomenon ultimately has an effect on the water quality of the lake and Pasig River. This is evident when viewed from aerial photographs in which the difference in water clarity is visible as water flowing between Pasig River and Laguna Lake appears cloudy and sedimented while stream flow that originates from Marikina River appears with better clarity and quality.

The other sub-watershed formations are named after the major stream that flows through the network of basic watershed units. Aside from the Pasig sub-watershed, there are the Tullahan and San Juan sub-watershed formations. The Tullahan sub-watershed formation, as the name indicates, is formed by Tullahan River which originates from the La Mesa Lake. The La Mesa Lake is formed by retaining the accumulated water supplied by upstream water in the dam which serves as a water facility that serves a portion of the population of Metro Manila. A water treatment facility is actually located adjacent to the lake, while the surrounding forest is a protected forest to help conserve the water resource of the watershed that provides water to the facility. A recreational park, the La Mesa Ecopark is also located adjacent to the lake as a recreational facility. The purpose of the ecopark are as follow: (1) to promote environmental education, mainly among schoolchildren and to the general public; (2) to raise funds to sustain watershed management; (3) to maintain watershed values and enhance biodiversity; (3) and to provide facilities to highlight the educational, recreational, and aesthetic resources of the watershed.[33] From the La Mesa Lake, various tributaries emanate forming the Tullahan River. The Tullahan River is connected with other major stream, the Pasig River, by Vitas Channel, a stream edged by densely populated communities.

[18] "Mission/Vision, La Mesa Ecopark and La Mesa Nature Reserve", http://www.bantaykalikasan.com, accessed 6 May 2013

4.3. Four Pillars of Issues of Metropolitan Manila
4.3.1 Biodiversity

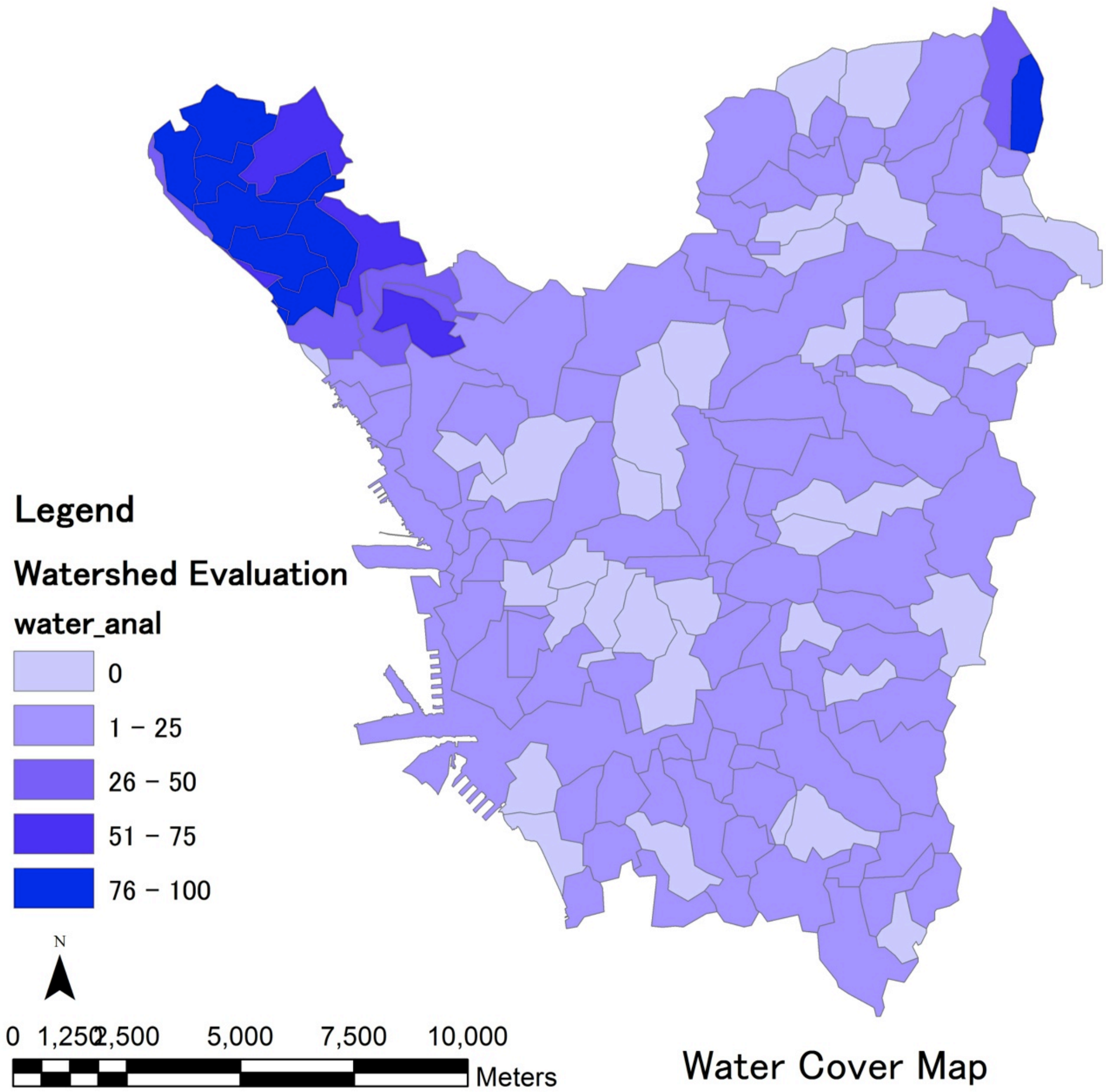


Figure 57: Water Cover Evaluation Map

The Water-related Evaluation relates the relationship of all water systems to the basic watershed unit. Spatial components included in this evaluation are the lakes, major rivers, ponds, minor rivers (tributaries and distributaries) and fishpond. The evaluation reveals that basic watershed unit traversed by rivers or has significant water bodies have higher water composition, the concentration of which is in the fishponds and lake. These basic watershed units serve important role in the watershed since both show the upstream-downstream relationship, which is connected by a river (Tullahan River). Incidentally, these basic watershed units are also considered core in the ecological structure, thus serving an important role in the ecological network for biodiversity.

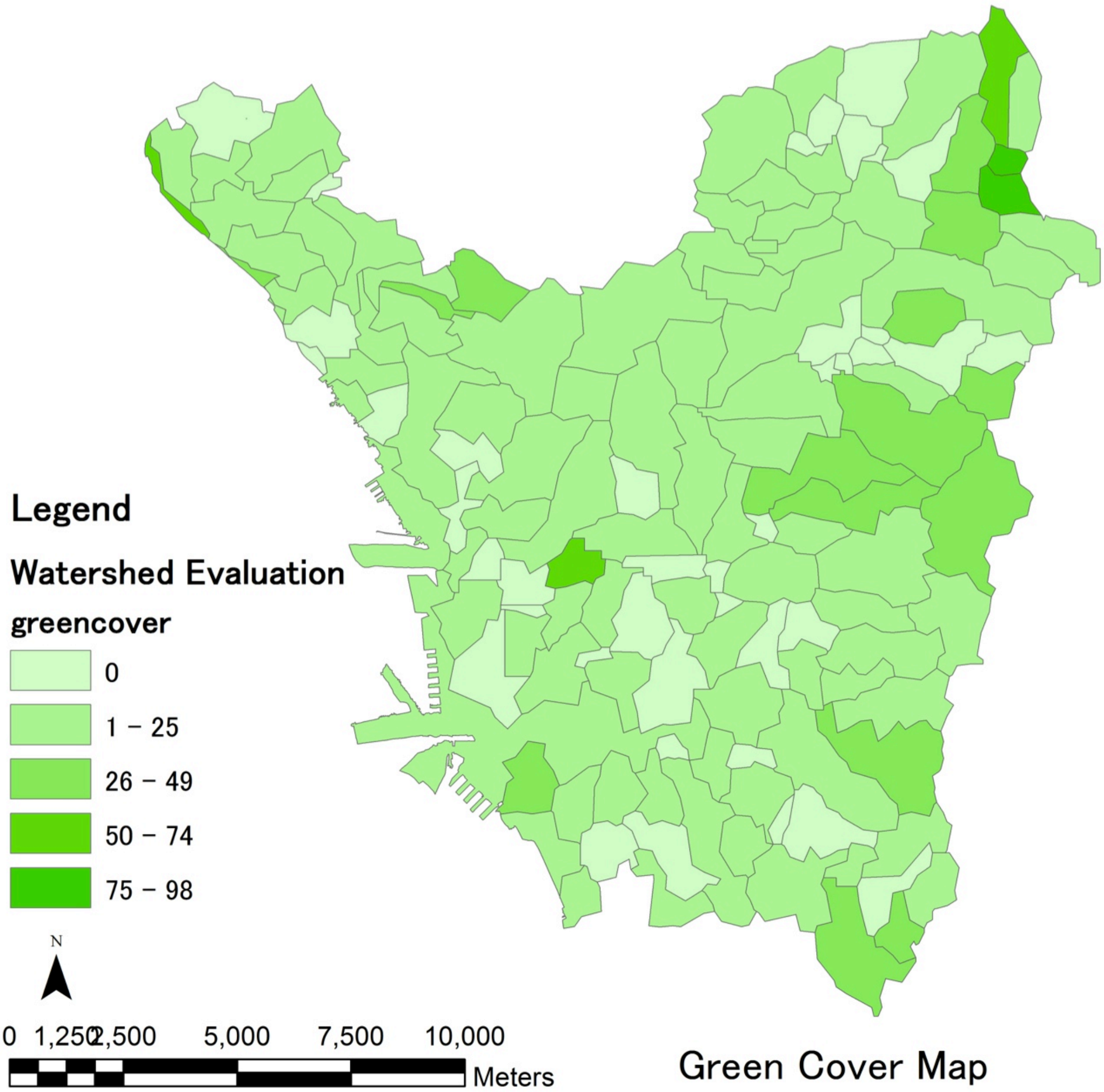


Figure 58: Green Cover Evaluation Map

The Greencover Evaluation measures the percentage of natural biotopes per basic watershed unit. It shows how much of the area of the basic watershed unit is covered by natural biotopes. The evaluation reveals that only one upland watershed unit is dominated by natural biotopes while the rest has varying degree of natural biotopes, most of the watershed having below than 20 percent greencover. The watershed unit where the ecological cores are located show 61 to 80 percent and 41-60 percent greencover, exhibiting higher greencover compared to the rest of the watershed region. This is true except for the area of fishpond in which it shows lower greencover since the vegetation is limited to dikes thus registering lower greencover value.

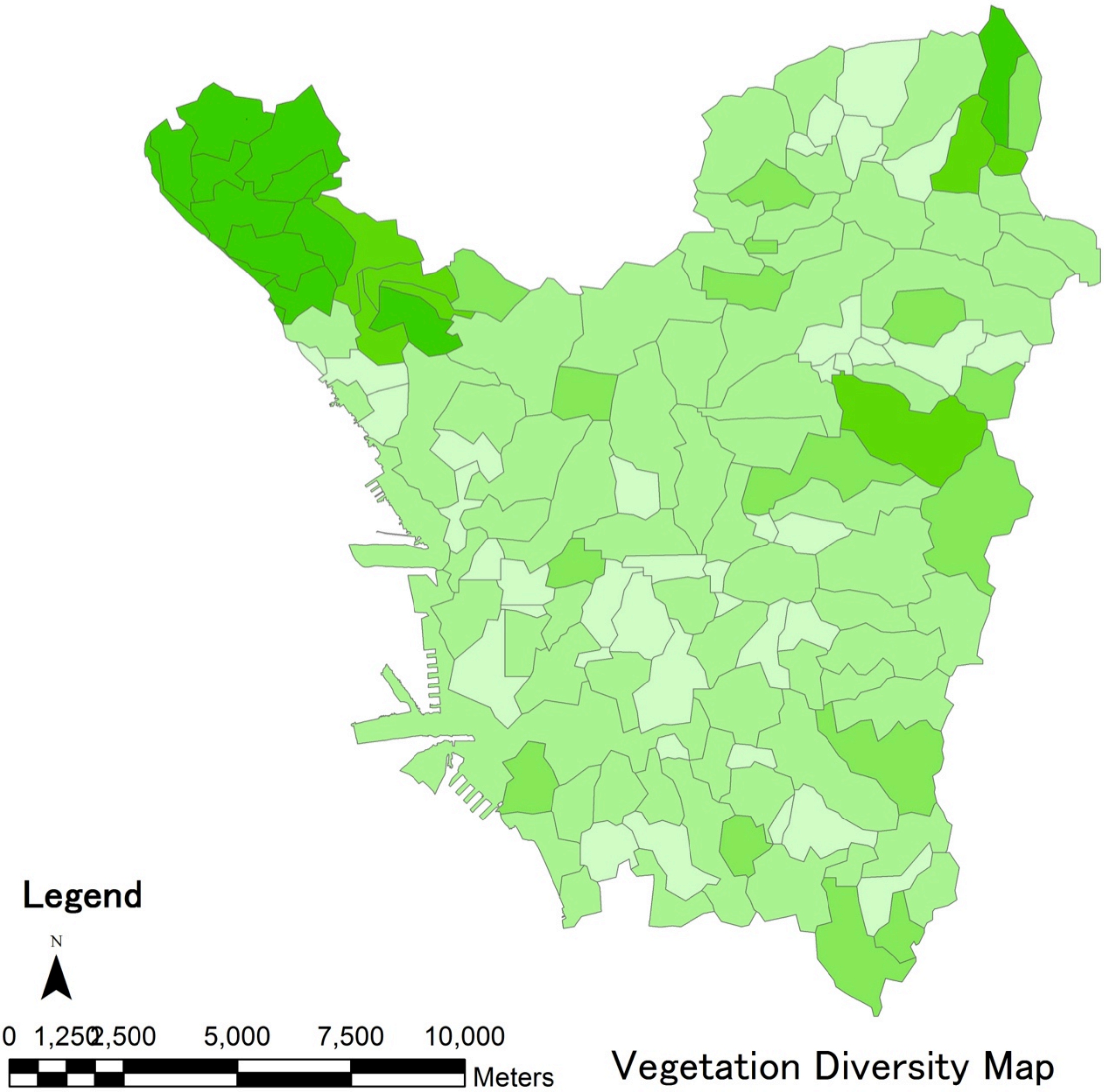


Figure 59: Structural Diversity Value Map

The structural diversity Evaluation shows the complexity of vegetation within the basic watershed unit. Compared to the greencover analysis, it take into consideration the stratification of vegetation, showing the integrity and potential of the basic watershed unit as ecological core, corridor, or patch. The vertical layers is manifested in tree canopy, shrub layer and cover, which provides greater possibilities for habitat types, yielding increased diversity and more possibilities for species survival.[34] Each natural biotope is given values ranging from three (3) to zero (0) with three given to natural biotopes having three vertical stratification such as the upland forest and some mangroves with understories, while those with less than three layers are given 2 or 1, while totally built-up or paved surfaces are given with zero. The computation involves computing the area of natural biotope multiplied by the structural diversity value, which will be added with the built-up biotope (mostly with value equal to zero) to come up with sub-total structural

[34] Cook, Edward A. (2002) Landscape structure indices for assessing urban ecological networks. Landscape and Urban Planning, No. 58, 269-280, in English.

diversity value of the basic watershed unit. The highest possible value of the basic watershed unit is three, and the lowest is zero.

The structural diversity reveals the relative lack of complexity in most area of the watershed region. Notable are the basic watershed units where the ecological cores 1, 2 and 5 are located, revealing more complex vegetation structure compared to the rest of watershed region. Basic watershed units where the corridors are located have less than 0.31 structural diversity value, which would imply intervention to improve the corridor function of rivers and streams. Large patches directly affect the structural diversity, raising the structural value of the basic watershed unit. This evaluation presents the potential of the watershed region based on the patches and corridors within the basic watershed units in the creation of ecological network for resilience management.

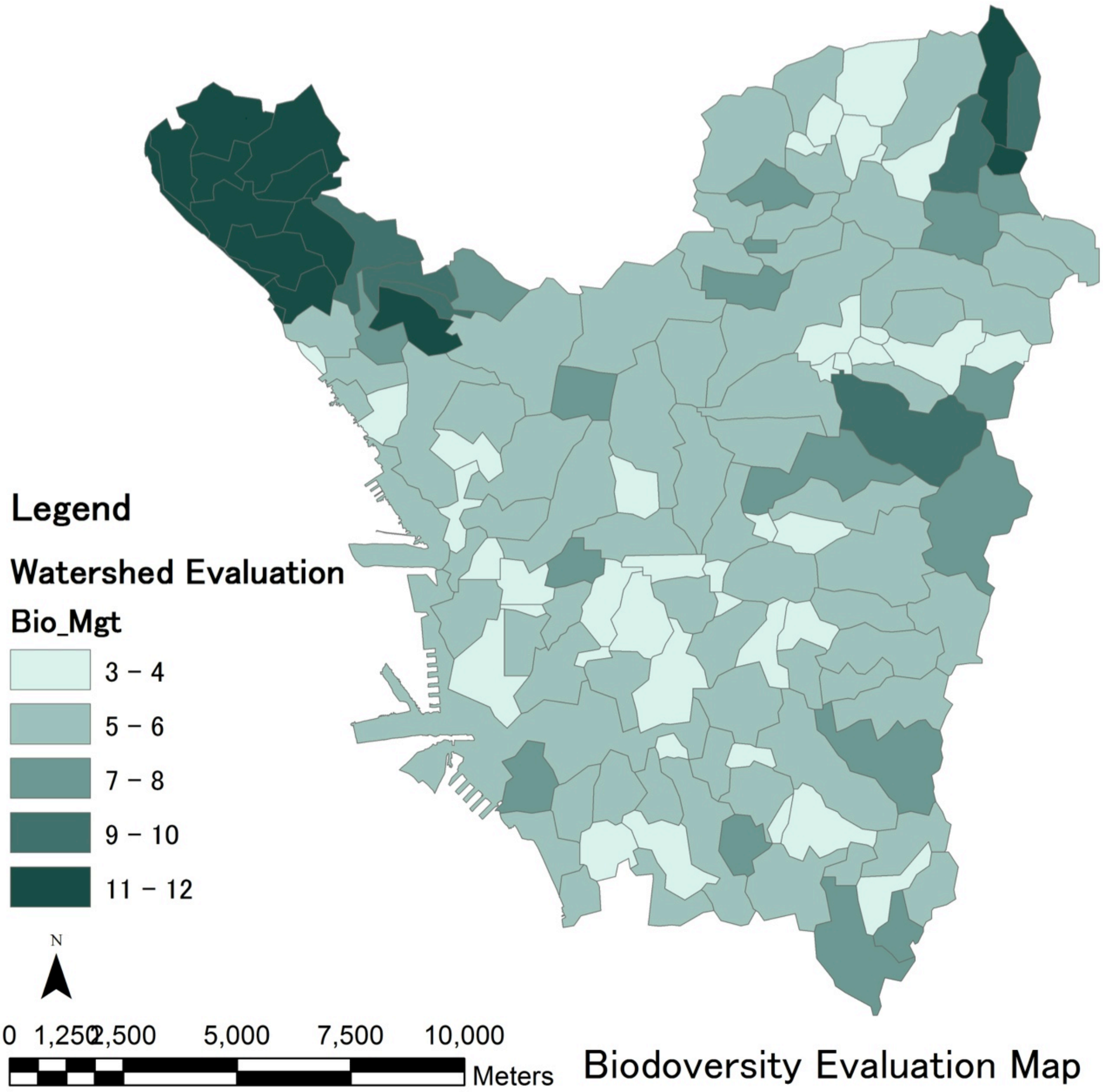


Figure 60: Biodiversity Evaluation Map

4.3.2 Flood

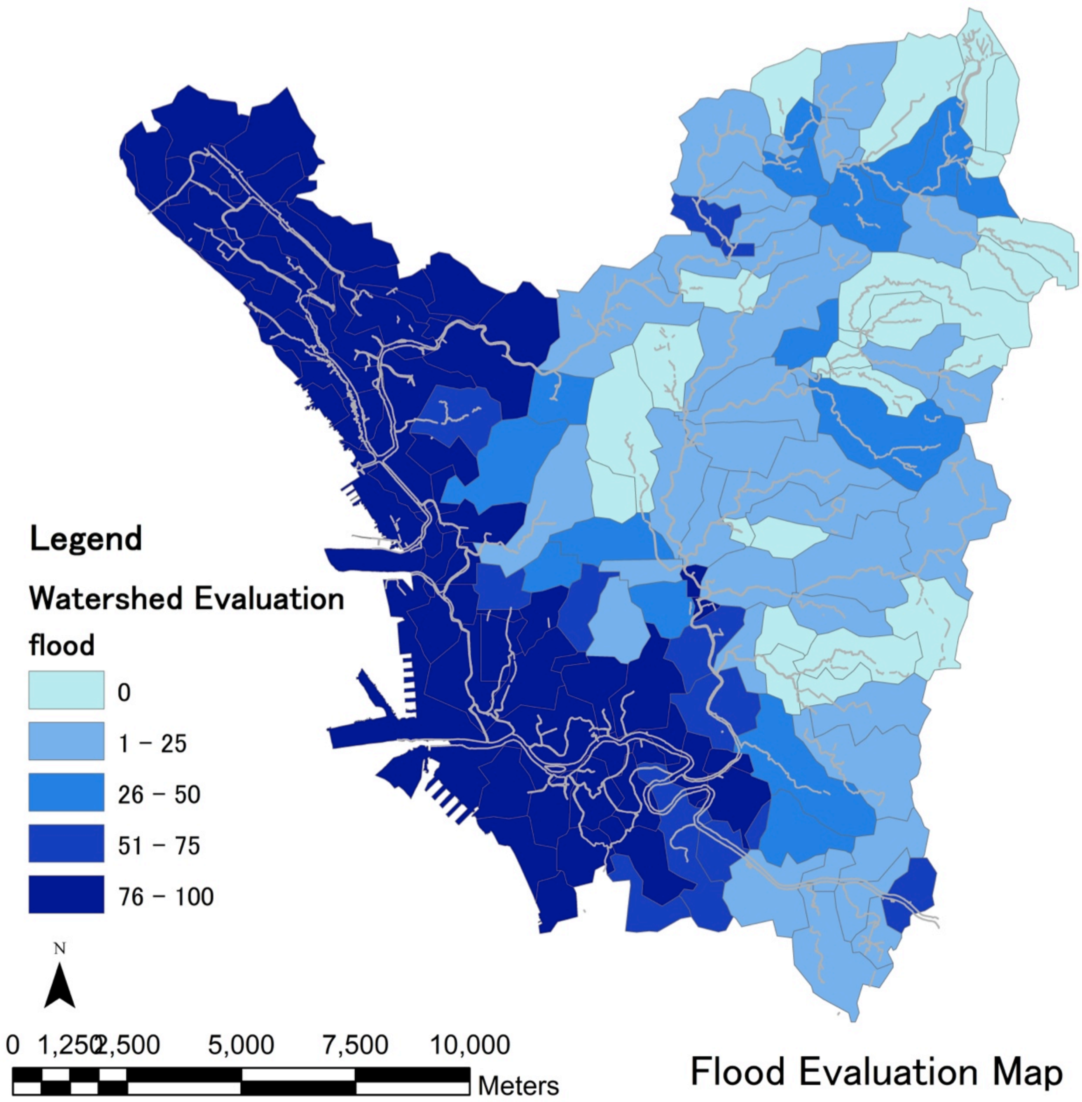


Figure 61: Flood Evaluation Map

The evaluation of flood is based on the total area that experience flooding for each basic watershed unit. The magnitude and intensity of flooding is not emphasized here and instead focused on the areas that are flooded either two to 10 year flooding cycle or 50 to 100 years flooding cycle. The flood data is based on the information from the Department of Environment and Natural Resources.

The flood evaluation reveals that the downstream, which includes the coastal inland and lowland experience very high frequency and intensity of flooding with 81 to 100 percent of the area being flooded. The upstream of the watershed region has lower incidence of flooding except in some basic watershed units with localized flooding. Noteworthy to point out is the basic watershed units at the immediate downstream river that connects to the lake and upland forest which experience relative frequent incidence of flooding. Other basic watershed units with rivers have relative higher incidence of flooding compared to the rest of the region.

4.3.3 Poverty

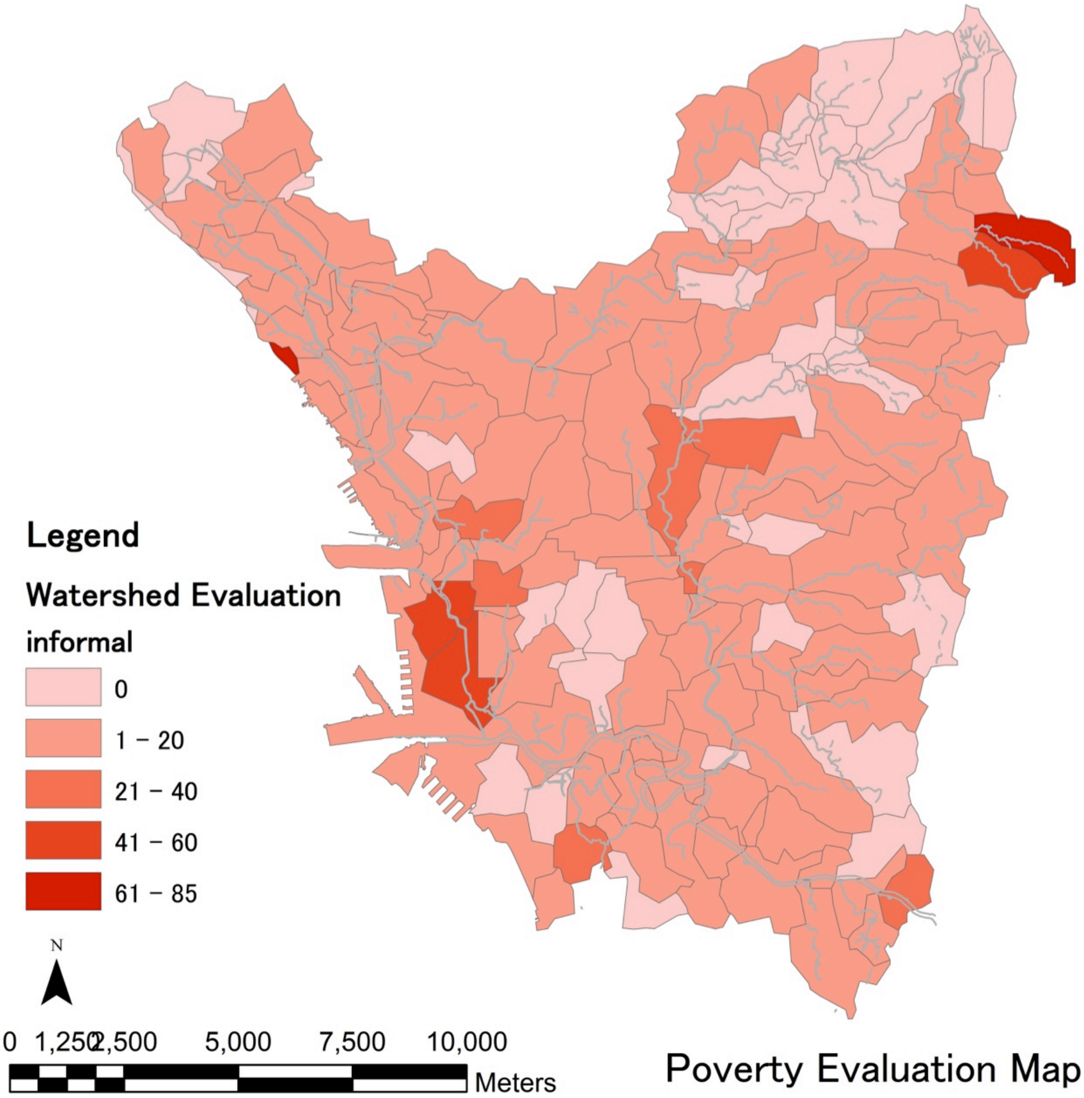


Figure 62: Poverty Evaluation Map

Evaluation of poverty of the watershed is based on the percentage of area covered by informal communities per basic watershed unit. The information regarding the distribution of informal communities is based on the landcover generated from aerial photographs that are confirmed by field work. The range of incidence of poverty is from zero to 85 percent. Aside from basic watershed units with higher concentration of informal communities, it is noticeable that basic watershed units with rivers and streams have about one to 20 percent informal communities, implying the prevalence of informal communities along water channels. On the other hand, the upstream watershed units where the ecological core is located have zero incidence of informal communities, which present less threat to the integrity of ecological core.

4.3.4 Culture

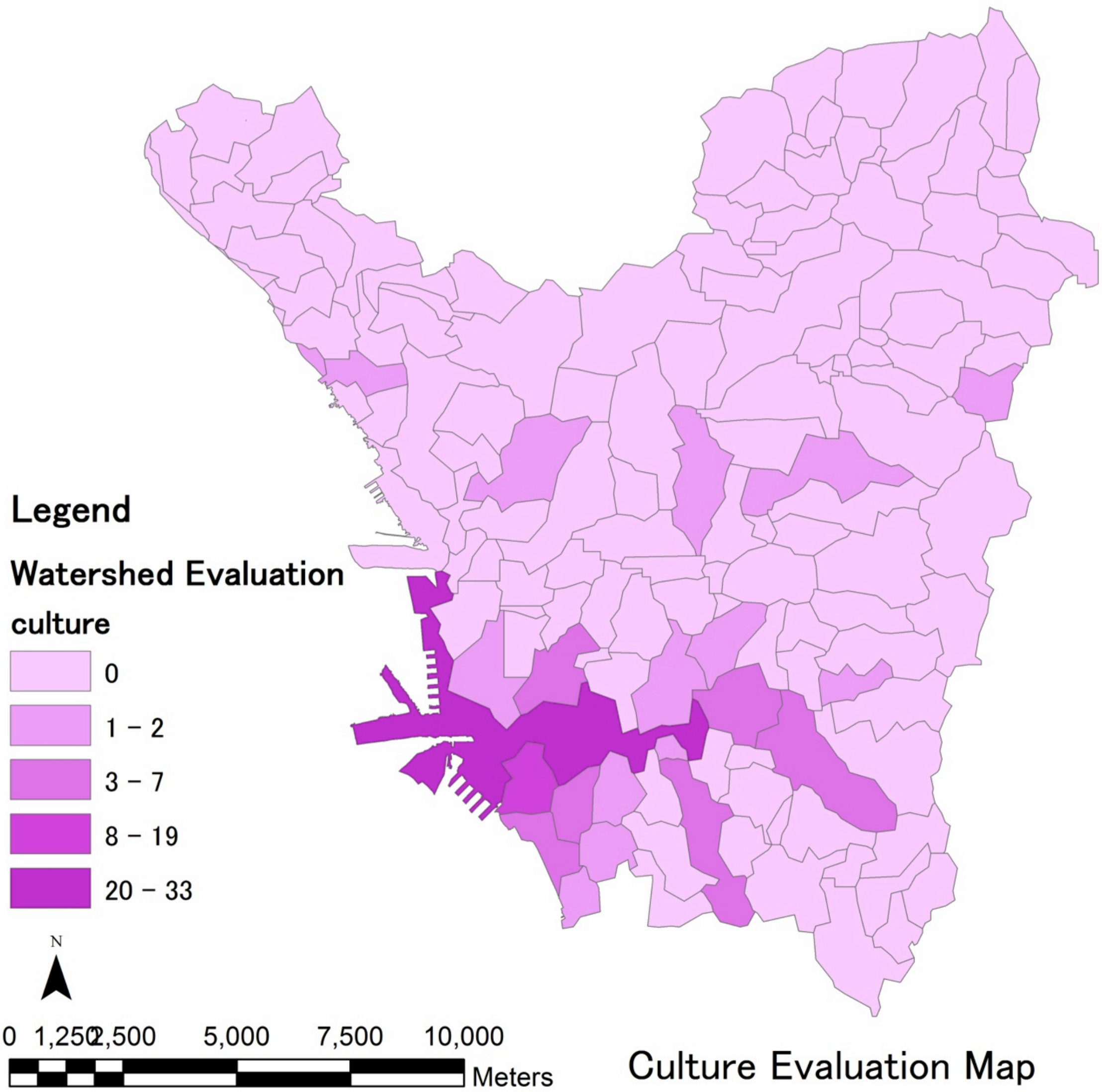


Figure 63: Culture Evaluation Map

The culture evaluation of the Metropolitan Watershed is based on the number of structures and landscapes with cultural and historical values derived from the list released by the National Commission for Culture and Arts. The different cultural sites are identified located in GIS to reflect the distribution per basic watershed unit.

Within the macro-scale watershed, a total of 103 cultural sites are found, of which they are concentrated on the downstream. The evaluation reveals that majority or 89 of the 103 cultural heritage artifacts are found in the Pasig sub-watershed. This shows that the Pasig sub-watershed contains the oldest settlement in the region and has experienced urbanization starting from the building of the first settlement in Manila. The traditional urban core, which is found in the old city of Manila houses most of the artifacts. The role of the Pasig River in shaping the history is also reflected in the artifacts found along the corridor. The robust trade that existed during the Spanish and early American period is reflected in the busy traffic of Pasig River. Along the river emerged the wealthy traders who built their palatial residences which still exist now. Serving as the main trade route, the Pasig river functioned as the main conduit for trade and transportation which encouraged local aristocrats to construct their houses along the river.

The expansion of the city of Manila beyond the confines of Intramuros is reflected as academic institutions that have cultural heritage values are found farther from the walls. The convenience of transportation also helped in allowing other important structures to be built farther from the banks of Pasig River. The outward distribution of artifacts with less years reflect the morphology of the growing city.

4.4 Summary of Ecological Management

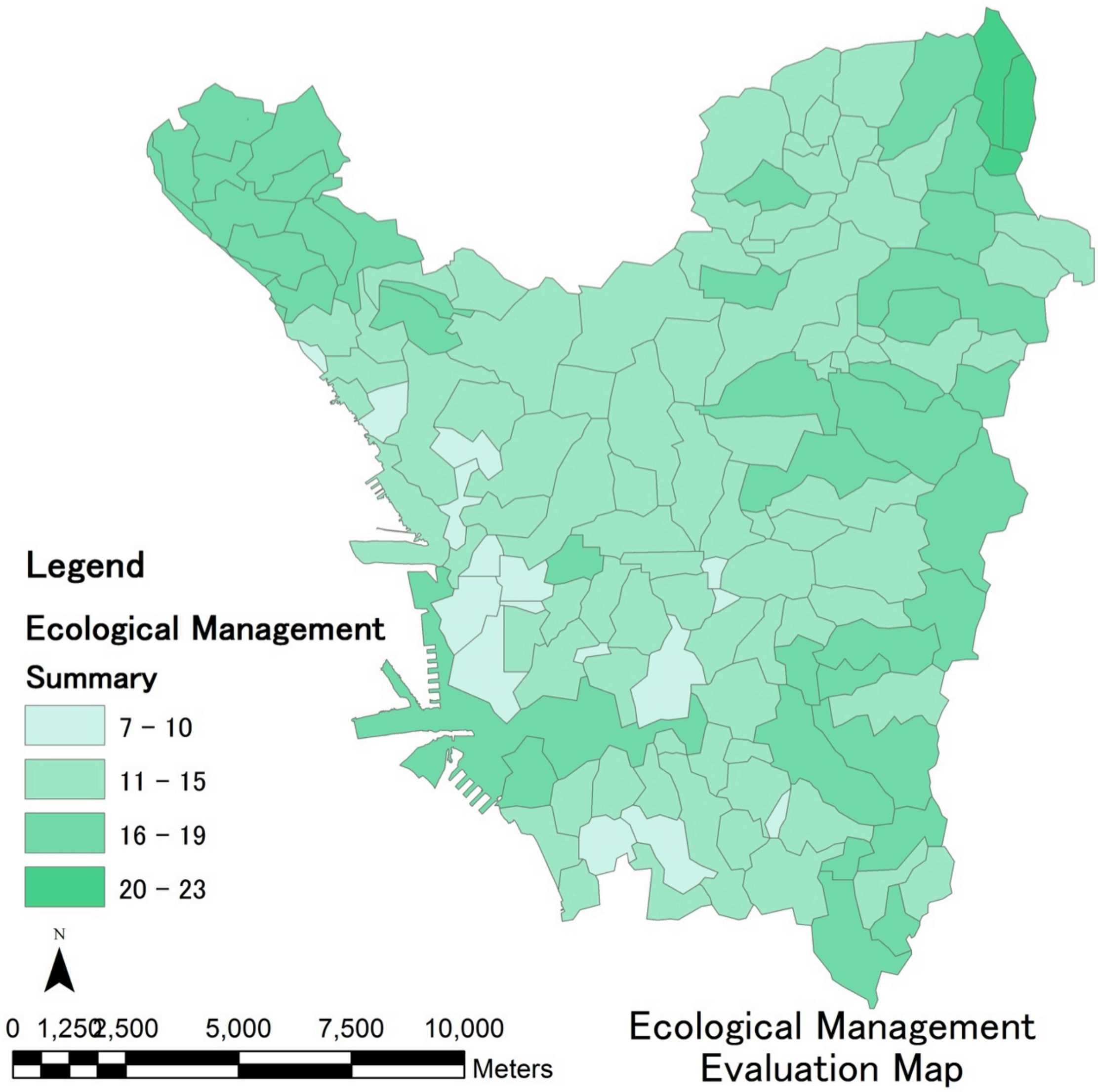


Figure 64: Ecological Management Evaluation Map

The four pillars are summarized in the Ecological Management Summary Map, which is based on the how the four pillars influence the watershed unit. The information used to derive the map includes the evaluation of Biodiversity, with the

Table 10: Valuation System for Ecological Management

Value	Water Cover	Green Cover	Vertical Structure	Flooding	Poverty	Culture
1	0	0	0	76-100%	61-85%	0
2	1-25%	1-25%	.000001-0.310	51-75%	41-60%	1-2%
3	26-50%	26-50%	0.310001-0.64	26-50%	21-40%	3-7%
4	51-75%	51-75%	0.640001 – 1.25	1-25%	1-20%	8-19%
5	76-100%	76-100%	1.250001-2.58	0	0	20-33%

Water Content Map, Green Cover Map, the Structural Diversity Map, Flood, with the Flood Risk Map, Poverty, with Informal Community Map, and Culture, with Cultural Heritage Artifact Map. The evaluation of these information are given values in terms of what strategy can be implemented to improve the watershed, with emphasis on the biodiversity as the most important pillar in the evaluation. In the process of summarizing all the information, the three maps for biodiversity is included to give more weight in terms of the impact of biodiversity in the ecological plan. The rest of the pillars, flooding, poverty, and culture are the same weight in terms of value in the ecological management. Watershed units that experience 76 to 100 percent are given lowest value of one (1), while five (5) is given to watershed units that experience zero (0) flooding. In terms of poverty, watershed units with 61 t0 85 percent covered with informal communities are given the value of one (1) and those with no presence of informal communities are given the value of five (5). Finally, for watershed units that contain cultural heritage artifacts and site are given value, ranging from one (1) with zero cultural heritage artifact or site to five (5) that have 20 to 33 cultural heritage artifacts and sites.

Table 11: Ecological Management Intervention Based on Total Value

Management Intervention Based on Total Value	
Total Value	**Management Strategy**
20 – 23	Protective Management
16 - 19	Integrative Management
11 – 15	Connective Management
7 - 10	Creative Management

Basic watershed units that receive higher total value points are considered for Protective Management. These watersheds require to be preserved from encroachment and the status quo should be maintained. Integrative Management is proposed in watershed that still support high biodiversity but is also used for urban purposes. The emphasis for this management is conservation of the existing biodiversity and improving condition with emphasis for biodiversity. On the other

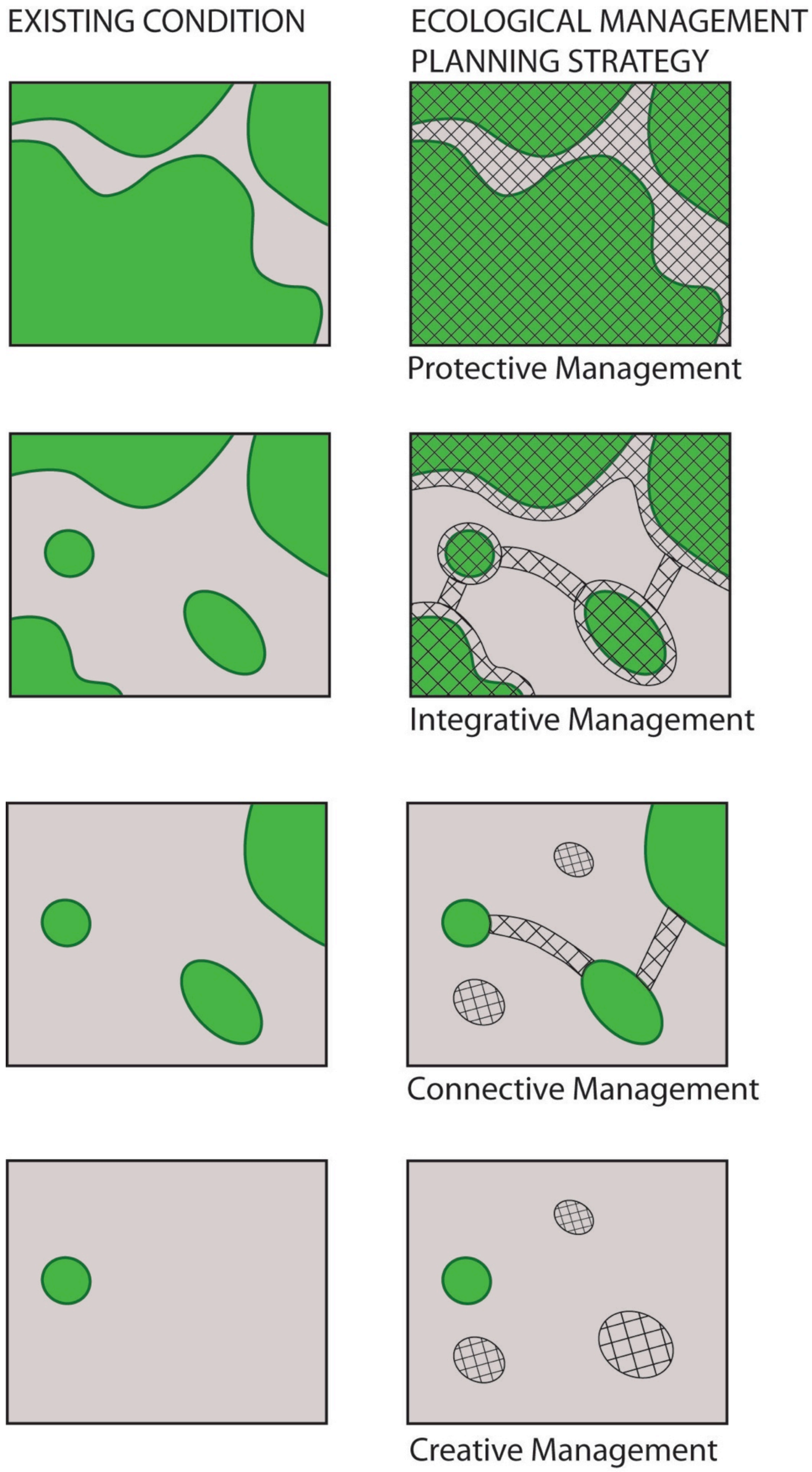


Figure 65: Ecological Management Strategy

hand, Connective Management recognizes the high urban use of the watershed, necessitating the non-disruption of urban activity and instead focus in improving the condition of the watershed by maintaining and connecting the small patches present with other patches. Creative Management is proposed in watersheds that are threatened by flooding and have high presence of informal communities. The management approach is to adopt mitigation measures to minimize the effects of possible disturbance by creating new green spaces.

The summary map indicates the different watershed units that need to be considered for Protective Management, Integrative Management, Productive Management, and Intensive Use Management. Watershed units that require protection and integration coincide with the location of the important ecological cores as part of the ecological structure. These watershed have relatively high biodiversity value, low flood occurrence, low poverty incident, and have important cultural heritage site On the other hand, watershed units that are the location of the corridor show that these spaces need to be improved, implying that these areas are highly urbanized, with many of these having high poverty incidence along the banks of the waterway. Other watershed units close to the coastal zone need to be improved also, since many of these watershed units are exposed to flooding. On the other hand, watershed units that need to have green spaces have low green cover and vertical structure value.

5 THE
ECOLOGICAL PLANNING

5.1 Environmentally-Protected Area

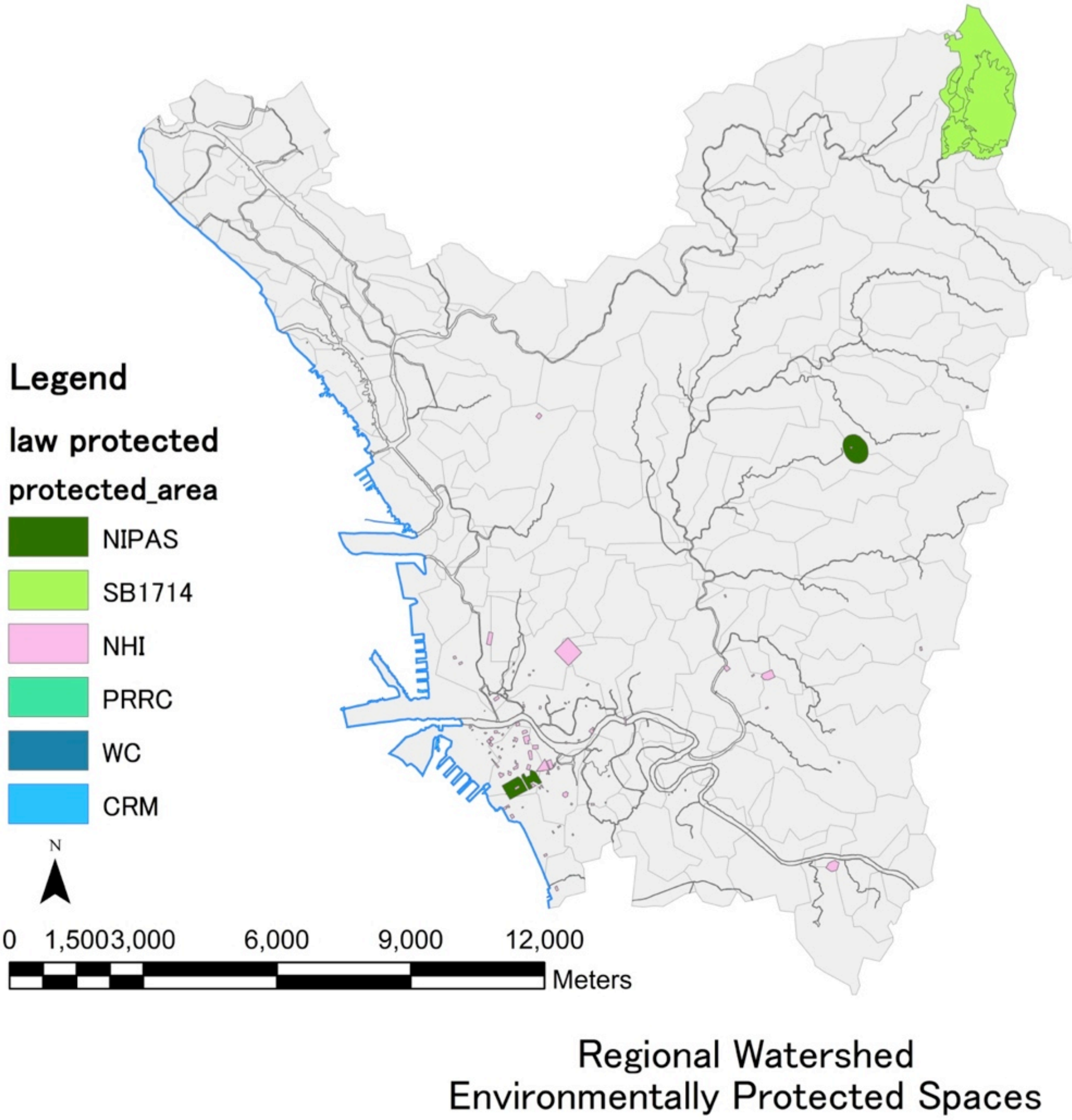


Figure 66: Environmentally-Protected Area

Table 12: Laws Protecting Areas in Metropolitan Manila

LAW	SPATIAL IMPLICATION
NIPAS	Protection of Rizal Park and Quezon City National Park (QCMC)
Senate Bill (SB)-1714	Protection of La Mesa for Watershed Reserve
NHI	Protection of Heritage Sites and Structures
PRRC	Provision of 10-meter easement along Pasig River
Water Code	Provision of minimum easement of 3-meter along all water channels
Coastal Resource Management	Provision of 30-meteer easement along coastal zones

A macro-scale map shows the different spaces covered by various laws and regulations that protect the important ecological spaces. This however reflect the lack of comprehensive plan or law that serves as a basis for having an integrated network of spaces or ecological network. Each of the law is passed by different agencies with the agendum of protecting the specific space but not as an integrated ecological spaces. The National Integrated Protected Areas System is envisioned to serve this purpose, however, as can be seen in the map, it only covers the two areas, the Rizal Park and Quezon Memorial Circle (or Quezon City National Park). Other components of the possible network is covered by other laws. Other spaces with important cultural and heritage values are under the law by the National Historical Institute by virtue of the Protection of Heritage Sites and Structures.

A law to protect the upstream forest and reservoir in La Mesa has been passed to the Senate. This area is also part of the larger watershed protected area, but the implementation and monitoring has been inadequate that a more specific law is needed to protect this important ecological space. This space is currently under the management of a private environmental group, Bantay Kalikasan, which reflects the inefficiency of the government in managing the La Mesa.

Concerning the streams and corridors, two separate laws govern the management of them. The minimum setback instituted by the Water Code require a 3-meter setback. This regulation is often violated based on the observation during the field work in which informal communities and even formal structures have encroached this setback. The inadequacy of this law has been addressed by the formation of another agency to specifically manage the Pasig River, which is the Pasig River Rehabilitation Commission (PRRC), which is in charge with coming up with short-term and long-term programs to revive the Pasig River. At present the PRRC implements a much-wider setback of 10-meter along the banks of Pasig River, in which they are currently developing linear parks.

The edge is basically governed by the Coastal Resource Management (CRM), which sets the setback at 30 meter from the high-tide line. From this setback, no built-up structures can be built and allow unobtrusive public access.

5.2 Ecological Planning Methodology

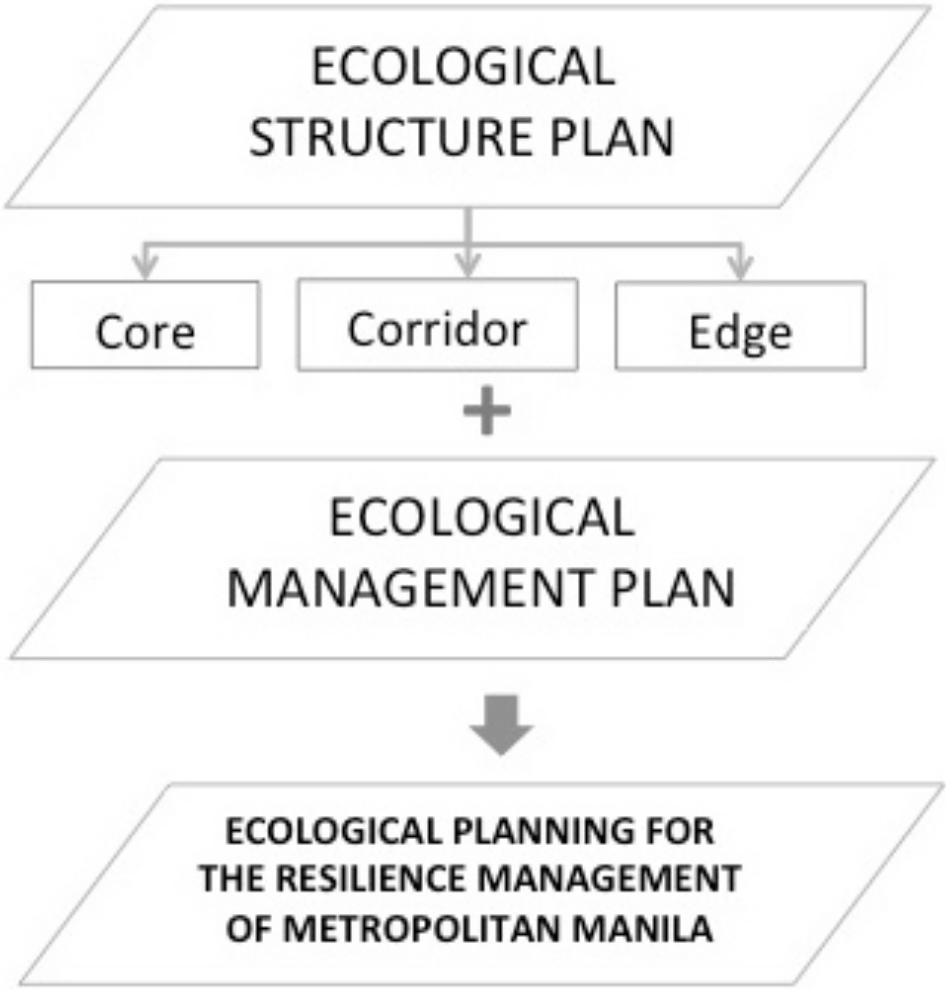


Figure 67: Flow Chart of Ecological Planning Methodology

The methodology for the ecological planning involves the merging of the Ecological Structure and the Ecological Management. The ecological structure reflects the basic ecological network of core-corridor-edge. The different components of the ecological structure are composed of different biotope types, in which strategies are proposed to improve the connectivity and linkages of the network. On the other hand, the ecological management uses watershed as the basic unit of analysis and evaluation of the four pillars. Appropriate management interventions are also proposed in order to optimize the watershed value. The resulting Ecological Planning for Resilience Management combines these two major components in which strategies and management for the ecological network are proposed.

5.3 Ecological Structure Planning

5.3.1. Ecological Cores

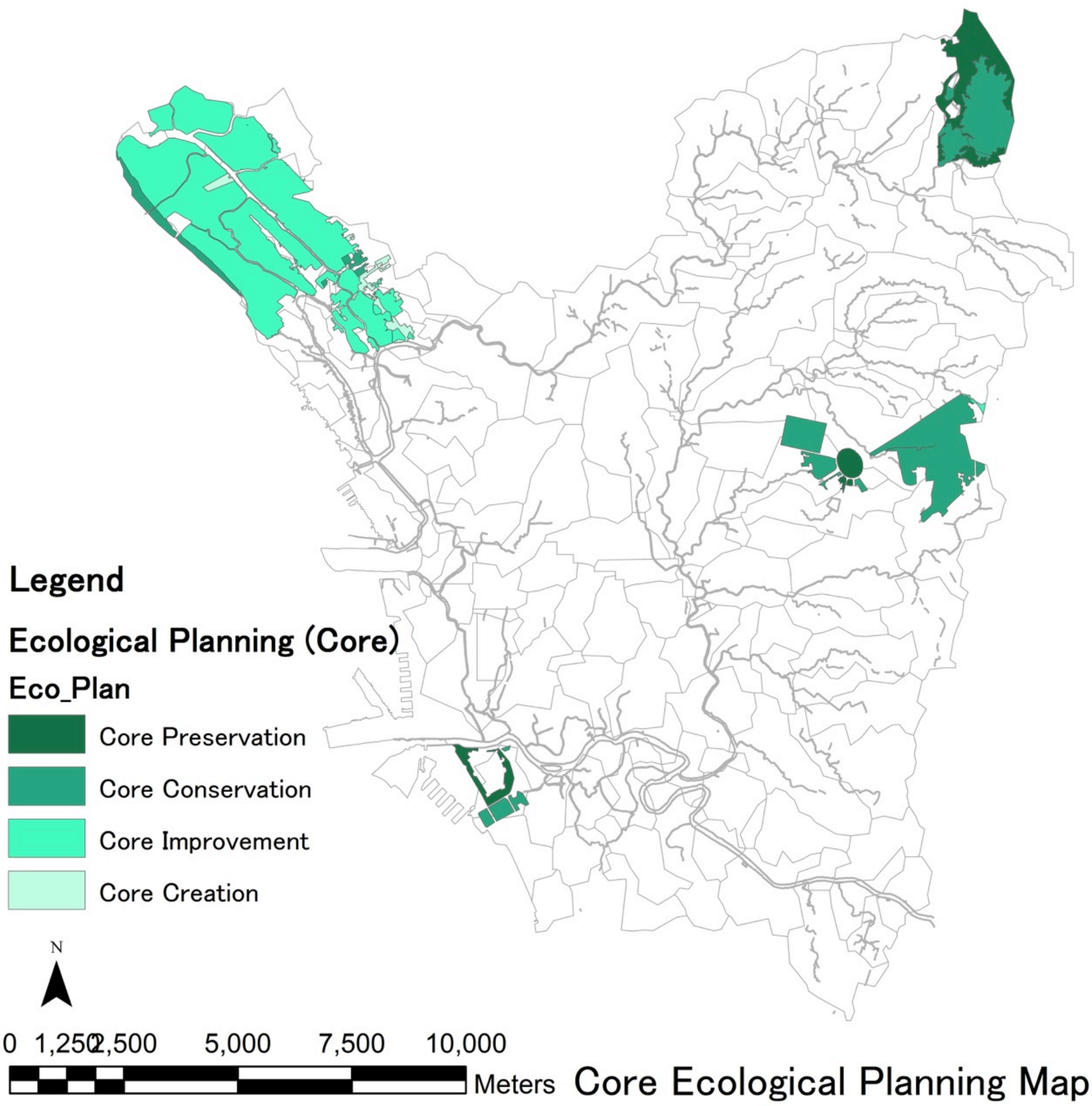


Figure 68: Ecological Structure Planning (Core)

Table 13: Ecological Planning (Core) Strategy

FUNCTION	Area (Ha)	Natural Biotope	Built-up Biotope	Strategy
Core 1	1,924.37	Coastal Grassland	Coastal Urban	- Conserve fishpond and mangroves - Regulate housing along coastline - Conversion of land use should be regulated
		Fishpond (Clay)	Coastal Informal Community	
		Fishpond (Hydrosol)		
		Fishpond (Sandy Loam)		
		Mangrove (Clay)		
		Mangrove (Sandy Loam)		
		Nypa		
Core 2	142.18	Forest (Riverbank)	Lowland Urban	- Create connection between different parks and culture biotopes
		Lowland Institutional Grassland	Port	
		Park		
		Culture		
Core 3	585.61	Riverbank Grassland	Upland Informal Community	- Conserve grasslands from conversion to other land uses
		Upland Forest	Riverbank Informal Community	
		Upland Institutional Grassland	Upland Urban	
		Upland Natural Grassland		
		Culture		
Core 4	523.11	Lake	Upland Urban	- Protect the eco-park and watershed forest reserve
		Upland Natural Forest	Upland Informal Community	
		Upland Natural Grassland		

The ecological cores manifest the composition of the watershed units in which they are found. Both the natural and built-up biotopes are included to reflect the biotope composition of the watershed units. Further, strategies on how to improve and implement the resilience management are also included in which proposal on how to manage the natural and built-up biotopes. It aims to present an integrated approach to increase the resilience of these spaces by promoting biodiversity, minimal development in flooded areas, reduced exposure to risk of informal communities, and conserving spaces with the cultural and historical values.

5.3.2 Ecological Corridors

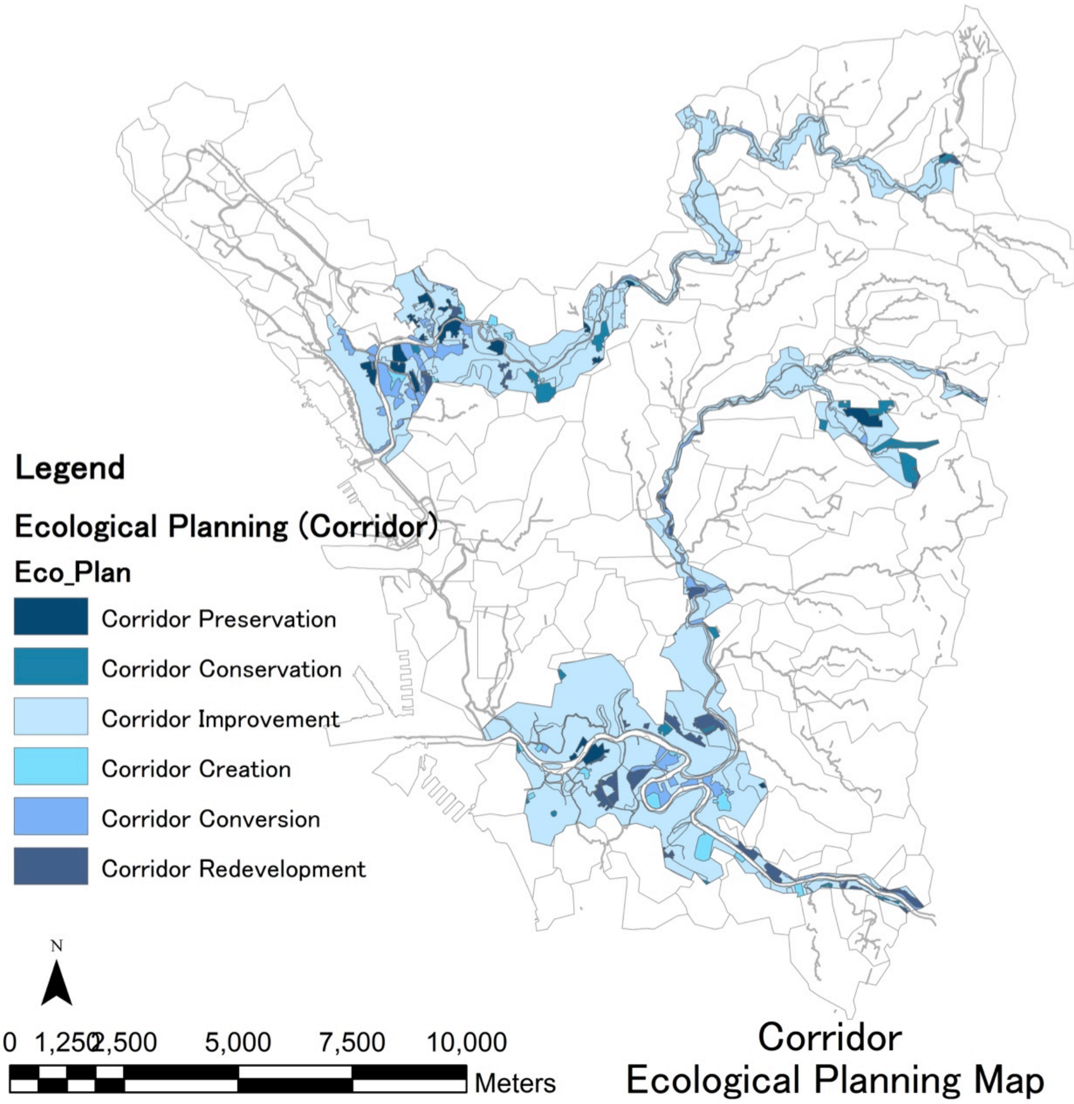


Figure 69: Ecological Structure Planning Map (Corridor)

Table 14: Ecological Planning (Corridor) Strategy

FUNCTION	Area (Ha)	Natural Biotope	Built-up Biotope	Strategy	ECOLOGICAL MANAGEMENT
Corridor Management 1	1,453.05	Coastal Grassland	Coastal Urban	Prevent encroachment of informal communities along river Preserve natural grassland and forest	Impose and increase easement along river Mitigate fragmentation of isolated patches by creating connection using the river
		Coastal Forest	Coastal Informal Community		
		Economic Forest	Lowland Informal Community		
		Fishpond (Clay)	Upland Informal Community		
		Fishpond (Hydrosol)	Riverbank Informal Community		
		Forest (Riverbank)	Upland Urban		
		Lowland Undeveloped Grassland			
		Mangrove (Clay)			
		Nypa			
		Riverbank Grassland			
		Upland Forest			
		Upland Natural Grassland			
		Upland Undeveloped Grassland			
Corridor Management 2	787.56	Lowland Institutional Grassland	Lowland Informal Community	Improve connectivity of natural biotopes High flood-risk area should not be built on	Conversion of high-intensive spaces into nature-oriented spaces
		Riverbank Grassland	Coastal Informal Community		
		Upland Forest	Lowland Urban		
		Upland Institutional Grassland	Coastal Urban		
		Upland Natural Grassland	Riverbank Informal Community		
			Upland Urban		
			Upland Informal Community		
Corridor Management 3	1,542.44	Culture	Riverbank Informal Community	Regulate the construction of informal communities along the river Control conversion of natural biotopes	Develop partnership with local community to serve as environmental managers
		Forest (Riverbank)	Lowland Urban		
		Lowland Industrial Grassland	Coastal Urban		
		Lowland Institutional Grassland	Lowland Informal Community		
		Lowland Undeveloped Grassland	Coastal Informal Community		
		Park	Upland Informal Community		
		Upland Forest	Upland Urban		
		Upland Institutional Grassland			

Three major corridor management has been clarified, which serves as major linkages to the different ecological cores and edge. The three corridor management areas are: the Tullahan, Pasig, and San Juan Corridors Management. Strategies are proposed based on the character of the corridor, which is mainly threated by the issue of encroachment of informal communities along their banks. In spaces that lack connectivity, it is proposed that some high-urban intensive spaces be converted into natural biotopes to serve as links to isolated patches along the corridor. On the other hand, corridor with high prevalence of informal communities but with less risk to flood, it is proposed that the residents be included as part of the solution by being environmental managers within their community. In this way, they will become part of the solution instead of the problem.

5.3.3 Ecological Edge

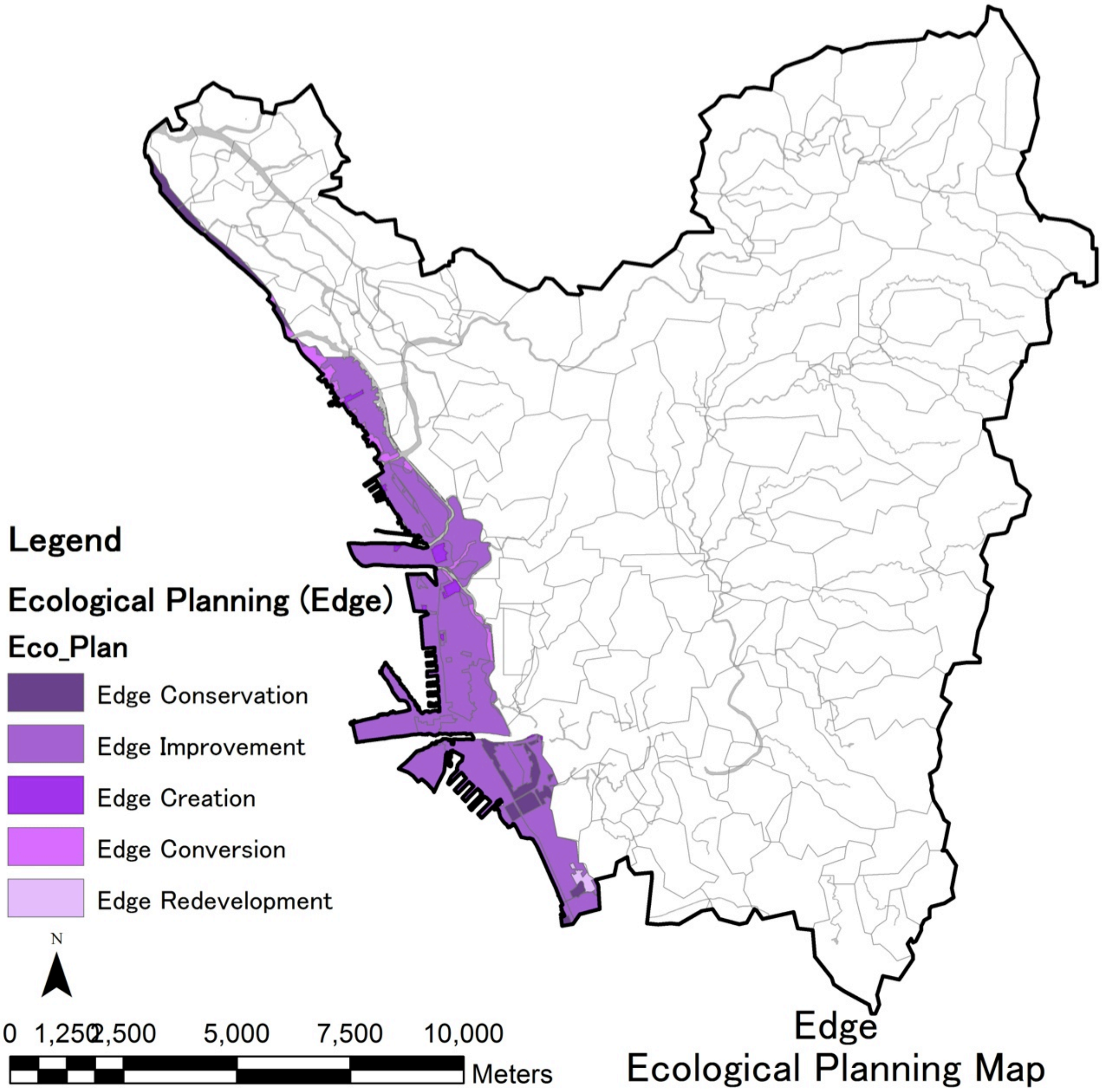


Figure 70: Ecological Structure Planning (Edge)

Table 15: Ecological Planning (Edge) Strategy

FUNCTION	Area (Ha)	Natural Biotope	Built-up Biotope	Strategy	ECOLOGICAL MANAGEMENT
Edge	1,800.24	Coastal Grassland	Coastal Urban	• Improvement of grassland • Preservation of Cultural Sites • Conservation of fishpond and mangroves	Fishpond and mangroves serve as buffer between sea and land processes (storm surge, flood) The edge to serve as interface to absorb the effects of coastal environment
		Culture	Port		
		Fishpond (Hydrosol)	Lowland Informal Community		
		Fishpond (Sandy Loam)	Coastal Informal Community		
		Forest (Riverbank)	Lowland Urban		
		Lowland Institutional Grassland			
		Mangrove (Sandy Loam)			
		Park			

The edge, being in a very ecologically sensitive zone while performing a very important urban function, presents a challenge in terms of managing resilience. The strategy is to improve the connectivity of the different natural biotopes while allowing the port to function. It is also recommended that informal communities found along adjacent or close to the port area be provided with the better housing in which they will have better resilience from disasters. The edge at the northern end also needs to be protected from further conversion into industrial land use in which the mangroves and fishpond serve as buffer and protection from flood and storm surge.

5.3.4 Summary of Ecological Structure Planning

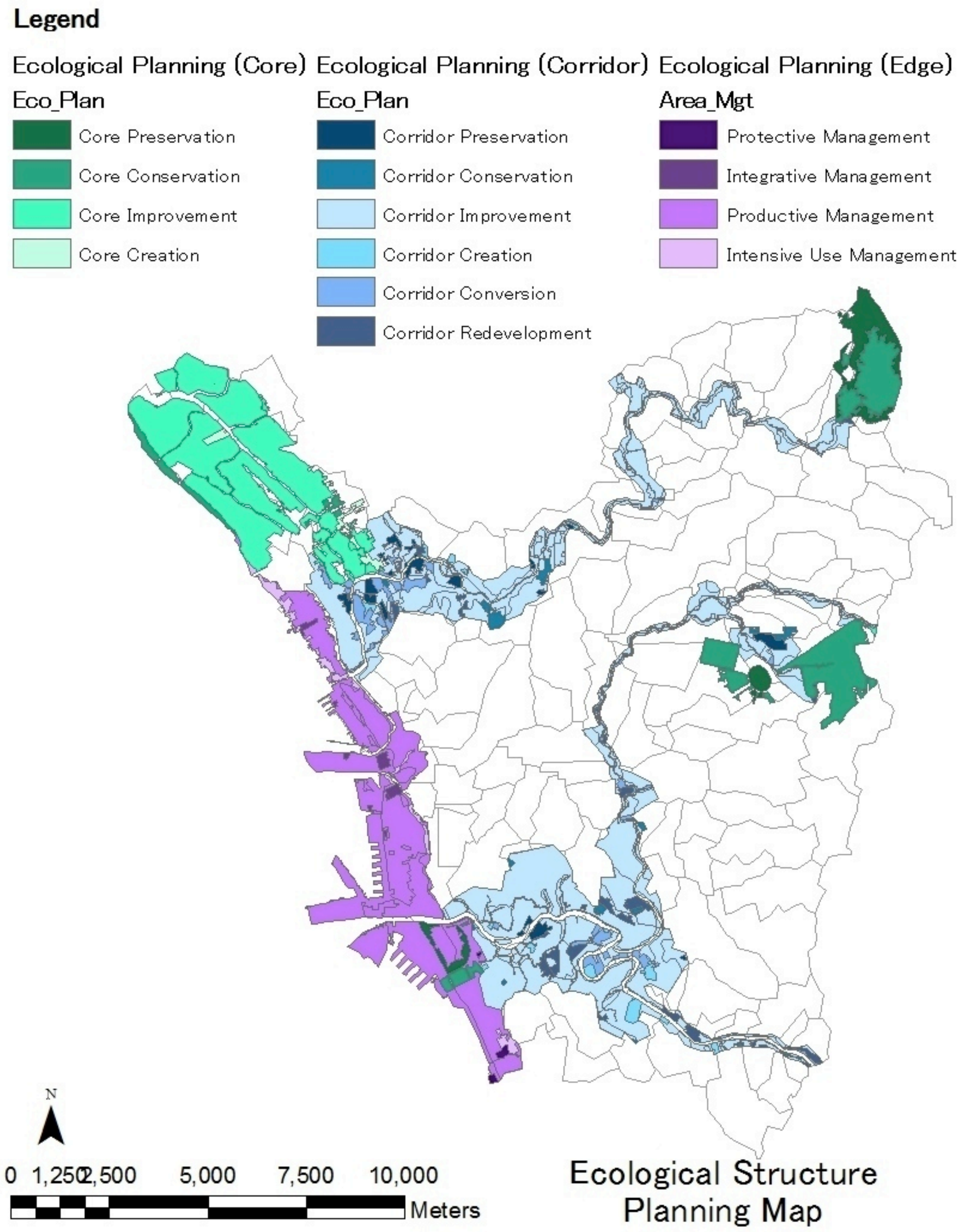


Figure 71: Overall Ecological Structure Strategy Map

The Ecological Structure Planning Map reflects the strategies proposed for the network of ecologically important spaces. The proposal is divided into strategies for the core and corridors, while edge has management intervention. The difference lies in the emphasis for preservation and conservation since the core and corridor are important in maintaining ecological function. On the other hand, the present edge has very urban function that needs management intervention to optimize the urban facilities. These spaces form a network of Core, Corridor, and Edge. Conventional ecological network planning usually emphasizes the core/patch-corridor-matrix network. However, in the case of Metropolitan Manila, it is essentially to delineate the edge since this space serves an important interface between the land and coastal processes.

5.4 Ecological Management Planning

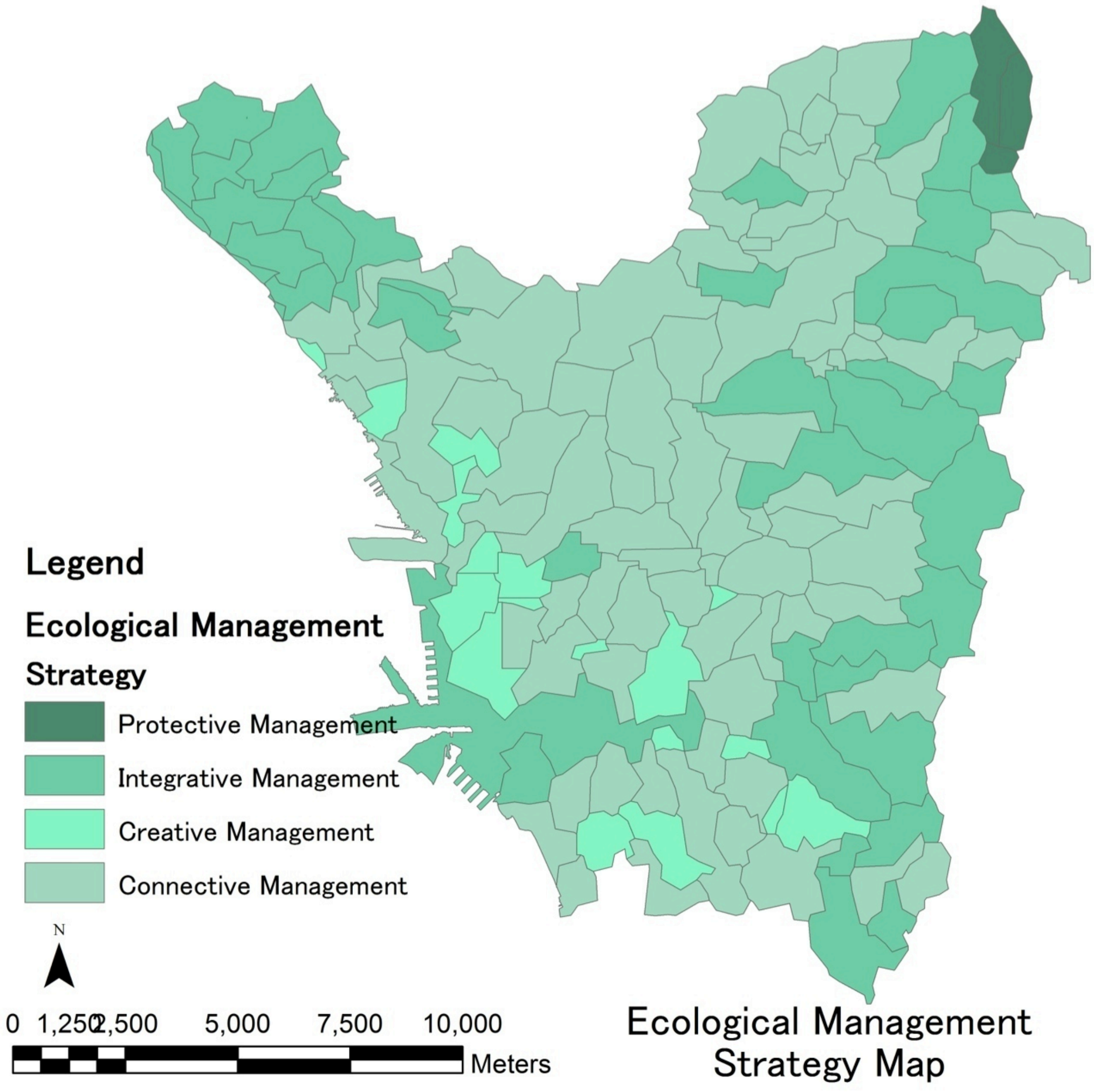


Figure 72: Ecological Management Strategy Map

The Ecological Management Plan reflects the overlaying of water cover, green cover, vertical diversity structure, flood, poverty, and culture per basic watershed unit. The map indicates the potential area to create an ecological network for resilience management based on the ecological structure and ecological management. Aside from biodiversity, it also manifests the evaluation of the different parameters such as Flood, Poverty, and Culture in which strategies are proposed. Following the structure of the ecological structure, the corresponding watershed units based on the ecological management is presented. The watershed-based ecological structure contains the management approach proposed. Taking into account the location of the ecological structure, the ecological management planning map reflects similarities in terms of strategies and management approach. Watershed that is the location of ecological cores have more ecological-oriented management, of Protective Management and Integrative Management, which compliments the preservation and conservation strategy proposed for the ecological cores. On the other hand, watersheds where the corridor and edge are located indicate high degree of urbanization and productive activity, necessitating Connective Management approach in which urban activities are allowed, provided that adequate improvement is implemented This also implies connecting isolated green spaces with other patches and existing water channels. Creative Management areas face high risk of threats of flood due to high presence of informal communities. Measures to mitigate possible impact of disaster need to be considered. Certain areas within the watershed need to be considered for conversion to less intensive use, reflecting the strategy in ecological structure for patches that require creation of new green spaces to ameliorate the effect of flood. At this scale, the community is enjoined to be part in proposing creative and community-based solution to their issues.

5.5 Ecological Planning for Resilience Management of Metropolitan Manila

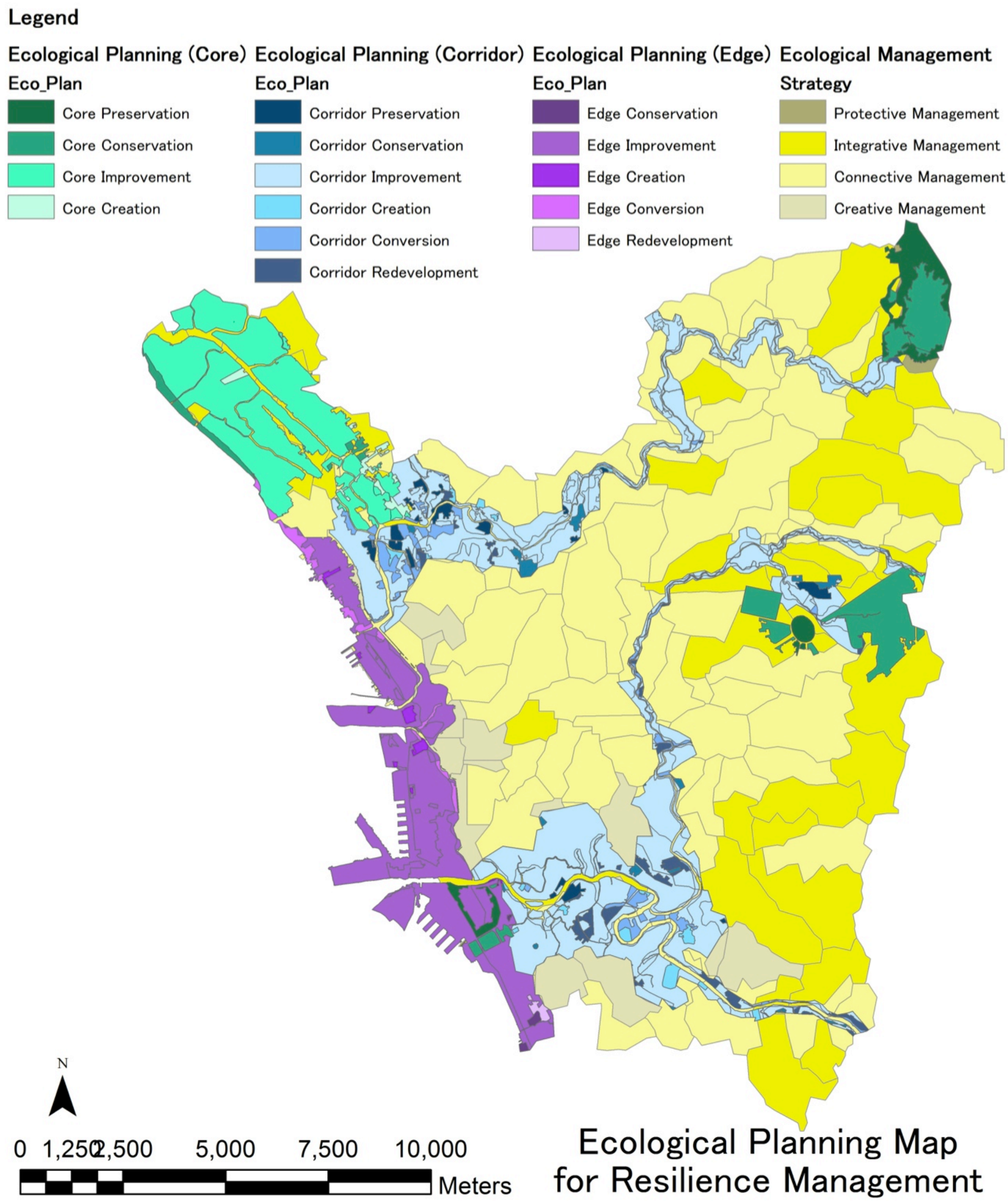


Figure 73: Ecological Planning Map for Resilience Management of Metropolitan Manila

Merging the ecological structure and the ecological management, the ecological planning map for resilience management is presented in which the function of the ecological network is combined with the basic watershed unit. The basic watershed units are clarified according to their function in the ecological network such as Core, Corridor, and Edge. Further, the ecological cores based on the ecological network for resilience management has been clarified, in which the number of ecological cores have been reduced from five to four. The two cores have been merged based on the proximity of the basic watershed units and to create a concentrated ecological cores.

The resulting Ecological Network for the Resilience Management of Metropolitan Manila is derived with the integration of the ecological structure map and the ecological management map. The map indicates the interconnected network of natural and built-up biotopes within the watershed unit. The different functions of the ecological network for resilience management are further clarified as to their role for resilience management. To optimize the ecological network, strategies on how to improve the current condition and develop connectivity and linkages between the different functions are proposed. Spaces that cause fragmentation within the defined function such as the core, corridor, and edge are proposed to be converted into more natural biotope types, while those with natural biotope types are either preserved or conserved, with the rest of the spaces that need to be improved. The corridor, which exhibits fragmentation and disconnect among natural biotope types are proposed to have new natural biotope types to be created. Through this, the gaps between natural biotope types will be filled and in so doing will form a connected link. This is an important strategy since the corridor serves an important role in the movement and flow of energy, nutrients, and species.

On the other hand, the surrounding ecological management spaces that are outside the ecological structure similarly need to be altered to optimize the resilience of the network. Watershed units that contain important ecological function, particularly the ecological core, need to be conserve since they will serve as buffer from possible changes along the fringes of the ecological core. Watershed units with ecological corridor and edge need to create more natural spaces, either along the bank of the river or as matrix of small patches to allow movement along the corridor and edge. The watershed units close to the edge serve as transition in which the changes in the land processes should not have adverse effect on the water environment. In turn, it should also protect the coast from possible effects brought by extreme weather condition that could affect the coastal processes, such as tidal flood and storm surges.

The ecological planning of Metropolitan Manila allows the natural processes to occur while improving the connectivity of natural spaces. Built-up spaces are protected from possible effects of flood, particularly the most vulnerable sector of informal communities. It also attempts to integrate the cultural heritage sites as part of its agenda to conserve green spaces that will make urban areas along coastal zones resilient from disturbances.

6 CONCLUSION

6.1 Urbanization of Metropolitan Manila

The geographic and physical characteristics of Metropolitan Manila make it vulnerable to a number of threats. Being a coastal city with rapidly urbanizing population, tremendous pressure is exerted on the environment, resulting to issues, which the metropolitan region should confront. From a small settlement that emerged at the mouth of Pasig River and along the coast of Manila Bay, it has grown into one of the thriving megacities in Asia. With the rapid increase of population, both by natural growth and migration, the demand for space in the urban environment saw the densification of residential and urban spaces, conversion of natural and semi-natural spaces into built-up and paved spaces, and deterioration of the quality of urban spaces. Along with these realities is the disruption of the natural processes that often result to the worsening of urban conditions, resulting to loss in opportunity cost, infrastructure damage, economic disparity, and even death. These environmental and urban issues have been closely interlinked that discussing one issue necessitates the discussion of other issues related to it. These challenges need to be faced in order to create a resilient city for the people of Manila.

The urbanization of Manila started even before the arrival of the Spanish colonizers. From an indigenous organization headed by local chieftains, the growth of the city accelerated with the colonization of the Philippines by Spain with the building of the fortified town of Intramuros. Similar to the walled cities in Europe, the seat of governance, politics, military, religion, and economy is within the walls with the surrounding community inhabited by the indigenous residents. The idea of the city of Manila expanded with the proposed plan of Daniel Burnham, in which he envisioned an expansive city beyond the fortified walls in the mold of the City Beautiful Movement. Historical events and changes in the political administration have resulted to abandonment of the Burnham Plan, ending up with partially implemented city plan of Manila. After the Burnham Plan, there has been no comprehensive city plan for the city while it experienced rapid expansion and changes. Several attempts have been made in terms of coming up with conceptual framework for the redevelopment of Manila, which has evolved into a Metropolitan Manila. The absence of a coherent and long-term vision has contributed to the inability of the city to face the challenges brought by both environmental and urban issues.

6.2 Issues of Metropolitan Manila

Foremost of the challenges faced by Metropolitan Manila is the issue of flooding. Historically the city of Manila has been flooded due to its physical characteristics and location. Located along the typhoon belt, a number of typhoons pass by the Philippines every year resulting to periodic inundation. This occurrence is exacerbated by its physical characteristics, which is low-lying, almost flat terrain, and dominated by clay soil type. The combination of this characteristics and the highly urbanized condition of Metropolitan Manila, which has vastly altered the natural drainage patterns and reduced the area absorbing the run-off and water-holding capacity of the soil. The dominant built-up landcover of the city has greatly reduced the capacity of the Manila to take in the effects of flood to its environment and its residents.

The rapid urbanization of Metropolitan Manila has seen the increase and intensification of built-up spaces at the expense of its green spaces. Another challenge faced by the city is the reduction of green spaces as expressed in lower biodiversity. Biodiversity has been identified as one the major issues that cities around the world need to confront, citing adverse effects as possible outcomes of low biodiversity in urban areas. Biodiversity in green spaces has been limited to parks and gardens, streetscapes, brownfields, and semi-natural spaces that have been modified by human activities. These green spaces more often exist as isolated greens in the sea of gray concrete buildings and paved roads. The low presence of green spaces have been attributed to the loss of habitat for wildlife, decline or disappearance of indigenous flora, increase in surface temperature, and the reduced capacity of the environment to perpetuate the hydrological processes. The importance of green spaces, aside from its ecosystem benefits, have major contribution to improving the quality of life in the form of elevating the urban aesthetic, allowing human contact with nature, and improving psychological well-being and fostering human-scaled city.

The development of the city has seen the proliferation of informal communities that reflect the state of poverty in the city. Residents of these informal communities have low or no access to basic amenities, exposed to greater risks of disasters, in unhealthy and disease-ridden area with poor sanitation and peace and order situation, and in constant threat of losing their homes. Many of these communities are found in marginalized location, flooded areas, and in deplorable state. The government's inability to provide decent and affordable housing program, the high natural birth rate and influx of migrants, and imbalance in the provision of opportunities have contributed to this phenomenon. The issue of poverty in informal communities has limited the ability of the city to respond to the disturbances that often confront the city.

The urbanization of Metropolitan Manila is the result of a long history of different rulers and colonization. The different periods of history are marked by buildings and landscapes that have stood witness to the history of the city. The different monuments, gardens, and architectural legacies are important legacy of the city, which require attention by the people and the government. Efforts to conserve these cultural heritage sites have been under the auspices of government agencies. However, in order to promote a long-term and enduring program to preserve these cultural heritage sites, it should involve the whole city so as to preserve both the artifact and the context. Promoting consciousness of the cultural heritage to the people necessitates the integration of these cultural heritage sites to the spatial awareness of the people and its city.

Among the myriad of issues faced by Metropolitan Manila, these issues stand in the forefront in challenging the resilience of the city. These issues have been selected in the creation of the framework for ecological planning due to the following reasons: (1) they are the most pressing issues that challenge the capacity of the city develop adaptation, (2) these issues have mainly shaped the urban form and structure of the city, (3) they can be spatially defined and translated into physical planning, and (4) there is an inherent interrelationship among the different issues, forming the four pillars of issues of Metropolitan Manila.

6.3 Methodology

With the four pillars identified and clarified, there is a need to provide an ecological planning framework to address these issues. The objective of the framework is utilize these four pillars of issues and develop the strategies using biotope mapping and watershed management as main method in defining the ecological structure and ecological management. The ecological plan for the resilience management of Metropolitan Manila is created by merging the ecological structure and ecological management, creating an integrated network of natural and built-up spaces. Strategies are proposed in order to strengthen the connectivity of existing ecological structure, while watershed units are proposed using area management to integrate the surrounding space of the ecological structure. The ecological network is an important structure that improves the resilience of the city from disturbances due to the following reasons: (1) it results to reduced fragmentation and discontinuity of green spaces, (2) connected green spaces allow a system to develop new level of stability after the disturbance, (3) it fosters exchange of energy, nutrients, and genes between green spaces allowing greater chances of recovery, (4) provides more and continuous amenity for the urban residents, and (5) it absorbs environmental stresses and allows environmental processes. The importance of this method is that is utilizes or mimics nature as the model in spatial or physical planning. This method forms the fundamental concept in developing the ecological plan for resilience management.

The flow of the research begins with the discussion of the different issues that challenge Metropolitan Manila. Second, from among these challenges, four majors issues having the most impact to the urban resilience of the city are clarified, forming the four pillars of issues. Third, the framework is designed to address the four pillars using ecological planning in proving strategies to manage resilience. Fifth, as part of the ecological planning framework, the ecological structure is defined and analyzed in which the existing basic structure is clarified. The main method for this part is the biotope map, in which natural and built-up biotope types that comprise the environment of Manila. Important functions of each biotope type is analyzed and its role in the existing ecological structure. The existing present structure is formed by the core, corridor, and patches that compose the matrices. From this present ecological structure, the ecological structure for ecological planning will be based from. Sixth, the ecological management is discussed using watershed as the main method in evaluating the four pillars and in coming up with strategies to improve the condition of each basic watershed unit. As an important spatial basis, the watershed is evaluated based on the cover and intensity of the biodiversity, flooding, poverty, and culture. The value of each four pillars becomes the basis for proposed strategies for ecological planning, with greater emphasis on biodiversity. Finally, the ecological plan for resilience management is created by merging the ecological structure and ecological management in which the ecological plan forms an integrated network of green spaces. This ecological plan for the resilience management of Metropolitan Manila is the first ecological planning proposal based on scientific and systematic method.

6.4 Ecological Structure Planning

The ecological structure is formed by different spatial units based on the interrelationships between human and natural environment. Geographic and hydrologic information is overlaid with the landcover, which manifests the influence of human system and activities in the environment. This approach is shown in the biotope map, wherein data sheets and the overall biotope map are used to define the functions in the ecological structure. The most important academic contribution and originality of this research is the creation and development of the Biotope Map. The information used and derived in the processing for the analysis and evaluation of the metropolitan region contributes in enriching the planning in the Philippines, particularly the ecological planning of Metropolitan Manila. The analysis uses micro scale-defined units, which is reflective of the biotope types and character, to create a macro-analysis and evaluation of the metropolitan area. It clarified the current condition of the city and how important ecological structure can be derived using this method. The resulting biotope map is further classified into two major divisions: the natural and built-up biotopes. The natural biotope types are actually semi-natural biotope types, which are green spaces that either (1) remnant of previous vegetation regime, (2) created green spaces as amenity, (3) resulting green spaces due to human activity and production, (4) or in green spaces that are currently or will be developed into built up space. Analysis of Metropolitan Manila has resulted to 21 natural biotope types, with coverage ranging from fishpond, mangroves, forests, grasslands, and cultural areas and parks. On the other hand, there are eight (8) built-up biotope types found in Manila, with informal communities distinguished from urban areas. Urban areas are comprised of or combination of the residential, commercial, institutional, industrial, utility spaces and paved spaces. The informal community is emphasized because it presents a unique situation in which formal planning does not exist or the urban form is not defined by institutional planning and instead emerged as spontaneous or organic organization of spaces. Both major biotope types are analyzed based on the different functions: biodiversity, flooding, poverty, culture, amenity, and productivity. The results of this analysis are used to form the strategy and role of each biotope type in the ecological structure, which are the core, corridor, patch, and edge. The edge has been added in this network because in the case of Metropolitan Manila, it has been found to be the most impacted zone from the coastal processes and, at the same time, is critical in forming resilience management for the metropolis. From this ecological structure, basic principles in ecological planning, the connectivity and linkages of the different ecological cores and corridors and edge can serve to improve the resilience of city.

6.5 Ecological Management Planning

Ecological management gives primacy to the hydro-geologic processes in terms of evaluating biodiversity, flood, poverty, and culture. The landcover, which is more of the function of urbanization, reflects its use according to the hydro-geologic condition, thus fishponds and mangroves are expectedly in areas that are frequently flooded in which they have adapted to the condition of constant inundation. On the other hand, urban-defined functions such as residential, commercial, institutional, industrial areas and informal communities often overlap with flood vulnerable areas, thus causing economic losses, infrastructure damage and human casualty.

Aside from the emphasis on biodiversity of the ecological framework, it also addresses the issue of flood vulnerability of Metropolitan Manila. Given this scenario, the watershed management is an important concept in understanding and planning the metropolitan region in conjunction with other issues such as poverty and culture. The framework assumes flooding not as an isolated or recent phenomenon but as a natural event that has actually contributed to the urbanization of Manila. This urbanization of Manila has resulted to the increase in number of informal communities. Similarly, the distribution of cultural heritage sites has relationship with the pattern of urbanization. The utilization of watershed in ecological management provides the fundamental in landscape planning in which strategies are proposed based on each basic watershed unit with the integration of these different relationships of the four pillars into a comprehensive ecological management map. The ecological management map emphasizes the importance of biodiversity by placing more weight on the evaluation that contributes to the improvement of biodiversity, such as green cover, water cover, and vertical structure values. Other values are similarly manifested spatially to identify areas that require strategies for ecological management. Based on the ecological management, four management strategies are proposed, which are: (1) protective management, (2) integrative management, (3) productive management, and (4) intensive use management. Protective management concerns spaces that have high biodiversity and cultural values that need protection of the watershed to preserve the existing green spaces and provide buffering from encroachment and conversion of the edge of the watershed. Integrative management encourages multiple functions, with emphasis on allowing the natural processes to occur. On the other hand, productive management is proposed in mainly built-up watersheds that maintain activities necessary in urban systems and network. These watersheds have high traffic and concentration of built-up structures and population, examples of which include basic watershed units containing port areas and commercial centers. The proposed management allows the urban activities to proceed while optimizing the green spaces found within the basic watershed unit. Compared to the integrative management, urban system productivity is emphasized, while the occurrence of natural processes is prioritized in integrative management. Intensive use management is proposed in basic watershed units that are built-up, mostly with informal communities, in which concentration of human components limits the capability of the natural processes to occur because of very low or absent green spaces. These basic watershed units require mitigation in terms of anticipating the effects of flood and or conversion into more suitable spaces that can absorb the effects of flooding. These management strategies are further reflected in the ecological plan for the resilience management of Metropolitan Manila.

6.6 Ecological Planning for Resilience Management of Metropolitan Manila

The concept of the ecological plan of Metropolitan Manila is to develop a framework that reflects the vulnerability to flood of certain areas while optimizing the function of hydrological and biological processes. The ecological structure provides a guide in which significant biotope types are linked to develop feedback mechanism between habitats while at the same forging an interlinked network of green spaces and water channels. This network provides continuity of the natural processes to proceed with minimal intervention by humans. The viability for resilience management of the ecological structure is enhanced by merging it with the ecological management, in which basic watershed units that surround the ecological structure are proposed with management strategy to buffer the ecological structure and links of the different spaces. Flooded watersheds are considered as part of possible spaces for management intervention while improvements in the general urban condition is also envisioned. The resulting ecological plan forms a comprehensive approach in terms of providing an ecological structure for intervention and also potential for management in micro scale. The merging of the the ecological structure planning and ecological management planning reflects the important of evaluating the environment at both the macro and micro scale, in which strategies cane be proposed that are responsive to the need of the overall network. This landscape ecology planning approach responds to the urgent need for the ecological planning in Metropolitan Manila.

The ecological plan for the resilience management of Metropolitan Manila is an opportunity for the city to be analyzed and evaluated using an ecological approach. The use of biotope in defining the ecological structure is a new concept in the local planning practice, in which information of the geography, soil, hydrology, and landcover are combined to present a more holistic scenario of the condition of Manila. The definition of ecological structure provides opportunities for planners and researchers in terms of collaboration to have an integrated network of green spaces while allowing natural processes to occur. This endeavor allows other professions to conduct multi-disciplinary cooperation to come up with more detailed intervention for the ecological structure. Contributions from the knowledge of professions required in this collaboration include the expertise of landscape architecture, urban planners and designers, foresters, geographers, environmental engineers, architects, and botanists and wildlife experts. On the other hand, the use of watershed in ecological management encourages the replication of this methodology in other setting, using other parameters required to address the challenges of the specific locality. With regard to this the role of policy makers, with coordination with environmental managers and designers, is highly important in coming up with plan of action based on the management intervention. At this scale, spaces within the basic watershed unit can be planned based on the communities' capacity and potential, involving the community participation. At this level, the ecological structure can be replicated with micro-scaled core, corridor, and matrix. Ecological management involves all levels of organization, from the regional environmental managers to community environmental managers.

The framework offers an alternative to conventional planning methodology. Through this, urban planning can develop ecological basis, instead of the idea of conventional planning which depends its decision on spatial organization and arrangement on economic and political consideration and instead use landscape planning's approach in solving problems based on ecological principles and simulating the nature's model in intervening urban problems. The framework is envisioned to offer hope to Metropolitan Manila in managing its resilience using ecological planning.

6.7 Future Research

Ecological planning presents plenty of opportunity in pursuing future researches. The ecological structure can be further discussed at the level of function of each component. Studies on how to preserve and conserve the ecological cores are important especially in areas with deteriorating environmental conditions. On the other hand, corridor studies need to be more emphasized with the continuous fragmentation of different green spaces. Innovative measures need to be proposed to compliment the urbanization and maintaining the ecological integrity of the network. Coastal cities, which face greater risks and threats need to emphasize the edge as part of the network since most of the city vulnerability can be found in this area. The exposure to environmental processes makes it necessary to come up measures to mitigate the impact of environmental disasters alongside urban pressures along this sensitive zone. Aside from analyzing the core-corridor, edge network, the matrix is an important component particularly in highly urbanized areas, such as Metropolitan Manila. which has so much potential in terms of analyzing the often fragmented urban landscapes. Detailed studies on how this can alleviate the effects of climate change and respond to the need to provide more green spaces to the residents of the city.

There remain a lot of areas in which studies about Metropolitan Manila can be explored and adopted. The continuous increase in population and modification of the urban environment need to be monitored and studied. These scenarios are further aggravated by the possible impacts of climate change, which will have dire consequences in coastal cities such as Manila. The Landscape architecture profession can be part in forming regional planning with their exposure to micro scale environment and for having larger perspective about ecological network at the same time. It can also take part in creating community-based solutions, particularly in impoverished communities, which do not have resources and opportunity to ecological planning. Involvement in these endeavors will benefit the greater population and the overall urban environment, creating a more resilient Metropolitan Manila.

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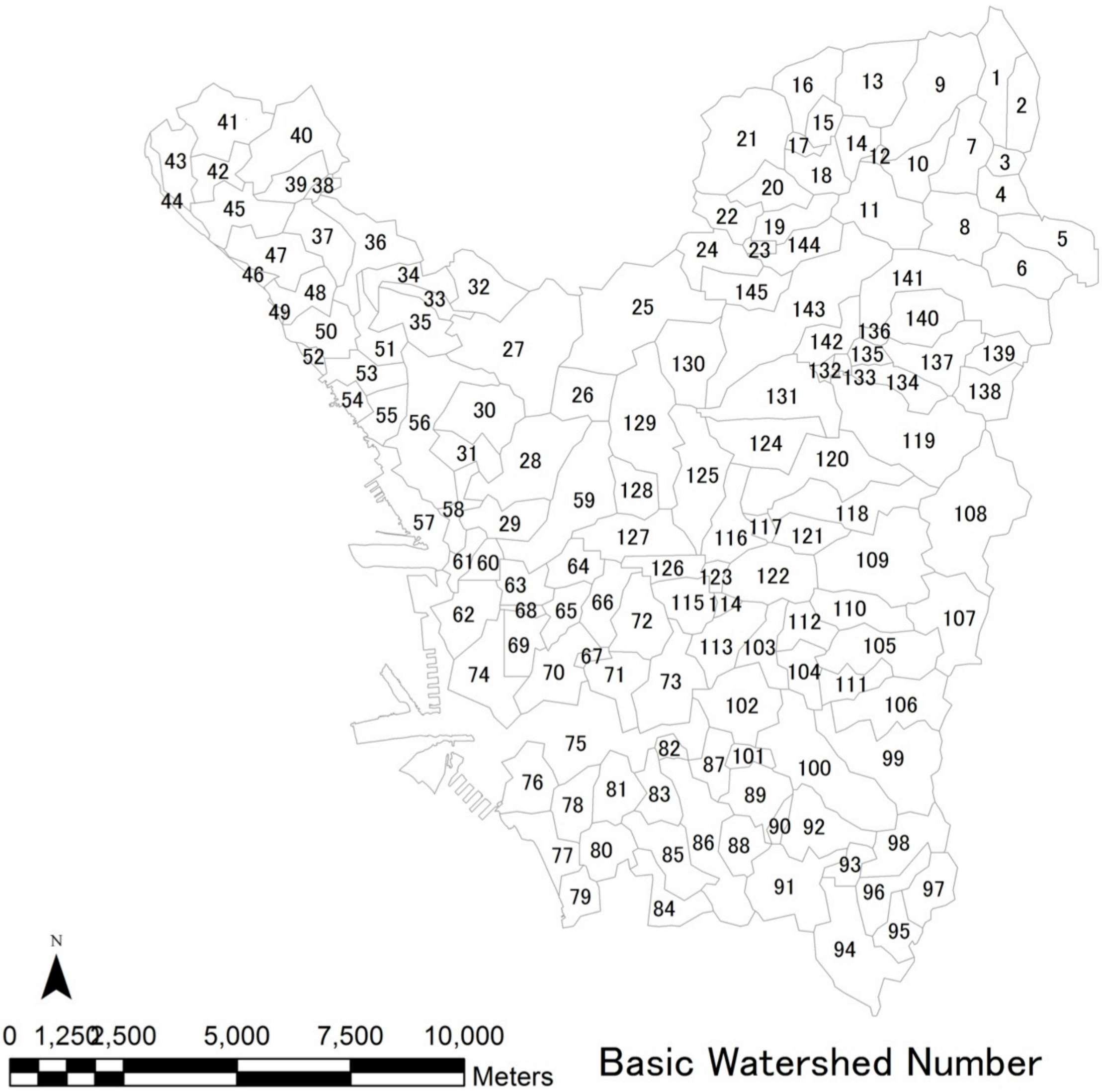
APPENDIX

Appendix 1: Assigned number of basic watershed unit



Appendix 2: Percentage coverage of water surface per basic watershed unit

Watershed Number	Water Cover (%)
1	36
2	79
3	4
4	0
5	0
6	1
7	7
8	1
9	1
10	1
11	0
12	5
13	0
14	3
15	3
16	0
17	4
18	1
19	0
20	1
21	2
22	4
23	4
24	3
25	2
26	1
27	8
28	0
29	5
30	1
31	0
32	15
33	33
34	37
35	64
36	54
37	82
38	83
39	91
40	65
41	100
42	97
43	86
44	31
45	89
46	61
47	95
48	83
49	100
50	29
51	44
52	0
53	13
54	4
55	15
56	17
57	5
58	6
59	1
60	16
61	7
62	4
63	0
64	0
65	0
66	0
67	0
68	1
69	1
70	1
71	1
72	0
73	0
74	3
75	9
76	0
77	0
78	6
79	1
80	1
81	5
82	4
83	8
84	1
85	0
86	6
87	18
88	11
89	5
90	0
91	5
92	0
93	8
94	1
95	0
96	5
97	6
98	2
99	2
100	1
101	7
102	4
103	1
104	2
105	2
106	1
107	0
108	1
109	1
110	2
111	0
112	0
113	7
114	10
115	0
116	2
117	1
118	0
119	1
120	2
121	0
122	1
123	5
124	1
125	2
126	1
127	1
128	0
129	0
130	0
131	2
132	5
133	3
134	0
135	3
136	1
137	1
138	1
139	0
140	0
141	1
142	0
143	2
144	0
145	1

Appendix 3: Percentage coverage of green cover per basic watershed unit

Watershed Number	Green Cover (%)
1	62
2	21
3	92
4	98
5	23
6	12
7	44
8	40
9	5
10	0
11	14
12	0
13	0
14	0
15	0
16	2
17	0
18	4
19	6
20	20
21	14
22	16
23	17
24	9
25	17
26	23
27	11
28	7
29	1
30	9
31	0
32	25
33	30
34	15
35	17
36	12
37	2
38	0
39	1
40	20
41	0
42	3
43	5
44	69
45	10
46	39
47	3
48	9
49	22
50	0
51	6
52	0
53	5
54	13
55	0
56	6
57	6
58	0
59	21
60	0
61	7
62	1
63	0
64	61
65	4
66	1
67	0
68	0
69	3
70	1
71	3
72	0
73	0
74	0
75	7
76	43
77	16
78	3
79	16
80	0
81	6
82	0
83	3
84	2
85	0
86	14
87	1
88	20
89	9
90	0
91	2
92	0
93	3
94	30
95	40
96	0
97	4
98	5
99	37
100	3
101	0
102	2
103	0
104	3
105	5
106	16
107	2
108	29
109	4
110	2
111	6
112	0
113	4
114	0
115	4
116	2
117	0
118	39
119	43
120	34
121	3
122	1
123	0
124	6
125	2
126	0
127	11
128	0
129	19
130	12
131	7
132	0
133	0
134	7
135	0
136	0
137	0
138	28
139	0
140	25
141	13
142	0
143	4
144	8
145	17

Appendix 4: Structural diversity value of each basic watershed unit

Watershed Number	Vegetation Diversity
1	2.22
2	0.64
3	1.25
4	0.11
5	0.08
6	0.14
7	0.76
8	0.11
9	0.16
10	0
11	0.19
12	0
13	0
14	0
15	0
16	0.04
17	0
18	0.07
19	0.18
20	0.35
21	0.28
22	0.31
23	0.35
24	0.05
25	0.3
26	0.34
27	0.22
28	0.02
29	0.02
30	0.14
31	0
32	0.44
33	1.01
34	0.79
35	1.44
36	1.13
37	1.51
38	1.7
39	1.66
40	1.43
41	1.74
42	1.82
43	1.66
44	2.58
45	1.79
46	2.52
47	1.89
48	1.58
49	1.77
50	0.24
51	0.79
52	0
53	0
54	0.25
55	0
56	0.18
57	0.12
58	0
59	0.19
60	0
61	0.15
62	0.02
63	0
64	0.61
65	0.04
66	0
67	0
68	0
69	0.06
70	0.01
71	0.02
72	0
73	0
74	0
75	0.07
76	0.39
77	0.04
78	0.04
79	0.29
80	0
81	0.09
82	0
83	0.07
84	0.03
85	0
86	0.17
87	0.01
88	0.39
89	0.17
90	0
91	0.03
92	0
93	0.1
94	0.45
95	0.46
96	0
97	0.02
98	0.05
99	0.33
100	0.05
101	0
102	0.02
103	0
104	0.09
105	0.06
106	0.14
107	0.02
108	0.58
109	0.02
110	0.05
111	0.07
112	0
113	0.08
114	0
115	0.03
116	0.03
117	0
118	0.17
119	0.92
120	0.63
121	0
122	0.03
123	0
124	0.06
125	0.02
126	0
127	0.12
128	0
129	0.1
130	0.08
131	0.07
132	0
133	0
134	0.11
135	0
136	0
137	0
138	0.57
139	0
140	0.5
141	0.28
142	0
143	0.07
144	0.15
145	0.34

Appendix 5: Percentage coverage of flood per basic watershed unit

Watershed Number	Flood (%)
1	0
2	0
3	0
4	36
5	0
6	0
7	34
8	12
9	0
10	35
11	28
12	5
13	6
14	17
15	30
16	0
17	8
18	41
19	8
20	10
21	4
22	55
23	66
24	4
25	25
26	34
27	90
28	26
29	94
30	51
31	97
32	100
33	100
34	96
35	92
36	98
37	93
38	100
39	93
40	94
41	87
42	91
43	89
44	97
45	96
46	100
47	96
48	93
49	100
50	87
51	95
52	100
53	90
54	100
55	86
56	90
57	97
58	94
59	17
60	91
61	95
62	96
63	62
64	36
65	100
66	63
67	100
68	99
69	99
70	99
71	98
72	19
73	76
74	97
75	92
76	100
77	100
78	94
79	99
80	99
81	95
82	96
83	92
84	62
85	98
86	67
87	82
88	56
89	88
90	64
91	25
92	47
93	20
94	2
95	6
96	17
97	67
98	3
99	9
100	46
101	93
102	68
103	1
104	0
105	0
106	10
107	0
108	21
109	23
110	9
111	0
112	0
113	61
114	90
115	31
116	4
117	0
118	4
119	26
120	2
121	0
122	16
123	77
124	8
125	10
126	25
127	27
128	0
129	0
130	0
131	12
132	19
133	0
134	0
135	0
136	0
137	10
138	8
139	0
140	0
141	0
142	29
143	29
144	2
145	0

Appendix 6: Percentage coverage of informal community (poverty) per basic watershed unit

Watershed Number	Poverty (%)
1	0
2	0
3	4
4	2
5	67
6	45
7	3
8	11
9	0
10	0
11	0
12	0
13	0
14	0
15	0
16	2
17	0
18	0
19	0
20	0
21	3
22	0
23	19
24	2
25	4
26	20
27	7
28	11
29	27
30	11
31	0
32	9
33	2
34	1
35	8
36	16
37	5
38	0
39	1
40	2
41	0
42	0
43	9
44	0
45	1
46	0
47	1
48	3
49	0
50	15
51	16
52	85
53	9
54	17
55	7
56	18
57	10
58	6
59	5
60	9
61	18
62	59
63	29
64	5
65	0
66	0
67	0
68	14
69	8
70	3
71	0
72	0
73	3
74	42
75	15
76	0
77	1
78	0
79	16
80	22
81	16
82	8
83	13
84	0
85	18
86	9
87	17
88	2
89	11
90	15
91	7
92	16
93	6
94	1
95	10
96	20
97	28
98	0
99	0
100	7
101	0
102	8
103	1
104	4
105	2
106	3
107	0
108	5
109	1
110	1
111	3
112	0
113	3
114	7
115	12
116	1
117	0
118	1
119	3
120	7
121	0
122	4
123	25
124	26
125	24
126	3
127	1
128	2
129	14
130	7
131	0
132	0
133	0
134	0
135	0
136	0
137	4
138	18
139	17
140	7
141	1
142	0
143	3
144	11
145	0

Appendix 7: Number of cultural artifact per basic watershed unit

Watershed Number	Culture (number of Cultural Artifact)
1	0
2	0
3	0
4	0
5	0
6	0
7	0
8	0
9	0
10	0
11	0
12	0
13	0
14	0
15	0
16	0
17	0
18	0
19	0
20	0
21	0
22	0
23	0
24	0
25	0
26	0
27	0
28	1
29	0
30	0
31	0
32	0
33	0
34	0
35	0
36	0
37	0
38	0
39	0
40	0
41	0
42	0
43	0
44	0
45	0
46	0
47	0
48	0
49	0
50	0
51	0
52	1
53	1
54	0
55	0
56	0
57	0
58	0
59	0
60	0
61	0
62	0
63	0
64	0
65	0
66	0
67	0
68	0
69	0
70	4
71	0
72	0
73	1
74	1
75	33
76	19
77	7
78	7
79	1
80	1
81	2
82	1
83	0
84	0
85	0
86	3
87	0
88	0
89	0
90	0
91	0
92	0
93	0
94	0
95	0
96	0
97	0
98	0
99	0
100	3
101	0
102	3
103	0
104	0
105	0
106	0
107	0
108	0
109	0
110	0
111	1
112	0
113	1
114	0
115	0
116	0
117	0
118	0
119	0
120	1
121	0
122	0
123	0
124	0
125	1
126	0
127	0
128	0
129	0
130	0
131	0
132	0
133	0
134	0
135	0
136	0
137	0
138	1
139	0
140	0
141	0
142	0
143	0
144	0
145	0

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