University of the Philippines
College of Architecture
Master in Tropical Landscape Architecture

ECOLOGICAL INFRASTRUCTURE PLANNING:

An Alternative Design Approach to Landscape Design in the Angat River Basin

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Abstract

Intensive land use and fragmentation in the Philippines has prompted land use planners to consider a strategic approach to conservation and development that channels urban growth and preserved lands into more suitable locations. Ecological infrastructure planning represents a strategic approach to natural and physical resource conservation that combines the efforts of previous conservation planning methodologies and practices into a systematic framework that encompasses larger and broader planning goals, particularly in watershed areas.

This research argues that ecological infrastructure planning approach is a viable approach to sustain air and water resources and contribute to health and quality of life in watershed areas such as Angat River basin/watershed. Ecological infrastructure planning approach is defined as decision-making and actions on interconnecting networks of waterways, wetlands, woodlands, wildlife habitats and other natural areas; green ways, parks, and other conservation lands; working farms, ranches and forests, and wilderness and other open spaces that support native species, maintain natural ecological process, This paper aims to provide a comprehensive understanding and description of ecological infrastructure, identify different ecological processes that affects landscape planning, apply ecological infrastructure planning process as guide in sustainable development of the urbanizing watershed areas. It hopes to contribute to the application and eventual integration of appropriate ecological infrastructure principles and strategies in local planning and decision- making process in Angat River Basin, focusing on the Angat Afterbay Regulatory Dam area.

Keywords: Ecological Infrastructure, ecology, environment, infrastructure, biodiversity, natural process, security patterns.

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CHAPTER 1. Introduction

Nested within the larger Pampanga River Basin (7,978 km2), the Angat River is the largest river located in the province of Bulacan and lies 40 kilometers north of Manila. The watershed area is bounded by Umiray River in the northeast, the Kanan River in the southeast and the Marikina River in the south. It is approximately 153 kilometres long with a catchment area of 1085 km2 and estimated volume of 8.6 million cubic meters collecting run-off from its main tributaries, Matulid and Maputi rivers (JICA 2002).

According to the DENR's catchment scale , the Angat River is defined as an inter-regional watershed. The Angat River flows westerly beginning in the Sierra Madre mountains through the lowland plains of Bulacan, into the Angat Reservoir and finally into Manila Bay (JICA 2011). Given its size and location, the Angat River Basin encompasses a number of upstream and downstream uses vital to the province of Bulacan, as well as Metro Manila. In addition, the Angat River supplies the diversion waters for Ipo and Bustos dams (Province of Bulacan 2008) and is a significant resource for Bulacan's growing industrial and resource extraction sector (e.g., fishing, quarrying, mining and logging) (PPDO 2010). Unpermitted uses are also significant, including the River's importance to the growing number of informal settlements resulting from slum relocation in Manila and rapid population growth from the northern, more rural areas of the province (PPDO 2010).

Intensive land use and fragmentation in the Philippines has prompted land use planners to consider a strategic approach to conservation and development that channels urban growth and preserved lands into more suitable locations. In the last decades of 20th century, with land use change and landscape fragmentation, nature conservation has changed from site protection to conservation of ecological networks. Landscape ecological principles have also been integrated into nature conservation and landscape planning. New initiatives, including ecological networks, greenways, green infrastructure and ecological infrastructure are emerging. They all emphasize the concept of spatial connectivity, of an integrated functional network, managed for multiple purposes, linking rural and urban environments (Walmsley, 2006; Ryan, 2004; Benedict, McMahon, 2001; Jongman, et al.,2004). Ecological infrastructure

planning represents a strategic approach to natural and physical resource conservation that combines the efforts of previous conservation planning methodologies and practices into a systematic framework that encompasses larger and broader planning goals, particularly in watershed areas.

In the study, ecological infrastructure planning approach is defined as decision-making and actions on interconnecting networks of waterways, wetlands, woodlands, wildlife habitats and other natural areas; green ways, parks, and other conservation lands; working farms, ranches and forests, and wilderness and other open spaces that support native species, maintain natural ecological process.

1.1. Project Objectives and Research Problems

This paper aims to do the following:

1. Identify different ecological processes that affect landscape planning in river basin.

1. Provide a comprehensive understanding and description of ecological infrastructure design approaches in river basin areas.
2. Apply ecological infrastructure design approaches and planning process as guide in sustainable development of urbanizing watershed areas such as Angat; and
3. Contribute to the integration of appropriate ecological infrastructure principles and strategies in local planning and decision- making process in Angat River Basin.

Statement of the Problem

Angat River and Watershed system display typical “tragedy of the commons” problem” where landscape design is often neglected because of its public space nature. Angat River also faces greatest challenges on management of freshwater. As the population increases and people resort to unsustainable development activities, pollution and environmental degradation take place, bringing down the quality and quantity of available

freshwater. All these are expected to have their impact on health and economic and social status of people.

Another factor that contributes to freshwater degradation is the effects of climate change . Climate change will directly impact the availability and quality of water resources, as seen in the aftermath of drought and typhoon events of 2010, As projected by the Manila Observatory and the Department of Environment and Natural Resources (DENR), Central Luzon is at high risk for climate disasters such as increased typhoons, droughts caused by El Nino and increases in temperature (Jose and Cruz 1999; Manila Observatory and DENR 2005). These in turn will manifest in changes in hydrological and crop water regimes, shortages in reservoir inflow (Jose and Cruz 1999), deterioration of groundwater quality due to saltwater intrusion, changes in streamflow and groundwater recharge and the sedimentation of reservoirs (Rincon and Virtucio 2008:17). In light of the projected increase in population, industrialization and water demand for both Bulacan and Metro Manila in the next decade, these impacts are of grave concern given the current stress of competing uses already apparent in the Angat Reservoir, particularly the Angat Afterbay Regulatory Dam area in the municipality of Bustos, Bulacan .

At present, one of the most pressing issues in the area of Angat River basin are related to the use of land. Perfect examples includes indiscriminate agricultural conversion, dumping of solid and liquid wastes on waterways, encroachment on banks by industries and settlements and illegal fish pen and quarrying.

In the light of the above statement of the research problem, this study will address the following primary research question: Given the particular ecological characteristics of Angat Afterbay Regulatory Dam in Angat River basin and watershed ecosystem, how can an ecological infrastructure planning approach be effective in addressing existing ecological risks and sustainability of the watershed?

It will also address the following secondary research questions:

1. What are the existing vulnerable infrastructure designs in the Angat river basin.
2. What are the current ecological risks affecting the Angat river basin and how does it affect the current ecosystem in the area?
3. What specific ecological infrastructure development proposals are appropriate for the future development in Angat river basin/watershed?

1.2. Study Relevance and Rationale

The research will benefit not just the profession of landscape architecture but also Bulacan local government units (provincial and municipal) and their respective planning agencies through extensive and in depth study of the use of an ecological approach to the existing infrastructure design in the planning proces. This will also be helpful for other researchers, students and other professionals involve in design and planning environmental studies and natural resource management, particularly those interested in alternative landscape design in watersheds and river basin areas.

1.2.1 Assumptions

This research is informed by the following assumptions. Like the urban infrastructure providing social and economic services (such as transportation, gas, sewage, etc.) that support the potential urban growth, the Ecological Infrastructure (EI) safeguards ecological services, protecting cultural heritages, providing visual and recreational experiences.

Ecological infrastructure planning approach provide a viable approach to sustain air and water resources and contribute to health and quality of life in watershed areas such as Angat River basin/watershed.

1.2.2. Scope and Limitations

The study will focus on ecological infrastructure in urbanizing watershed such as Angat River Basin, by studying various ecological systems within the areas. It is not interested in analyzing processes, but only on the application of principles involve in ecological infrastructure planning.

1.2.3. Hypothesis or Key Argument of the Research

Urban development creates ecological problems and other gaps that the field of urban planning failed to address. Thus, the use of the Ecological Infrastructure approach will be beneficial in addressing these gaps. First, the research will conduct a data gap analysis to identify the relevant biophysical, infrastructure and socioeconomic information in and around Angat watershed. Then an ecological infrastructure planning approach will be applied to fill in the gaps created by urban development through its application in the Angat River Watershed. In other words, it is argued that the ecological infrastructure planning approach provides a positive alternative design to urban form and growth patterns and safeguards a sustainable ecosystem essential for the livability of the area and the health of its people.

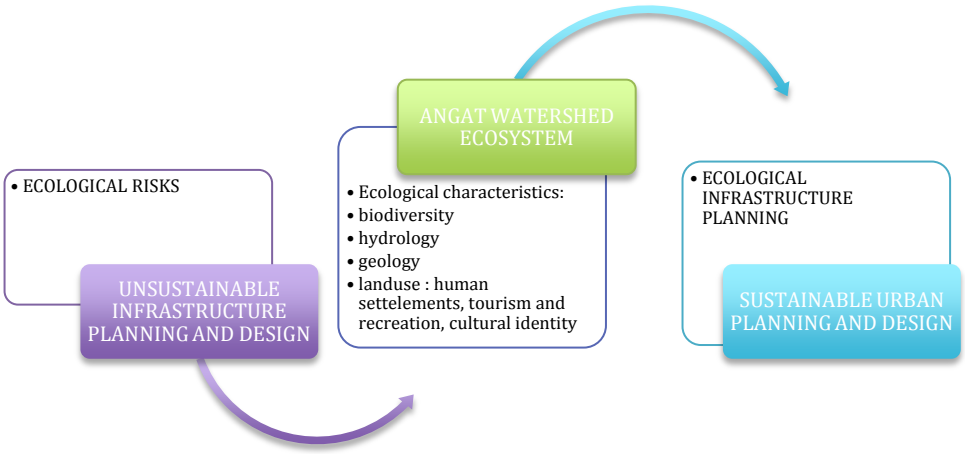
1.3. Conceptual-Analytical Framework

Sustainable urban planning and design which is within the purview of environmental planning proceeds from the development of goals and objectives, resulting from the inventory and analysis of environmental resources including their ecological characteristics. The goals and objectives are directed at efforts and activities (or plans) towards achievement of sustainable development. The process is characterized by optimum enhancement or conservation, protection, preservation, improvement and environmental rehabilitation of a particular resource. In practice, one of its

good features has been the stakeholders' engagement where socio-cultural dimensions are given importance in the process.

The strategy as well as advocacies for more sustainable planning and design has been furthermore informed by the prevailing mode of thinking in environmental resource use and planning in the last decades or so. Maximizing or exploiting the resource consciously or un-consciously, has been the mode; unsustainable infrastructure design therefore becomes the rule rather than the exception. Designs are more often than not un-systemic, promote curative components rather than preventive and are not impact-oriented. Hence, environmental risks are developed or increased.

At a micro-setting, a sustainable urban planning and design can be initiated or pursued. However, analyses of various components are required to undertake it. Initially, a trans-boundary assessment of the environmental processes is carried out within the setting, including among others, land use, human settlement, recreation, etc. Trans-boundary assessment is a unique feature using watershed approach as resources are not unique to a single political or geographic boundary. Although there is site-specific planning involved, it is consciously undertaken in consideration of the larger scale or context. Further, new technologies that will be introduced in the design are considered or evaluated from the ecological, natural resource, technical, social, economic and institutional standpoints.



Definition of Terms

- **Ecological Infrastructure (EI)-** Open space in urbanised areas, including all undeveloped sites such as parks, riparian areas, greenways, and urban forests, helps to create healthy and sustainable urban environments. These sites perform numerous functions similar to those found in natural ecosystems. An open space network provides habitat for urban wildlife, offers recreational and alternative transportation opportunities for urban dwellers, and facilitates storm water, infiltration which is important in ground water recharge and flood prevention (Girling and Helphand 1997). The open space network can provide a natural alternative to the traditional infrastructure system of storm sewers, treatment plants, and concrete structures. This approach to open space is known as "ecological infrastructure."
- **Security pattern (SP)**- an approach to identify and establish EI, which is based on the theory and methodology of landscape ecology and also the relationship between landscape process and pattern.
- **Ecology-** is the scientific study of the relations that living organisms have with respect to each other and their natural environment.
- **Ecosystem-** is defined by the network of interactions among organisms, and between organisms and their environment.
- **Ecosystem services-** services provided by the ecosystem like water delivery , water purifications, filtration and storage.
- **Ecosystem Management-**is a process that aims to conserve major ecological services and restore natural resources while meeting the socioeconomic, political and cultural needs of current and future generations
- **Biodiversity-** is the degree of variation of life forms within a given ecosystem, biome, or an entire planet.
- **Biophysical-** a good understanding of the biophysical characteristics of the landscape and its hydrology is required to

identify where natural environments could be restored and maintained to provide important services and benefits to local populations.

- **Infrastructure-** the location and condition of human built environments can assist with identifying opportunities for ecological investments.
- **Socioeconomic-** demographic and economic information could provide insights for the suitability of ecological infrastructure within a particular context.

1.4. Review of related literature

This section provides the framework of the present study. Articles cited here focus on emerging paradigm and concepts that influence sustainable design in landscape architecture.

Introduction

Ecosystems are vulnerable to the negative impacts of various factors particularly the human activities and the increasing negative man-environment interactions. For purposes of common understanding, fragile or vulnerable ecosystems are those systems that face the risk of losing their stability due to an external impact. Studies have shown that although there are ecosystems that are more vulnerable than the others, the richest ecosystems like the wetlands, coastal areas and tropical forests are the most vulnerable. In recent times, the one factor that has put these ecosystems and other resources (water included) in increased vulnerability is climate change. Climate change has negatively impacted freshwater availability in some regions of the world. In fact, in a recent report by the Intergovernmental Panel on Climate Change (IPCC), in Asia, freshwater availability is projected to decrease in Central, South, East and Southeast Asia by the 2050s; coastal areas will be at risk due to increased flooding; death rate from disease associated with floods and

droughts expected to rise in some regions due to global changes in climate. (Source: IPCC 2007, Summary for Policymakers, in Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press, Camb)

Watershed, reservoirs and watershed management

Watersheds are those land areas that that deliver run-off, sediment, and water soluble substances to a major river and its tributaries. Reservoirs, on the other hand, are those areas that are large and deep, human-created body of standing fresh water often built behind a dam. Darghouth and others (2008) of the World Bank defined a watershed as the area that drains to a common outlet. It is the basic building block for land and water planning. However, this definition overlooked the people or communities and their socio-economic activities, which according to Thapa (2001) is "the prime matter of concern of watershed management endeavours". A more complete definition of watershed, according to him, would include both a biophysical and socio-economic unit comprising all natural resources, people and their socio-economic activities within the confines of the drainage divide.

Darghouth and others further wrote that:

> "Degradation of watersheds in recent decades has brought the long-term reduction of the quantity and quality of land and water resources, as shown in the cases of Lesotho and Morocco. Changes in watersheds have resulted from a range of natural and anthropogenic factors, including natural soil erosion, changes in farming systems, over abstraction of water, overgrazing, deforestation, and pollution. The combination of environmental costs and socioeconomic impacts has prompted investment in watershed management in many developing countries."

Traditionally, development plans for communities are prepared for administrative units since they are formally recognized as planning areas whose boundaries do not follow watershed boundaries. Data required for planning are collected for administrative units. Watershed is however deemed the best planning unit. Therefore, planning and design and management of watershed require adjustments in political boundaries and in the information base.

Cognizant of their roles in addressing or mitigating the cumulative effects of climate change in vulnerable ecosystems and other natural resources as the watershed, various professions and disciplines have endeavoured to shifting their theoretical perspective as well as practice to adapting landscapes and places to the changes and in managing the built and natural environment. Landscape architecture, among other disciplines, has taken the challenge about the negative impacts of global warming, where design and planning are more towards sustainability, i.e., sustainable use of resources and development of sustainable communities, among others.

From non-sustainable to sustainable landscape practices

Environmentalists and planners are in agreement that traditional landscape practices have been non-sustainable. Literature have presented non-sustainable practices such as soil contamination, air and water contamination, persistence of toxic compounds in the environment, non-sustainable consumption of natural resources, (http://en.wikipedia.org/wiki/Greenhouse_gas_emissions and invasive species.) Reported effects of non-sustainable practices include severe degradation of the surrounding ecosystem; harm to human health, especially in the case of degraded drinking water supplies; harm to flora and fauna and their habitats; sedimentation of surface waters caused by storm water runoff; chemical pollutants in drinking water caused by pesticide runoff; health problems caused by toxic fertilizers, toxic pesticides, improper use, handling, storage and disposal of pesticides; air and noise pollution caused by landscape

equipment; invasion of wild lands by non-native weeds and insect pests; and over-use of limited natural resources.

Traditional approaches to landscape design and planning furthermore are directed at constructing designs that do not consider critical elements in environmental planning. Data suggest that in 2010, nearly two-thirds of the globe's ecosystems were considered degraded as a result of damage, mismanagement and a failure to invest and reinvest in their productivity, health and sustainability.

The continuous adverse effects of non-sustainable practices to people and communities has led to re-thinking of new paradigms and search for new orientation. The concept of sustainability was coined and it was first used in the 1980s in IUCN World Conservation Strategy (Botequilha and Ahern, 2002). The UN FAO approves that the concept of sustainability is the "handling and conservation of natural resources and the orientation of the technological and institutional change so as to ensure the continuous satisfaction of the human needs for present and future generations." This new sustainable paradigm includes the systems approach, where a particular system is able to or has the capacity to maintain and support life and persist as a system (ibid, 2002). Hence, the concept of sustainability is relevant at a local scale.

Leitao and Ahern further wrote that:

"Many scientists believed that promoting sustainability is the overarching goal of landscape planning including planning for conservation, protection and appropriate use of land and natural resources…To some, subjectivity is the major objective of any planning. Sustainable ecologically-based approaches to planning and management are desirable, and their application is widely advocated".

Sustainable landscape architecture is considered a category of sustainable design and energy-efficient landscaping. It is concerned with the

planning and design of outdoor space. Design techniques include planting trees for shading and protecting structures from wind, using local materials, on-site composting and chipping to reduce green waste hauling, and also may involve using drought-resistant plantings, etc. Practitioners in sustainable landscaping are now taking a holistic approach needed to create environmentally sustainable places where people want to live and work. Endeavours to pursue sustainable planning and design have taken centre stage, as in recent years, unstable planning and design has increased the state of vulnerability of some ecosystems.

A sustainable landscape is designed to be both attractive and in balance with the local climate and environment and it requires minimal resource inputs. Thus, the design is considered “functional, cost-efficient, visually pleasing, environmentally friendly and maintainable", (CSUE). As part of the concept called sustainable development, sustainable landscape pays close attention to the preservation of limited and costly resources, reducing waste and preventing air, water and soil pollution. Also, compost, fertilization, grass cycling, pest control measures that avoid or minimize the use of chemicals, integrated pest management, using the right plant in the right place, appropriate use of turf, irrigation efficiency and xeriscaping or water-wise gardening are all components of sustainable landscaping. Sustainable landscaping primarily encompasses various practices that have developed in response to environmental issues. These practices are used in every phase of landscaping, including design, construction, implementation and management of residential and commercial landscapes.

Landscape ecology for watersheds

Landscape ecology takes the spatial and temporal perspective on land use, biodiversity and the strategic planning of ecosystem services. It involves the study of landscape patterns, the interactions among the elements of these

patterns, and how these patterns and interactions change over time. In addition, landscape ecology involves the application of these principles in the formulation and solving of real-world problems. As a discipline, landscape ecology is distinguished from other disciplines by its focus on: 1) spatial heterogeneity, 2) broader spatial extents than those traditionally studied in ecology, and 3) the role of humans in creating and affecting landscape patterns and process. (McGarigal, 2012)

The focus of landscape ecology is sustainable landscape planning. Planning professionals are increasingly required to estimate the social, economic and environmental impact of development on flooding, climate change and carbon consumption.

The Economic Rationale for Restoring our Degraded Ecosystems

Natural capital is the "ecological infrastructure" providing the many goods and services that sustain all life. It is estimated that ecosystems deliver essential services worth between US$21-72 trillion a year as compared to the 2008 World Gross National Income of US$58 trillion. Our global stocks of natural capital are being drastically depleted and are in urgent need of restoration. In 2010, nearly two-thirds of the globe's ecosystems were considered degraded as a result of damage, mismanagement and a failure to invest and reinvest in their productivity, health and sustainability (Nellemann, C., E. Corcoran (eds). 2010).

The Millennium Ecosystem Assessment (MA 2005) clearly demonstrated that ecosystems provide myriad benefits to human society, while offering an equally compelling social imperative for restoration: maintaining intact and resilient ecosystems enhances human health and well-being.

The Economics of Ecosystems and Biodiversity (TEEB 2010) study concluded that restoration activities could bring high rates of return across a range of biomes, particularly when the value of nature's goods and services are properly accounted for.

Whether restoring a watershed to provide clean drinking water for

large urban areas or restoring mangroves for fisheries and storm protection, societies and governments can save billions of dollars by helping nature do what it does best. Investing in our ecological infrastructure is a cost-effective strategy for achieving national and global objectives, such as increased resilience to climate change, reduced risk from natural disaster, and improved food and water security - all of which contribute directly to poverty alleviation, sustainable livelihoods and job creation.

A new economic approach that prioritizes investment in our ecological infrastructure is gaining increasing attention, giving real substance to that often vague and misleading phrase, the "Green Economy". A critical first step is the development of legislative and regulatory frameworks as well as innovative finance mechanisms and other incentives to protect and restore our natural capital. This new approach to investment must also consider appropriate scale and time horizons so that the values of, and trade-offs between, ecosystem services are used wisely to inform decision-making in both the public and private sectors.

Mainstreaming ecosystem restoration requires the assimilation of biodiversity and ecosystem services values into decision-making processes governing all economic activities that manage and use natural capital. A new economic approach to investing in our ecological infrastructure by restoring degraded ecosystems will generate timely stimulus recognizing that:

- **Human health and economic prosperity** ultimately depend on natural capital and its biodiversity values, which underpin ecosystem functioning and the delivery of goods and services.
- Investing in our ecological infrastructure makes **economic sense in terms of cost-effectiveness and rates of return**, particularly when we consider the full range of costs and benefits at all spatial and temporal scales.
- It is usually much **cheaper to avoid degradation** than to pay for ecosystem restoration especially when species and their assemblages and functions cannot be fully recovered. Investments in ecosystem restoration can provide **multiple co-benefits to society**, ranging from improved livelihoods and human health, increased food and water security to enhanced carbon stocks and socio-ecological resilience.
- Protecting and restoring natural capital also has an important role to play in

disaster mitigation and adaptation, helping to reduce the risks of extreme events and their consequences when they do occur.

- As long as ecosystem goods and services continue to be treated as public goods, **direct government investment and strong public-private partnerships** are indispensable to this new economic approach.

Integrated water basin management

The following are illustrative cases of sustainable watershed planning and design in the US which are reported by Sangameswaran and Rowan (2009).

Restoration Design of Herrick Hollow Creek, NY

This case study involved detailed fluvial geomorphologic and stream channel and floodplain engineering to restore Herrick Hollow Creek at the Richardson Hill Road Landfill Superfund Site. Herrick Hollow Creek, located in the Catskill Mountains in upstate New York, discharges into the Delaware River and Cannonsville Reservoir operated by the New York City Department of Environmental Protection (NYCDEP).

Previous stream restoration measures failed multiple times and much of the fill material placed in the stream corridor had been washed downstream into the municipal drinking water reservoir. The situation was very tense due to the need for the NYCDEP to comply with US Environmental Protection Agency (USEPA) regulations limiting turbidity in the reservoir, and the NY Attorney General's office was involved. We adopted a three phase approach including (a) immediate short-term field engineered remedies to reduce sediment mobility and stream channel incision; (b) stakeholder meeting to establish restoration goals and objectives; and (c) stream restoration design based on site-specific hydrologic data, stream hydraulic data, combined with data from multiple geomorphically similar "reference reaches" known to perform the prioritized habitat functions. After ecological performance was clearly linked to earth science parameters such as channel geometry and base flow, full geotechnical and hydraulic engineering analysis was conducted to validate and refine the treatment designs.

The interdisciplinary design and restoration master planning approach brought a level of stakeholder communication and engineering rigor to the project which served to maintain constructive interaction even in the face of severe weather and construction delays. Integrating the hydrology, fluvial geomorphology and floodplain ecological aspects received stakeholder support, and the consensus process allowed clear communication when change was needed. Supervision during various phases of construction, follow-up monitoring of the performance of the restoration and all work was conducted under the close scrutiny of multiple agencies was essential to ensure project success.

Mill Creek River Restoration, OH

The City of Cincinnati, Office of Environmental Management was looking for a cost-effective, environmentally sensitive bank stabilization plan for a portion of Mill Creek to halt erosion threatening to uncover waste materials contained in the Center Hill Landfill. The eroding bank was approximately 27 feet high and 600 feet long with clay strata overlain by highly permeable, loosely compacted sandy and gravelly soils mixed with landfill materials creating a zone of intense seepage at the interface. Both leachate and solid waste were entering the river due to on-going bank erosion of this highly urbanized river. The site is immediately above a concrete lined flood control channel and within the limits of a US Army Corps of Engineers flood control project area. A detailed field investigation of site geomorphic and hydrologic parameters, existing geotechnical data was performed.

The next steps were to identify appropriate measures, provide construction documents, and overseeing the bidding and construction process. Bioengineering treatments were selected because of their ability to aid stabilization, assist in leachate extraction, and enhance wildlife habitat, water quality, and aesthetics. The bioengineering design featured the use of live poles integrated into a riprap toe, brush layers, geogrid lifts, live staking, and a brush fascine. An innovative design for incorporating vegetation into a leachate collection system used phreatophytic (highly water consuming)

species to intercept and extract leachate from a gravel collection trench. Vegetation and geosynthetic materials function to stabilize the over-steepened bank, with trees and shrubs adding shade along the stream corridor. The chosen treatments were highly resilient to flashy peak flows, urban floatable debris, and potential future hydrologic impacts due to increasing development within the watershed.

The regulatory community, local citizens groups, and municipal engineers were all extremely pleased with the design and its performance. Additionally, our design offered a savings of 30% over a different bioengineering design by others, while being favored for ecological integrity and stability. Accurate cost estimating and thorough construction supervision helped achieve the financial goals. After more than five years of highly effective performance, the community opted to expand the treated area to cover two miles of riverbank upstream and downstream of this site, incorporating a public greenway to allow recreational access to what has become a stable, beautiful, and biologically diverse riparian corridor.

Alewife Brook Restoration - Cambridge Storm water Wetland

As part of a massive sewer segregation project designed to eliminate Combined

Sewer Overflows (CSO's) to the Alewife Brook as part of the Boston Harbor Cleanup, the City of Cambridge needed to construct a stormwater management basin. The most feasible alternative was to construct the basin on land owned by the state, an idea at first rejected by the owner agency. Located within the 100-year floodplain in the Alewife Brook Reservation, an urban wild, the site currently serves as habitat for a diverse wildlife population and as a recreational area laced with informal hiking and bike trails.

The challenge was to design a constructed wetland and detention basin that met the technical requirements for detention and treatment while simultaneously meeting the habitat and recreational functions envisioned for the area in the Massachusetts Department of Conservation and Recreation (DCR) master plan for the Alewife Brook Reservation. The solution was to design a stormwater management facility as a multifunctional wetland that

serves the combined objectives of stormwater detention, water quality improvement, wildlife habitat enhancement, and recreation/education.

The tasks included formulation of alternatives, participation in public meetings and outreach, Massachusetts Environmental Policy Act (MEPA) and other permitting support, preparation of responses to comments, completion of a wildlife inventory, and bioengineered design of the detention basin as a stormwater wetland park. The stormwater wetland was designed to minimize flooding of the Alewife Brook by retaining up to 10.3 acre-feet of stormwater to shave peak flows to the Alewife Brook during major storm events. The stormwater wetland provides treatment of the stormwater "first flush" via sediment removal, biological filtration, and thermal regulation while providing recreational trails, enhanced wildlife habitat and wetlands, and an educational feature promoting stormwater management best practices. A new entrance to the reservation was designed to improve public access and the park's amenities including an amphitheater/outdoor classroom, boardwalks, overlooks, benches, and interpretive signage highlighting the historical, ecological, and hydrological features of the site.

This project was described in the Boston Globe as "a far cry from the traditional treatment prescribed by engineers". The stormwater wetland incorporated both conventional and bioengineered structures designed with a natural "look and feel" that won praise from stakeholder groups. The wetland increases base flows in the brook and enhances the health of adjacent natural wetlands via infiltration for groundwater recharge.

In addition, the stormwater management park incorporates a site layout and plant species selected for synergistic relationships with existing ecological patterns and natural processes that provide a significant improvement over the existing degraded habitat. The City was delighted to save more than $15 million dollars compared to the alternatives, and the DCR was pleased to have a cost-sharing partner to implement elements of its Master Plan, a win for those parties as well as the natural systems and local communities.

The cases presented here illustrate that using various elements of the hydrological cycle, understanding the ecology of a system and an

engineering design using natural systems and materials are essential to retaining and enhancing ecological functions, which is the key to sustainable watershed master planning.

1.5. Research Methodology

The study will primarily apply desk research methods, reviewing and analyzing different base maps of the selected study site. Review related literatures and case studies on ecological infrastructure. Study the process involve in ecological infrastructure and projects implementing this process.

1. Primary Research:

- Conduct individual interviews with selected resource persons (mayors, baranggay captains and residents within the areas), Bulacan Provincial Planning Development Office (PPDO) officials, urban planners and environmentalists (BENRO and DENR) will be conducted.

- Conducted field investigations to explain the geographical character of the research site .
- Conduct direct observation of activities and problems occurring in research site.

2. Processing, analysis and interpretation

- Identify sources, points of origins for different process and identify landscape patterns: properties on a general surface model of flows and processes.
- Divide the research site into four strategic landscape points such as buffer zone, inter-core linkages, radiating routes and strategic points.
- Analyze the data obtained from the research site to define the specific security patterns commonly includes strategic landscape points and positions

- Integrate the analysis with the existing policies, plans and programs of the government.

3. Conclusion and Recommendations
   - Make specific recommendations and proposals appropriate for the research site.

CHAPTER 2. VARIOUS TRADITONAL AND ALTERNATIVE ECOLOGICAL APPROACHES TO PLANNING: PRINCIPLES AND ADVANTAGES AND OPPORTUNITIES

2.1. Traditional Approaches

2.1.a Land use planning

The current trend used in planning is based on the principles of land-use planning. Land-use planning is an overall or special arrangement on land-use in a certain range of time and space, according to land resources land suitability and demands of economic and social development **(**Zheng Weiyuan,2000). Nowadays, the demand of construction land is increasing continuously because of the rapid urbanization; conflicts between huge population and limited land resources become increasingly prominent. Meanwhile, the land-use planning is no longer keeping eyes on "serving for social and economic development" and "protecting arable land". It must be changed to promote coordinately the development of population, resources, environment, and social economy. Land-use planning must shoulder the social responsibility of solving the conflicts on the spatial strategy between social development, resource utilization and ecological protection.

The existing land-use planning can't meet the demand of sustainable land using and higher requirement on ecological protection in the new era. According to Qing, et. al., all conventional land-use planning is the direct purpose of land-use. Although ecological functions was started to be

considered recently, there is still no systematic way to reflect the concept of nature services in the land-use planning. Land-use planning, as its name said, still focuses on land utilization instead of land protection. The conventional land-use planning cares more about indicators, quantities and zoning. Actually, land is an organic system, which is structural, rather than homogeneous or medley. It even has its own pulse and flow. Therefore, we must establish the meridians of land.

2.1.b Landscape Planning

Landscape planning can be defined as the practice of planning for the sustainable use of physical, biological, and cultural resources. It seeks the protection of unique, scarce, and rare resources, avoidance of hazards, protection of limited resources for controlled use, and accommodating development in appropriate locations (Fabos 1985).

Landscape planning is most fundamentally linked with the spatial dimension, and predominantly at the scale of the landscape. Landscape plans are actually hypotheses of how a proposed plan (i.e., landscape structure) will influence landscape processes. The landscape plan offers specific recommendations regarding, land-use allocation, designation of levels of protection and management, and setting a strategy to undo' negative changes in the landscape from the past.

Landscape planning is an activity that promotes the wise and sustainable use ofresources, hazard avoidance, and management of the process(es) of landscape change. It determines the capacity and limits of natural resources and the effects of chances. Landscape planning, has been described as "the process of choice based on knowledge about people and land" (Steiner 1991, p. 520). McHarg defines ecological planning as "that process whereby a region is understood as a biophysical and social process comprehensible through the operation of laws and time.

Landscape planning, "cuts across" numerous planning sectors, and is performed at multiple scales and governmental levels (Kiemstedt 1994). As a professional activity, it has roots in landscape architecture and physical planning (Fabos 1985). As these definitions and statements suggest, landscape planning is

an inherently interdisciplinary field with biological, physical, and social science components, as well as strong connections with the creative traditions of landscape architecture.

Ndubisi (1997) defines two fundamental theories in landscape planning: substantive and procedural. Substantive theories originate in the natural and social sciences and provide descriptive and predictive information. Procedural theories concern the methodology of planning. The interaction of the two theoretical types produces a tension that both challenges and rewards interdisciplinary research. Hersperger (1994) suggests that in true landscape ecological planning, the distinction between substantive and procedural theories might blur.

2. 2. Alternative Ecological Approaches

2.2.a. Ecological infrastructure

Open space in urbanized areas, including all undeveloped sites such as parks, riparian areas, greenways, and urban forests, helps to create healthy and sustainable urban environments. These sites perform numerous functions similar to those found in natural ecosystems. An open space network provides habitat for urban wildlife, offers recreational and alternative transportation opportunities for urban dwellers, and facilitates storm water infiltration which is important in ground water recharge and flood prevention (Girling and Helphand 1997). The open space network can provide a natural alternative to the traditional infrastructure system of storm sewers, treatment plants, and concrete structures. This approach to open space is known as "ecological infrastructure."

Ecological infrastructure promotes connectivity, which supports a multitude of ecological and cultural processes. Therefore, maintaining and supporting these processes (e.g. species habitat and movement, hydrology, soil stabilization, recreation) through greenways, promotes a sustainable landscape condition.(Ahern 2002)

An important component of ecological infrastructure is the river system. River systems can be considered as ‘interconnected transport systems’. Rivers and riparian corridors represent potential wildlife corridors, "'wetland multipliers of

ecosystem integrity," scenic resources, recreational facilities close to home, greenway links between neighborhoods and parks, and are an important element in the purification and conveyance of storm runoff (Ferguson 1991). The quality of a river depends on the interaction of many different physical and biological processes, and each is influenced by the degree of urbanization present in the surrounding watershed. Urbanization generally leads to an increase in impervious cover in a watershed, impacting the morphology, water quality, and biodiversity of river systems (Schueler 1995). The challenge for local government units is to preserve riparian corridors, promote sustainable design, require alternative stormwater management techniques, and undertake watershed planning in order to protect local streams.

Rivers are open systems in which energy and chemical and biological matters are exchanged with an external environment (Knighton, 1984). Within drainage basins numerous exchanges between different water stores (vegetation, soil, groundwater, etc) take place and water will often follow many pathways before it reaches the channel system. The erosional, transportational and depositional roles played by river systems create an enormous variety of river network, channel forms and wetland environments. These ecological systems are sustained by the supply of water and nutrients maintained by river flows. The hydrological, geochemical, and ecological continuum in river basins is such that the character and behavior of a river at any particular point is dependent upon the interaction of upstream controls including climate, geology and land use. Similarly, downstream controls, such as base level, also have a controlling influence.

Angat River

source: author's documentation

2.1.2 Comparing built and ecological infrastructure

Water scarcity, projected climate change impacts, the worsening global food crisis and the global financial crisis are powerful drivers for major investments in water and other built infrastructure. Many people now have direct and regular access to a variety of socio-economic services that this type of infrastructure provides. Water, energy, transport and communications infrastructure (Table 2.1) is used by so many of us so often that we consider them to be essential (Australian Government Treasury 2004).

Table 2.1. Built infrastructure, associated systems, and the services and benefits they provide.

Infrastructure*	Systems	Services	Benefits
Water	Dams, channels, treatment plants	Water for urban, agricultural, Industrial use	Sufficient quality water; Flood mitigation
Energy	Power stations, power lines	Generation, storage, transmission of energy	Energy for construction, maintenance & equipment operation
Transport	Road, rail, terminals ports	Dispatch, delivery, receipt of goods & services	Access to goods, services and travel
Communication	Transmitters, cables, receivers, satellites	Information storage, transport and delivery	Connecting individuals, organizations across space and

			time

** Also includes health, education, industry, defense and other built infrastructure*

Investing in built infrastructure provides increased capacity for the delivery of various services required by growing populations. In addition, built infrastructure investments are used to stimulate rapid economic growth, and billions of dollars are now being invested by a number of countries in a wide range of public and private infrastructure developments as part of their response to the global financial crisis. As with built infrastructure, we note that rivers, soils, aquifers, wetlands and other landscape elements are key components of an 'ecological infrastructure' that supports the continuing delivery of ecosystem services required by natural systems for their survival, and mankind for human well-being (Table 2.2).

Table 2. 2 Ecological infrastructure, ecosystems, and the services and benefits they provide.

Ecological Infrastructure*	Ecosystems	Ecosystem Services	Ecosystem Benefits
Rivers	River ecosystems	Water delivery within and between elements (and ecosystems)	Provides water, sediment, nutrients to floodplains, wetlands, aquifers, estuaries; and habitat

Aquifers	Aquifer ecosystems	Water capture, storage, purification, dilution (underground)	Soil moisture, stream flow, wetlands (base flows) in dry seasons
Wetlands	Wetland ecosystems	Water storage, filtration and purification	Inception & dilution of non beneficial organic & inorganic materials; habitat
Soils	Soil ecosystems	Support medium, storage and supply of water & nutrient for plants; waste treatment/removal	Maintain (& increase) soil biological and vegetation productivity & biodiversity)

**Also includes catchments, forests, rangelands, vegetation, floodplains, estuaries etc.*

Source:

Ecological infrastructure as an underlying framework that includes landscape components, ecosystems, their services and the interconnections within and between them. 'The key aspect of this concept of "an underlying framework" is that of connectivity (Bristow,2009). Fig 1

Just as human infrastructure is purposefully interconnected for maximum service effectiveness--like hospitals, roads and communications infrastructure-ecological infrastructure also requires a certain type and level of connectivity to sustain the environmental services that all living organisms and society depend on; he says. Dr Bristow points out that while rivers, forests and wetlands are easily recognised, the ecological infrastructure is not visible in its entirety because many of the crucial interconnections are not obvious, or unknown.

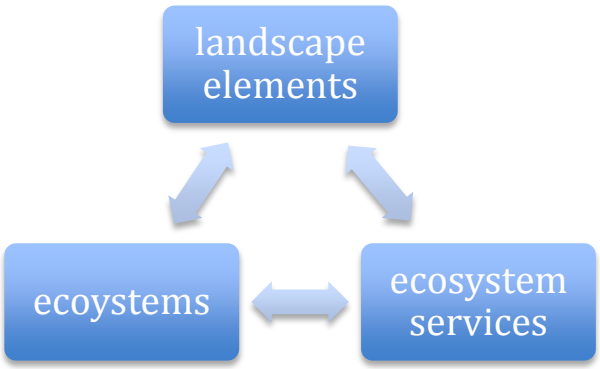


Figure 1. Ecological infrastructure consists of landscape elements, ecosystems, ecosystem services and the interconnections within and between them.

2.3. COMPONENTS OF ECOSYSEM MANAGEMENT

The earth's ecosystem is composed of different components that contribute to the continuous cycle of life on our planet. If the ecosystem is understood as the basic unit of landscapes, then ecosystem structure and function are essential to understand in landscape planning (Turner 1989). The dynamic relationship of landscape pattern to process is therefore fundamental to both landscape ecology and to landscape planning. Ndubisi et al. (1995) call for an integration of abiotic, biotic, and cultural understanding of landscapes as a basis for landscape planning at multiple scales. The cultural component should also consider the appearance of the landscape because people express understanding and preferences about ecological quality from the look of the land, and this, in turn is vital in landscape planning (Nassauer 1992). Some of the ecosystems that are found in Angat River are forest ecosystem, agricultural ecosystem, urban ecosystem and wetland ecosystem, which should be considered in ecological infrastructure planning.

Forest ecosystems contribute to soil and water conservation and some of them have their own unique micro-climate within the system. Several forestry and silvicultural practices have been evolved for protecting and conserving these 'environmental reserves'. The watershed is a natural integrator of all hydrologic processes within its boundaries, and as such, it is a logical unit for planning optimal development of soil, water and bio-resources.

www. denr.gov.ph

The management of agricultural watersheds, arising at appropriate development of land, water and bio-resources within their capability and treated according to their needs. Agricultural ecosystems should be protected against all forms of soil deterioration, stabilize critical run-off and sediment producing areas, improve grass lands, wood lands and wildlife lands, should be provided with necessary drainage and irrigation and reduce floods and sediment damage (Chow, 1964).

Vegetable plantation in Brgy. Niugan, Angat

source: author's documentation

The watershed or the watershed within which the urban area falls may be considered as a unique ecosystem, and in most of the cases such a watershed may have high population pressure and subsequent anthropogenic activities. The management of such watersheds not only calls for comprehensive policies but also valid and reliable indicators and appropriate models. The interacting issues and crisis in the context of such an integrated approach may be listed as: (i) water supply and demand crisis representing a predominantly engineering dimension; (ii) deteriorating water quality

crisis that can be considered as an ecological dimension; (iii) transboundary dependencies representing a geo-political dimension; (iv) organization crisis exemplified in a management dimension; and (v) data and information crisis, not only in terms of availability and validity but also as part of combining data and judgment, modelling, and the establishment of useful Decision Support Systems.

Wetlands are managed for environmental protection, water conservation, production of renewable resources, wildlife, recreation, aesthetics and tourism. The important goals of wetland management are maintaining the water quality, reduce erosion, protected from flooding, provide a natural system to process airborne pollutants, and provide buffers between urban residential and industrial segments. It should also maintain a gene pool of marsh plants and provide examples of complete natural communities. It should also provide aesthetic and psychological support for human beings. Produce wildlife and habitats for fish spawning and other food organisms and should facilitate scientific inquiry.

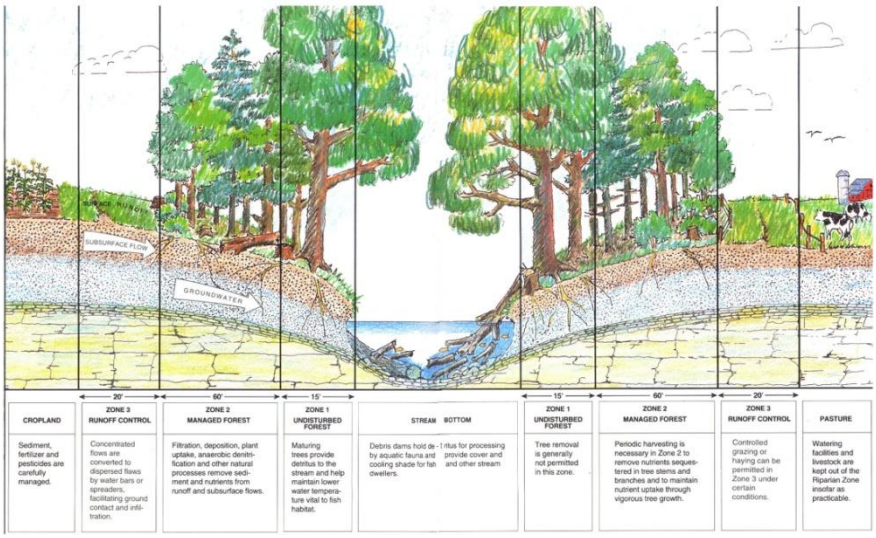
wetlands near Angat River

source: author's documentation

Integrating wetlands into river basin management and development is good not only for wetlands – for the biodiversity that they sustain and for the people who depend on them – but also for the river system as a whole, since in general wetlands perform functions that have an effect far beyond their place in the system.

In the past, only the functions and values of the wetland pertaining to fisheries, agriculture and wildlife were well recognized. The role of wetlands in water conservation and management was recognized only in the recent times. Wetlands have a key role in natural flood control, groundwater recharge, water supply and purification. Furthermore, water allocation to wetlands is essential to enable these ecosystems to support the plants, fish and other animal species that, in turn, are often critical to the survival of local human settlements.

Wetlands generally provide benefits downstream; improving river flows downstream; controlling floods; groundwater recharge; etc. Inland wetlands often influence the coastal wetlands. On a global scale, wetlands have an influence on global nitrogen, sulphur and carbon cycles.

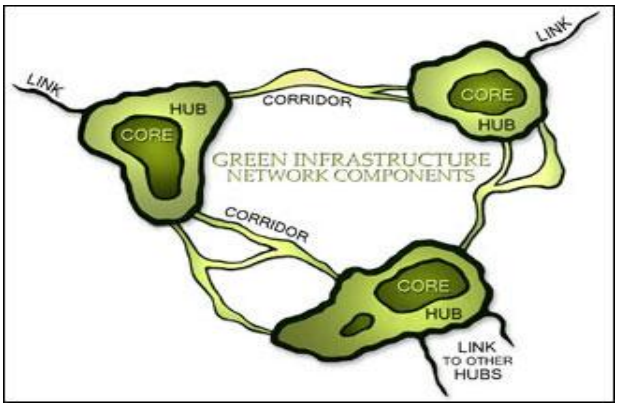


source:www.cayugawatershed.org

2.1.2. Green Infrastructure

Green infrastructure is defined as an interconnected network of green space that conserves natural ecosystem values and functions and provides associated benefits to human populations. "Green infrastructure is our nation's natural life support system — an interconnected network of waterways, wetlands, woodlands, wildlife habitats, and other natural areas; greenways, parks and other conservation lands; working farms, ranches and forests; and wilderness and other open spaces that support native species, maintain natural ecological processes, sustain air and water resources and contribute to the health and quality of life for communities and people.

"According to "Green Infrastructure: A Strategic Approach to Land Conservation", green infrastructure is the ecological framework needed for environmental, social and economic sustainability—in short it is our natural life sustaining system. Green infrastructure differs from conventional approaches to open space planning because it looks at conservation values and actions in concert with land development, growth management and built infrastructure planning. Other conservation approaches typically are undertaken in isolation from — or even in opposition to — development. Green infrastructure is "smart" conservation that addresses the ecological and social impacts of sprawl and the accelerated consumption and fragmentation of open land.



source: http://linkinglands.org

2.3 . **Comparative analysis between land-use planning and planning based on EI**

Based on the analysis and research done by Qing,et al., they evaluate the two planning methods. One is land-use planning and the other one is planning based on Ecological Infrastructure. Below is the table stating the differences between the two.

Table 2.3: Differences between land-use planning based on EI and the conventional land-use planning

	Traditional land-use planning	**Land-use planning based on EI**
Planning goals	"Serving for social and economic development" and " protecting arable land"; Aiming at maximum of economic benefit from land resources.	Based on the ecological processes, land-use planning is supposed to promote the coordinative development of population, resources and environment, and exert economic, social and ecological benefits.
Land-use status analysis	Contents: Land-use degree, structure, layout and benefits; More vertical process analysis.	Besides traditional analysis, ecological process is also analyzed; Both vertical and horizontal process analysis.
Land-use assessment	Mainly focus on the economy of development and construction activity, construction land quality assessment(e.g.); The assessment factors include landform, geology, foundation bearing capacity, slope, geological hazard distribution, hydrological conditions, etc.	Comprehensive assessment for land protection; Considering not only land characteristics but also effects of land-use layout on ecological functions.
Construction land scale	Usually predict the scale of construction land based on land demands which is decided bypredicting population, farmland demand, etc.	Besides traditional ways of demand prediction, also predict the restriction in terms of ecological bearing capacity by EI research.
Land-use layout	It is a process from quantity to layout;	Confirm land-use scale and

	Firstly, balance the demand quantities of all types of land, then arrange the land-use layout.	adjust land-use layout at the same time; Land-use layout considers not only land suitability, but also spatial relationship between different land-use types.
Land-use zoning	Through the combination of land-use district planning and land-use control indicators, implement the measures of planning goals, contents, adjustment of land-use structure and layout to spatial zoning.	Not only consider the coordination and control of internal function within districts, but also achieve the horizontal contacts of all districts through crucial corridors planning.

Numerous benefits of ecological infrastructure and reduced imperviousness are reported in the literature based on case studies and other information. Several types of benefits, organized under the economic, social, and biophysical categories of the evaluative model are presented.

Ecological infrastructure enhances topographic diversity and recreational opportunities in a community. It "brings nature to people and makes the ecology of landscape knowable" (Thayer and Westbrook 1989). Residents begin to recognize that they are a part of a water cycle and they become more connected with their local ecosystem. In addition, an alternative system incorporating wetland vegetation, grassed swales, and an increase in green spaces enhances the quality and visual aesthetic in a community (Condon 1998).

2.4. Methods Used in Ecological Infrastructure as Planning Method

Ecological Infrastructure involves the application of landscape ecological planning. The important abiotic processes focus on geologic factors, storm water and flood management. Geological structure and topography are taken into consideration for safety. Hydrological data and flood water levels in history and the changes in surface water are analyzed and stored in a geographical information systems. The living of

native wildlife is the main biotic processes. Three indicative species are analyzed for they represent various habitat types and different activity patterns. Some of them live far from human settlement, and others can tolerate human interference.

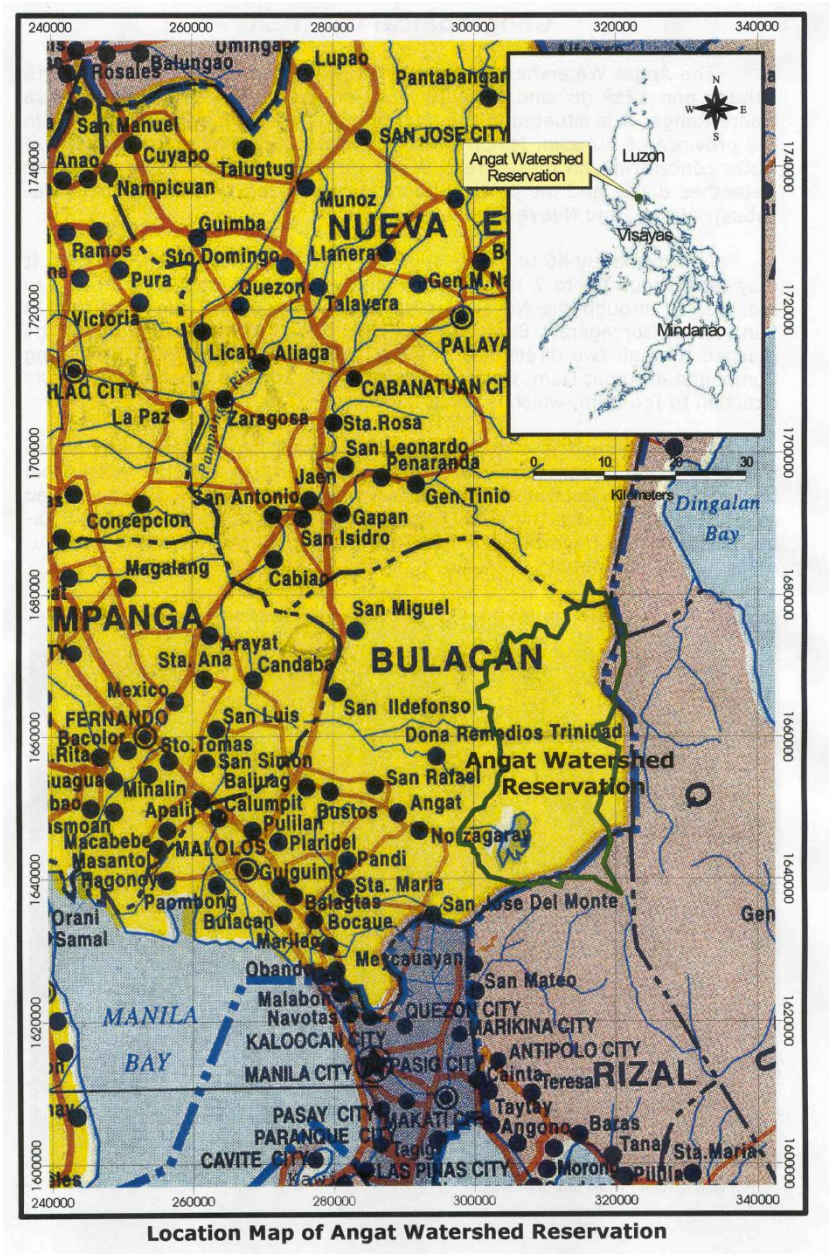
The targeted cultural processes include historical processes of cultural heritage sites, visual experience, and the process of recreational use of the landscape. All kinds of cultural heritage and recreational resource in open space are identified for a more comprehensive analysis (*Li Bo,2008).*

CHAPTER 3. ECOLOGICAL RISK IN ANGAT RIVER

3.1. Background

Angat River is located in Central Luzon , province of Bulacan traversing the municipality of Bustos, Angat and San Rafael, a major tributary of the Angat River system. The river is bordered to the north and south by significant agricultural lands and alluvial riparian corridors and wetlands. The soils formed on this rugged geologic base of Angat have rich agricultural potential. Angat river is used for flood control, informal settlements, industrial, mining, quarrying, logging, recreational and aquaculture.

Nested within the larger Pampanga River Basin (7,978 km2), the Angat River is the largest river located in the province of Bulacan and lies 40 kilometers north of Manila (see Figure 2.3). The watershed area is bounded by Umiray River in the northeast, the Kanan River in the southeast and the Marikina River in the south. It is approximately 153 kilometres long with a catchment area of 1085 km2 and estimated volume of 8.6 million cubic meters collecting run-off from its main tributaries, Matulid and Maputi rivers (JICA 2002). According to the DENR's catchment scale3 , the Angat River is defined as an inter-regional watershed. The Angat River flows westerly beginning in the Sierra Madre mountains through the lowland plains of Bulacan, into the Angat Reservoir and finally into Manila Bay (JICA 2011).



Location Map of Angat Watershed Reservation

The principal river, Angat River, originates from the western flank of the Sierra Madre Mountains. It then cuts through the mountainous terrain in a westerly direction to the dam site. The elevation within the watershed rises to a maximum of 1,115 meters at the Sierra Madre Mountain range and is lowest at the dam site at 100 meters. It has three major tributaries, namely, the Talaguio, Catmon and Matulid Rivers. The Angat Watershed has a moderate to intensive forest cover and has a drainage area of about 568 square kilometers, which receives an average annual rainfall of about 4,200 millimeters.

Given its size and location, the Angat River Basin encompasses a number of upstream and downstream uses vital to the province of Bulacan, as well as Metro Manila. As regulated by the Department of Environment and Natural Resources (DENR), the upstream portion of Angat River falls under Recreation Water Class I use

which is intended for 'primary contact' recreation such as bathing, swimming and diving. The downstream portion falls under Fishery Water and Recreational Class II which is intended for the propagation and growth of fish and other aquatic resources, boating and manufacturing processes after treatment (DENR 2005 as cited in PPDO 2010: 47). In addition, the Angat River supplies the diversion waters for Ipo and Bustos dams (Province of Bulacan 2008) and is a significant resource for Bulacan's growing industrial and resource extraction sector (e.g., fishing, quarrying, mining and logging) (PPDO 2010).

Unpermitted uses are also significant, including the River's importance to the growing number of informal settlements resulting from slum relocation in Manila and rapid population growth from the northern, more rural areas of the province (PPDO 2010). Examples of these uses were observed during my field course in Plaridel, where informal settlements along the Angat River used the waters for sewerage and waste disposal but also for livelihoods such as fishing and kangkong (water spinach) farming (see Figures 3.1 and 3.2).

Below is the physical framework plan of Bulacan. Where in one of the priority project is improvemnet major river channels like Angat River.

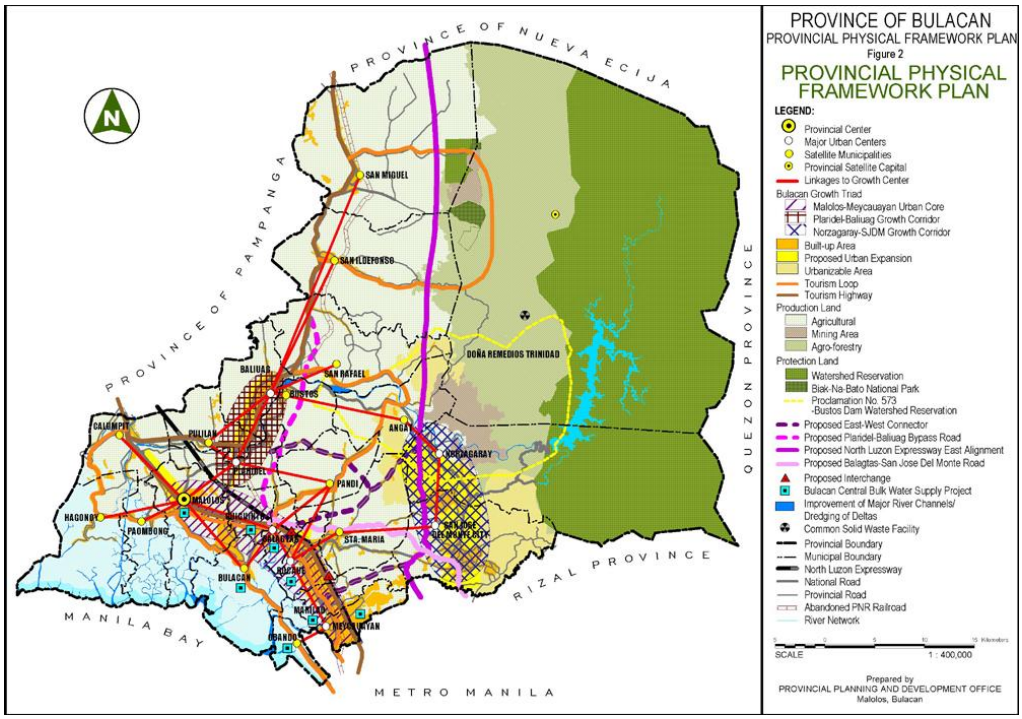


Figure 3.2 Provincial Physical Framework Plan of Bulacan source: PPDO 2007

3.2. The Site: Angat Afterbay Regulatory Dam

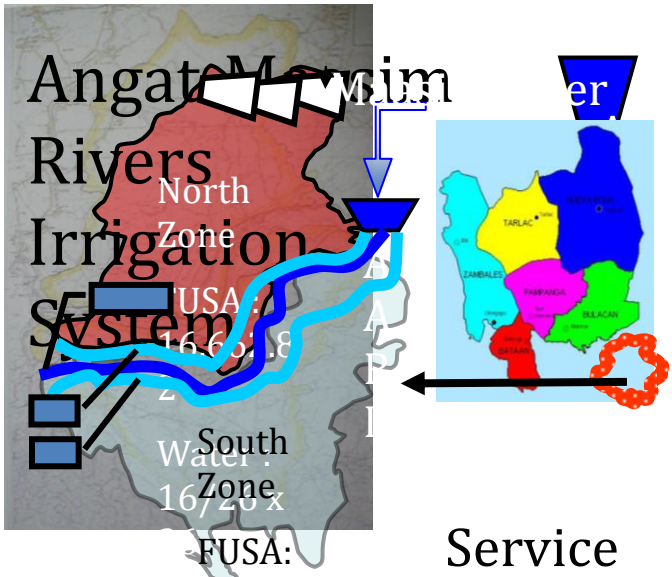
The study site is focused in Angat Afterbay Regulatory Dam (AARD). It is one of the tributaries of Angat River system. The Angat Afterbay Regulatory Dam popularly known as Bustos Dam is one of the longest rubber dams in Asia and is the primary source of irrigation serving approximately 31,000 hectares of agricultural land in the Province of Bulacan and in the fourth district of Pampanga. It is owned an and managed by the National Irrigation Authority (NIA) and located in Barangay Tibagan, Municipality of Bustos.

The Bulacan Angat-Maasim Rivers Irrigation System (AMRIS), has been operational since 1972. AMRIS is one of the oldest and largest irrigation systems in the Philippines and the aggregate service area stretches across the provinces of Bulacan and Pampanga. The 16 municipalities served in 12 municipalities in Bulacan and 4 municipalities in Pampanga.

In 1967, the Angat Multipurpose Dam was built 50 kms. upstream for the purpose of generating power, domestic water supply and irrigation. As a result, Bustos Dam was heightened by 2.5 meters by installing sector gates and was called the **Angat Afterbay Regulator Dam (AARD)**, thereby increasing the service area of AMRIS to 31,485 ha. The present service area of AMRIS is 26,791 ha., which is divided into the North and South Zone by the Angat River.

Figure 3.2: Angat Afterbay Regulatory Dam or Bustos Dam

Sourcce : AMRIS



FUSA: 10,128.67

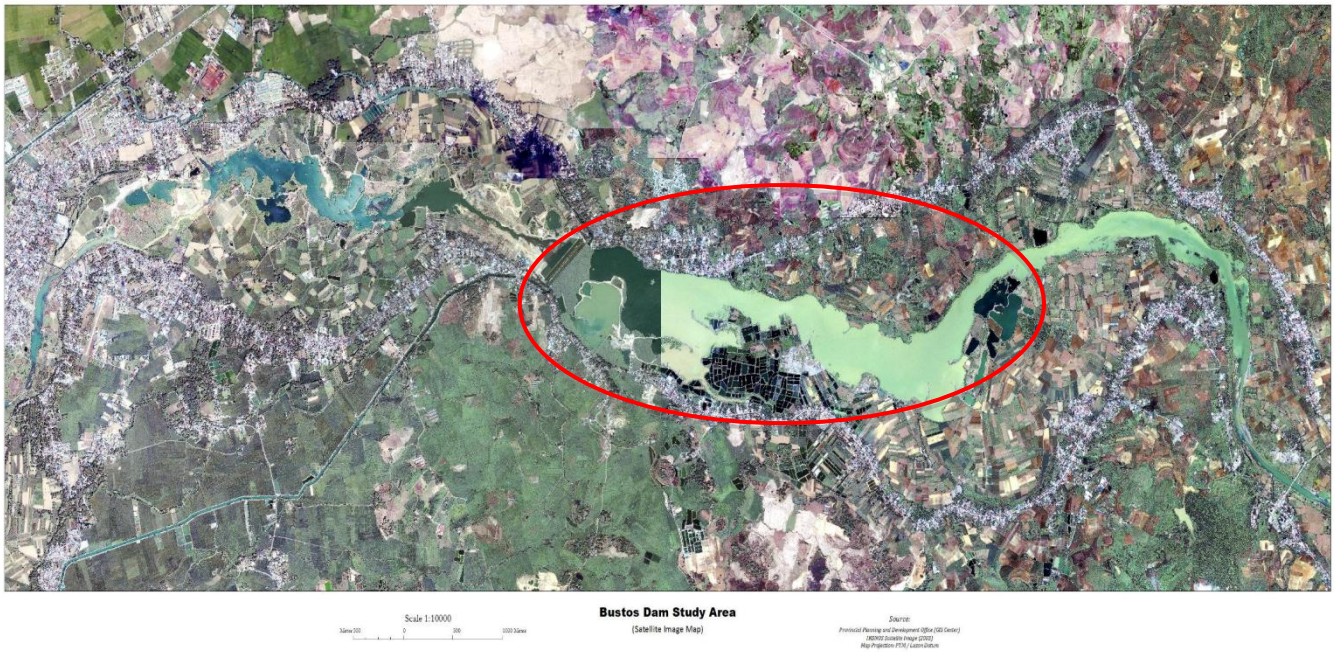
Water : 10/26 x 36

Max Q 19.39

Service Area : 31,485 has.

22,000 Farmer Beneficiaries in 20 Municipalities of 2 provinces

source: AMRIS



Study Area: Bustos Dam Source : PPDO

3.3. Land Use Related Risk in the Area

The study site is bounded by 3 municipalities, namely San Rafael in the north, Bustos in the southwest and Angat in the south east side. Each municipality contributes to the different land use related risks found in the riverbanks.

Based on the interview conducted with the municipal planning officers of each municipality, the common land use related risk is human settlement along the river bank. The urbanizing riverbanks resulted to non-treatment or management of effluent discharges and sewage cause pollution of the waterways and add to groundwater contamination. Failure to address these concerns would diminish what economic advancements the town would attain in the long run, with these depriving the municipality's people and economy of sustainable quality and quantity of environment and resource.

Another issue that faces the municipality of San Rafael is the low opportunities for communing with the environment especially in built-up areas, incompatible land uses, e.g. agri-industries operating adjacent to residential areas, flash-flood prone areas in the southern part of the town (near Angat river). Demand-driven reclassification of agricultural lands to other uses and land conversion, extensive residential area development, extensive swampy lands. Figure 3.5 is the existing land use map of San Rafael and the proposed comprehensive land use plan for 2013-2022 is in Figure 3.6.

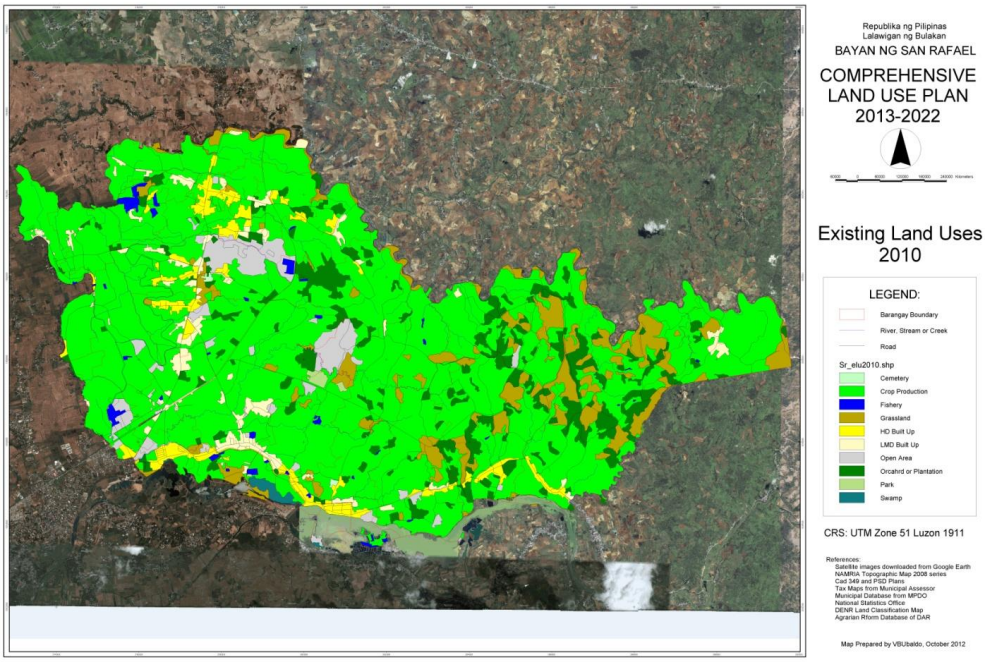


Figure 3.5 Existing Land use map of San Rafael.

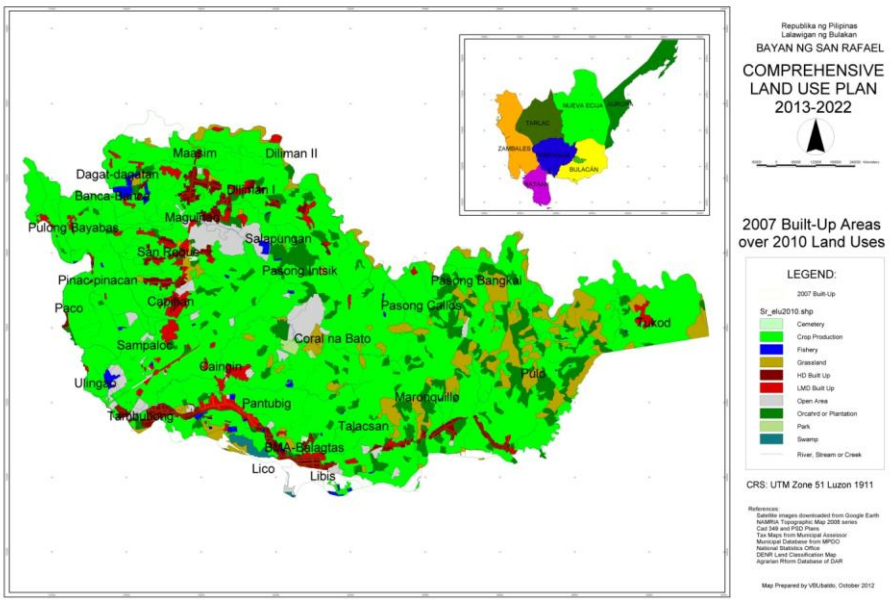


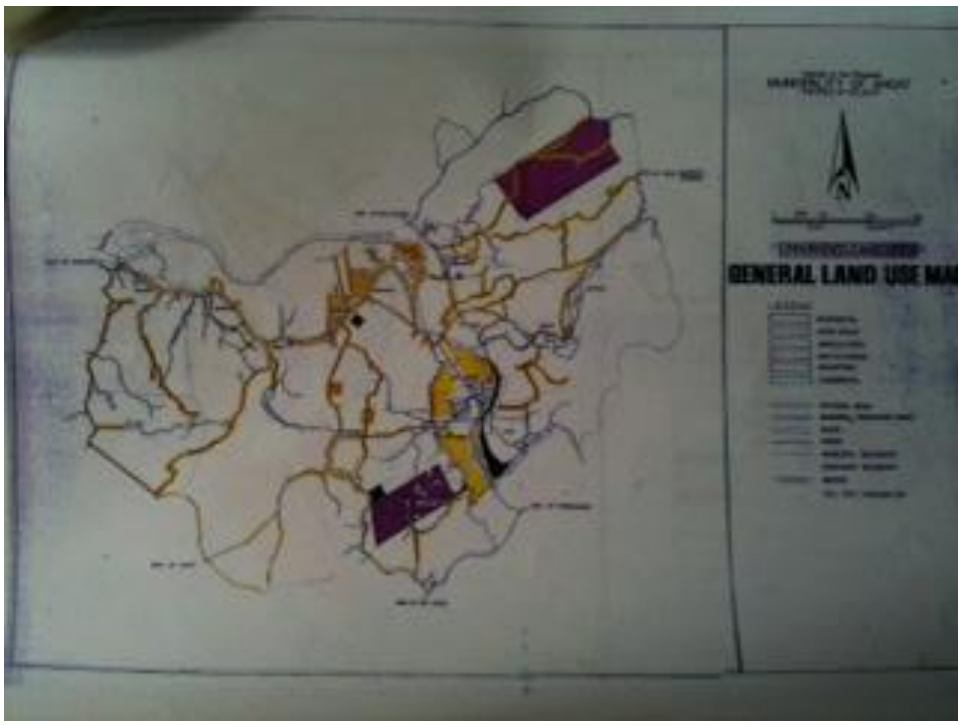
Figure 3.6 Proposed Comprehensive Landuse for 2013-2022

The municipality of Bustos , where the major part of the Dam is located also faces different land use related risk. Low laying areas near the river experienced flooding if the dam releases water due to heavy down pour during rainy season while during summer season drought is prevalent. Encroachment of the river

banks by illegal settlers also become a non-point source of pollution along the waters of Angat. Quarrying in the river banks is also prevalent in the area.

The area in the river along Angat municipality also has issues on land use related risks. Agricultural lands and fishponds were along the river banks that diminishes river flow. These ecosystems also produces contaminants from pesticides and herbisides and even residues from fish feeds.

Figure 3.7 Municipality of Angat General Land use Map



Source: Angat MPDO

Figure 3.8. Angat Comprehensive Land Use Map Source : Angat MPDO

River encroachment : existing reclaimed river not used as fishpond and agricultural land

Previously fishponds are now used as livestock farm

3.4 Disaster Related Risk

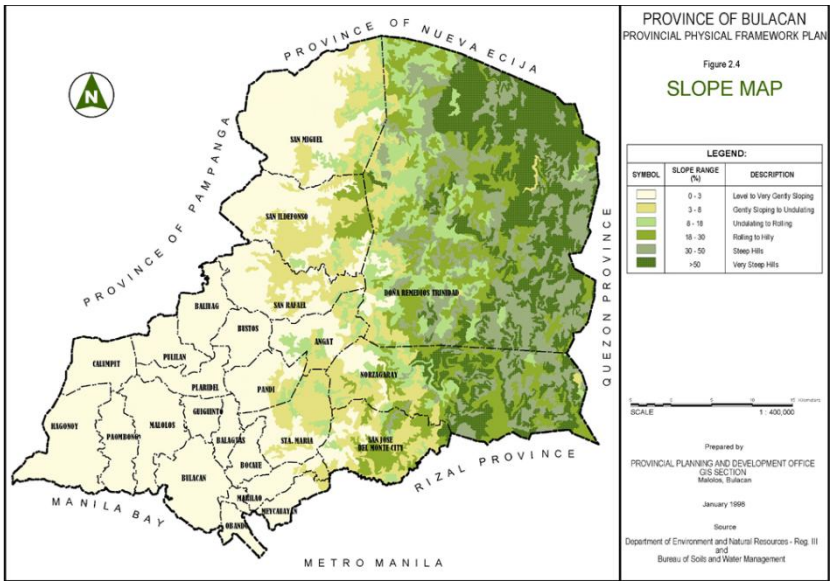
Problems found in the area are extreme flooding and extreme drought, erosion , siltation river bed. To be able to understand the issues on disaster related risk, baseline data were gathered. Shown are different maps that will fully give basic information on the issue.

Angat watershed forest vegetation also plays an important role in water holding and water absorption. Decrease in forest vegetation puts many communities at risk of different hydro-meteorological hazards because of our country's very close location to the Pacific Ocean. If the forest cover is small, there will be small amount of rainfall that will be directly intercepted by trees and other vegetation to be stored in the

aquifers. Surface run-off occurs mostly in deforested/cleared areas, resulting to erosion and siltation of the rivers, creeks, and other tributaries. Coupled with improper garbage disposal this in turn lead to the clogging of the waterways and cause flooding.

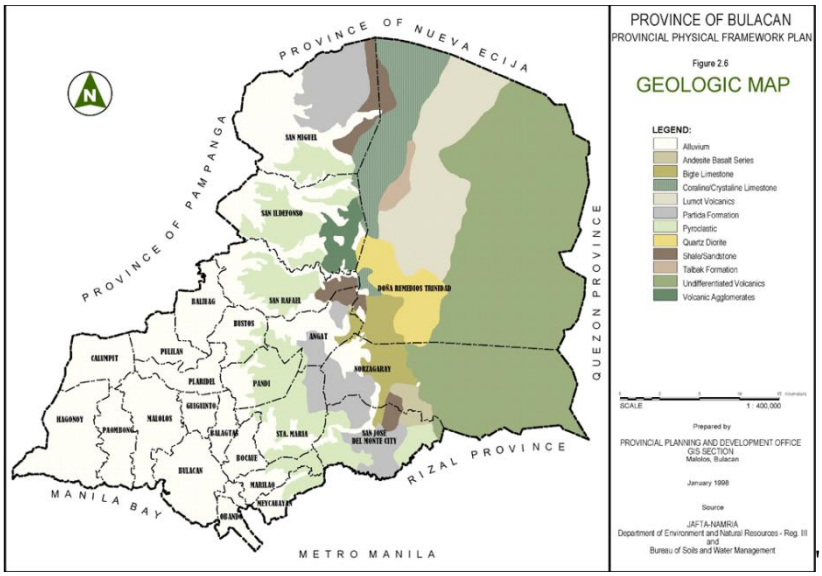
Angat watershed forest cover plays an important role in the hydrological cycle. The smaller the forest cover, the greater surface run-off will occur. If there is enough forest cover, great amounts of rainwater will be intercepted and stored in the aquifers. This also means that there will be a healthy recharge of ground water for household consumption in the areas that greatly depend on the forests.

Under several proclamations, the Angat River Basin has been declared a national protected area (The Angat Watershed Reservation), which is one of the last remaining, well-forested watersheds in the country (NAPACOR 2010). It is managed by the National Power Corporation(NAPACOR), a public corporation that also oversees the Angat Dam and Reservoir.



Bulacan Province Slope Map *source: Bulacan PPDO*

Bustos dam and commercial developments beside it



3.5. Infrastructure – Vulnerability

Flood-prone areas in the low lying parts of the Angat River basin include the municipalities of Calumpit, Plaridel, Baliuag, Bustos, Angat and San Rafael are prone to riverine flooding. Other headstream flooding occurs along tributaries that drain the western footslopes of Angat Watershed which also experience heavy precipitation. This triggers flash floods in the downstream section of the Angat river with flood waters rising 2m at the peak of the flood. Floods have a tremendous socio-economic impact. The main effect of floods is to retard development. A flood-stricken area must first be restored to normalcy before any development activity can be carried out. Restoration can take time. Flood damage is incalculable. Floods usually occur in association with other destructive natural phenomena. In addition to the directly determinable losses the indirect potential losses may be added. These result from unproductivity in many areas, e.g. in business and trade, commerce and in other spaces as well.

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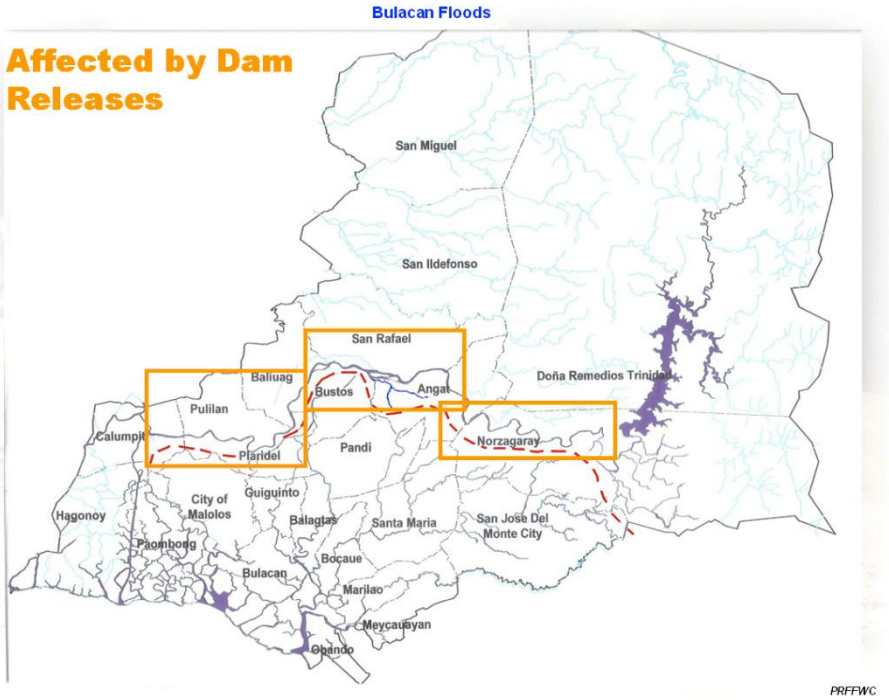
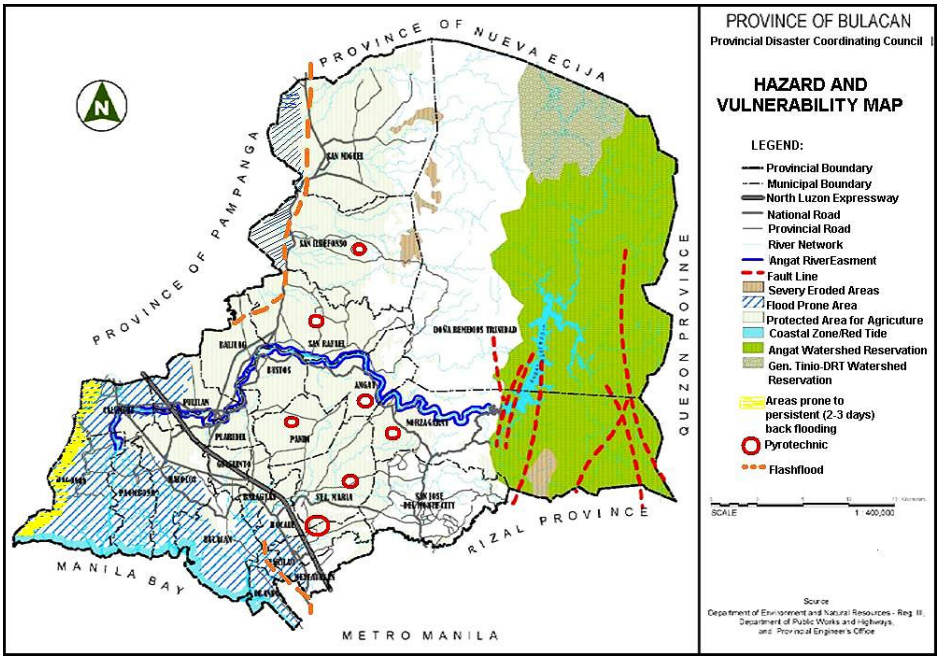


The river basin of Angat is mainly used for fishing, irrigation, flood control, informal settlements, industrial areas, mining , quarrying and logging. Evidence of ecological infrastructure is present in the area like acid soils, changing patterns of runoff , recharge and river flow and declining connectivity between floodplains and streams. A survey was conducted on the general perception on the river resources by the the local community, according to the survey result many perceived that the river is beneficial, slightly dangerous and water quality is slightly clean.



3.6. Ecological systems found in Bustos Dam

3.6.1. Existing Biodiversity

The site is located Central Luzon , province of Bulacan traversing the municipality of Bustos, Angat and San Rafael, a major tributary of the Angat River system. The river is bordered to the north and south by significant agricultural lands and alluvial riparian corridors and wetlands. The soils formed on this rugged geologic base of Angat have rich agricultural potential.

An assessment of abiotic resources was conducted and identified the following as key resources to be protected in the open space plan: the upland ridges that define the character of the town, provide important wildlife habitat, and recreational opportunity; the Angat River and floodplain that provide flood protection, a wildlife habitat, and recreational and amenity benefits; a system of forested and non-forested wetlands that provide multiple benefits and functions; important for wildlife, recreation, and cultural amenity; and two large irrigation canals provides a major portion of the province's water irrigation system

According to an interview done by the author with the Municipal Planning officer of San Rafael,Engr. Emmanuel San Roque the river is a source of livelihood for some fishermen. Commonly caught freshwater animals are fishes like tilapia, dalag, gurami, bia and janitor fish; ulang (native lobster), few water snails, reptiles other invertibrates.

bia/ dalag

janitor fish /tilapia

salamander, ground lizard(bubuli), frog

Several birds were also seen in the area particularly egret, batu-bato, kingfisher, tikling , maya and kamang.

bato-bato/ tikling

philippine egret or tagak

tikarol/ kingfisher

maya

CHAPTER 4: APPLICATION OF ECOLOGICAL INFRASTRUCTURE DESIGN PRINCIPLES TO AARD AREA

4. 1. CURRENT PLANS AND PROGRAMS:

Study on the current plans and programs of the national government for environmental protection is stated in the Department of Environment and National Resources' programs , activities and projects (PAPs) for the fiscal year of 2012. Below are the programs and projects for the different umbrella agencies of the department.

A.III.a.5 Soil Conservation and Watershed Management

The goal of soil conservation and watershed management activities are directed

at promoting environmentally sound and sustainable land-use particularly in upland watershed areas. Activities involving soil conservation and watershed management are focused in preventing soil erosion in upland areas which in turn disrupts the operation and effectiveness of water-related infrastructure downstream due to siltation and sedimentation.

Watershed management starts with watershed characterization and the development of the corresponding management plans. Primary development component activities include: 1) reforestation/afforestation of degraded portions of the watershed; 2) assisted natural regeneration – a low-cost conservation technique where lands of steep slopes with high erodibility are set aside for soil conservation; and 3) soil conservation – whereby construction of vegetative and structural soil conservation measures are applied in order to stabilize and control soil erosion. For FY 2012, the Department will pursue vigorously the implementation of soil conservation and management of watersheds especially the critical ones.

A.III.a.6 Forest Boundary Delineation and Land-Use Allocation

The program involves the establishment of boundaries between permanent forests and alienable and disposable lands, clearly marked and maintained on the ground, with infrastructure or roads, or concrete monuments at intervals of not more than five hundred (500) meters in accordance with established procedures and standards, or any other visible and practicable signs to insure protection of the forests.

Major steps for the delineation/and or relocation survey of forest boundaries include: preparation of base maps; forestland-use assessment; relocation survey; monumenting; inspection, verification and approval of survey; final map preparation; preparation of draft bill; conduct of public hearings; revision of the draft bill; finalization of the bill; and enactment into law by the
President of the Philippines.

The implementation of forest boundary assessment and delineation in the entire Philippines will be completed by the Department in year 2011. Its completion will address the issue of open access nature of forestlands as one of the major causes of encroachment and conversion of forestlands into non-forest uses. Further, this will ensure protection and sustainable development of the forestlands including the resources therein. It will also determine the proper land use and appropriate management of forestlands.

A.III.c.9 Biodiversity Conservation Program

This program deals with the preservation of biological diversity and genetic resources. Major activities under this program are: 1) cave conservation which is

concerned with the conservation and sustainable management of caves and cave resources; 2) **wetland conservation which deals with the management and protection of wetlands critical to biodiversity and water crisis**; and 3)wildlife conservation and management which deals with the conservation and protection of wildlife resources and their habitats.

A.III.d ECOSYSTEMS RESEARCH AND DEVELOPMENT

The integrated research and development program on ecosystems pertains to various priority projects and studies addressing various issues and problems in the forests, environment, lands, mines and geosciences and the coastal and protected areas. Concerned with the conduct of various research studies and projects that are timely and relevant to the sustainable management of Philippine ecosystems and natural resources, there is now a more pressing need for science-based information and technologies as output of research and development (R and D) that will serve as tools of the Department in formulating policy recommendations and in decision-making.

A vital component of the program is the promotion, transfer, and utilization of research results, information or technologies to all possible clientele/stakeholders concerning the aforementioned ecosystem types, and provision of technical assistance to other DENR bureaus and offices and regional units.

A.III.d.1 Ecosystems Research and Development Services

The Ecosystems Research and Development Bureau (ERDB), as the primary research arm of the DENR, together with the research sector of the different regional offices, is now more focused on applied and demand-driven researches that would provide science-based information and technologies geared at improving the lives especially of the marginalized sector of our society.

Current RDE efforts are geared towards addressing issues and concerns on climate change adaptation and mitigation. Research and development and extension programs and projects are restructured to cater to different stakeholders and external clienteles of the department and to the DENR sectors namely Forest, Lands, Protected Areas and Wildlife, Environment, and Mines and Geo-Sciences. Based on the Integrated Environment and Natural Resources Research, Development, and Extension Framework for FY 2011-2016, a new set-up of Research, Development, and Extension Programs (RDEPs) has been formulated in alignment with the National Research and Development Priorities Plan (NRDPP) on ENR.

These are as follows:

a) RDEP1 – Program on Climate Change;

b) **RDEP2 – Program on Sustainable Upland and Coastal Areas Development;**

c) RDEP3 – Program on Water Resources Management;

d) RDEP4– Development of Standards/Technologies on Land Disposition, Allocation, Land-Use and Management;

e) RDEP5 – Program on Mined and Degraded Areas;

f) **RDEP6 – Program on the Conservation and Management of Biodiversity;**

g) Program on Environmental Management and Pollution Control; and

h) RDEP8 – Technology Transfer and Commercialization Program pursuant to Republic Act No. 10055, known as the Philippine Technology Transfer Act of2009.

The National Water Resources Board (NWRB) has been created to replace the National Water Resources Council (NWRC) as the Policy-Making Body for the Philippine Water Sector. NWRC was created in 1974 under Presidential Decree No. 424, otherwise known as the "Integrated Reorganization Plan". It was subsequently renamed as NWRB pursuant to Executive Order No. 124-A.

The missions are:

a) To ensure access to safe, adequate water supply and sanitation at acceptable rates and levels of service;

b) To allocate sufficient water that will ensure food security and spur economic development of the country; and

c) To protect the water environment in order to preserve flow regimes, biodiversity and cultural heritage as well as the mitigation of water related hazards.

One of NWRB Strategic Goals is to ensure sustainable development and management of water and related resources: promoting water stewardship (wise water use; pattern of use/consumption of water) among key water users .

The identified policy areas/current proposed 7-point policy agenda are:

· Promotion of water use efficiency for the agricultural sector

· Promotion of water use efficiency for domestic and municipal purposes

· Identification of additional sources of water supply

-Adoption of volumetric pricing for various users/usage; prevention of pollution and contamination of water resources to ensure quality of water supply

· Water related risk management (e.g., prevention/mitigation of impacts of water-related disasters, drought management)

· Flood management (e.g., productive use of flood waters)

Per Section 3 of Presidential Decree (PD) No. 705, known as the Revised Forestry Code

of the Philippines, critical areas of a river system supporting existing and proposed hydro-electric power and irrigation works, need immediate rehabilitation as they are to fast denudation causing accelerated erosion and destructive floods. They are closed for logging until fully rehabilitated. PD 705 is already a comprehensive and updated forestry law. But it was further amended by PD 1559 during the martial law era, there was a prolific issuance of unnecessary presidential decrees and letters of instruction.

Since many of these new laws were impossible to be implemented or beyond the capacity of the forestry agency said laws remained un-implemented to this date. In spite of the designation and proclamation of many areas as mossy forests, protection forests, watershed areas, forest reserves, national parks and birds and wildlife sanctuaries for specific purposes and with corresponding prohibitions. Letters of instruction Nos. 917 and 917-A were issued for the proclamation of wilderness areas. Ecosystem Research and Development Bureau (ERDB).

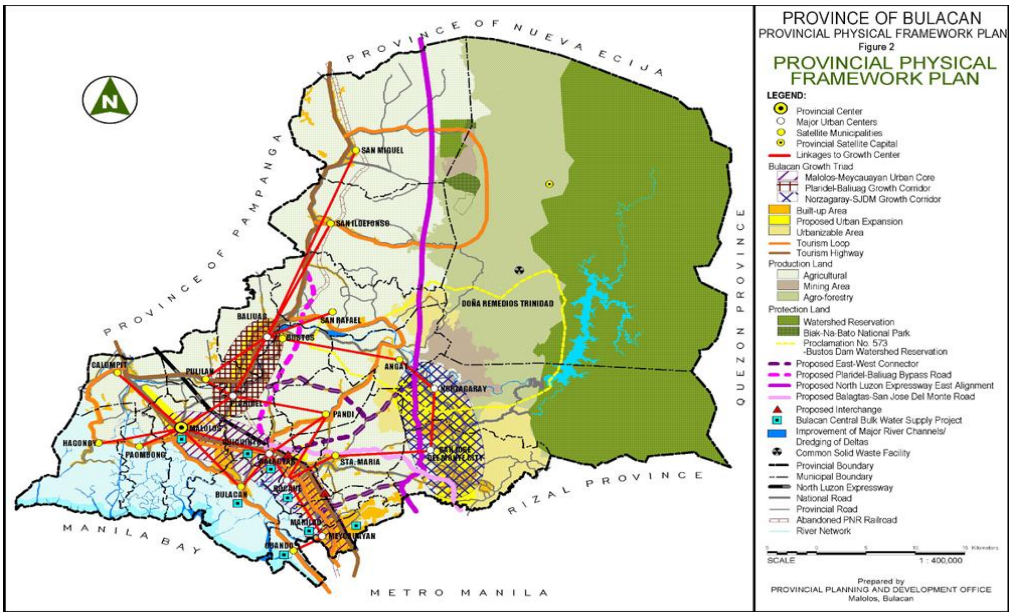
The function of the Ecosystem Research and Development Bureau (ERDB) is to back up government programs with the necessary technology through scientific findings and technical assistance. The bureau is designed to work hand in hand with other agencies to protect and conserve our soils. Revegetation of reforestation is the primary control measure applied, complemented by structures such as terraces, check dams and gully plugs (Reyes, 1980). Different mechanical measures such as modified land management, cropping schemes and the likes are evaluated. The effects of combinations of biological and structural control measures are also studied. (*Source: Land Use Planning Strategies on WatershedManagement and Disaster Reduction in the Philippines, Paragas, Vicente S. et.al.)*

4.2. PROVINCIAL LEVEL:

The Provincial Physical Framework Plan of Bulacan was based on the following overarching goals: ecological balance, economic development, equitable access to infrastructure and basic services and people empowerment and good governance. Based on these goals, specific goals and objectives were also identified for the three major components of the plan. These are: settlement, land use and infrastructure. Under the infrastructure component the goal is to improve access to appropriate infrastructure and urban services. This goal can be achieve thru establishing and constructing additional infrastructure systems to meet present and future requirements; integrate infrastructure

development with environmental protection; develop and maintain infrastructure to promote environmental quality and to ensure environmentally sound infrastructure projects.

The PPFP identified three possible spatial development strategies namely: Adoption of Current Trends, Stick-to-the-Rules and Angri-Industrial Development. Under the Adoption of Current Trends the Base Plan, merely adopts the existing pattern of development wherein market forces play a major role in the identification of the type and tempo of land usage. Although this pattern of land development maximizes economic benefits, it however often leads to using land in conflict with its inherent characteristics. While the Stick-to-the-Rules strategy tries to overcome the negative effects of the first option by calling for strict observance of established laws and policies such as the National Integrated Protected Areas System (NIPAS), preservation of prime agricultural lands, protection of environmentally critical areas and other relevant laws.



Bulacan Gov. Wilhelmino Sy Alvarado said the Angat River is being developed into a water sports center and at the same time, serve as a wildlife haven. The ecotourism project is expected to provide a new adventure package for enthusiasts who want to enjoy sports and nature at the same time, Alvarado said. The provincial government is preparing for the launching of the water park and encourages nature and fun lovers to visit Bulacan and experience the beauty of its natural wonders.

Bulacan Environment and Natural Resources Office (Benro) former chief Rustico “Teddy” de Belen said the project will be built in two major locations: one on the upstream of Bustos Dam in Bustos town and the other on the upstream part of Bakas to Pugpog of the Angat River in Angat town. Bustos Mayor Arnel Mendoza said

Tourism Infrastructure and Enterprise Zone Authority (Tieza) Chief Operating Officer Mark Lapid expressed his support for the project's realization. The project, once completed, is expected to boost tourist arrivals, both local and foreign, and help spur the economic growth of Bustos and Angat.

4.3. MUNICIPAL LEVEL Plans and Programs:

Municipality of Bustos:

The local municipal government proposes to make Bustos Dam a major economic driver, this huge reservoir of water is an ideal place for an eco-cultural park. Make it relevant to the lives of the residents; thereby, sparking off volunteerism and love of environment towards sustainable development**. The project "DAMbuhalang Saya!": Bustos Dam Eco-Cultural Park Development. It will benefit both the local economy and the environment: foster sustainable use and management of natural, cultural and historical resources,** encourage growth of the local economy, create jobs and business opportunities (hotel and tour services, food production, cottage industries and housing construction) and offer new opportunities for small scale investments.

Municipality of San Rafael:

The municipality of San Rafael drafted a comprehensive land use plan for their socio-economic development that adheres to the principles of sustainable development supported by citizens. The four major aspirations of the people of San Rafael for their development are progress, security, sustainability and cityhood. Under the sustainability the use of solar panels or of biogas digesters shall be common sights. Common areas shall be richly planted to trees to serve as carbon sinks. **The Angat River quality shall be maintained to class AA where residents and visitors may enjoy water-contact activities.** Other priority projects pertaining to protection of the river bank is to improve access to the banks of Angat River, protect the slopes of Angat River and contribute to the protection of Angat River watershed.

Municipality of Bustos:

The Municipality of Bustos however, aims to improve Bustos Dam into an eco-tourism park. What was once a tourist attraction is now a forgotten area that served as a swimming destination a few decades ago. Its aging and inadequate facilities do not meet with demands and does not ensure visitation and longer stay in the park. Lack of recreational amenities contributes to the decrease in tourist visits throughout the year. So the local government initiate and propose a rehabilitation of the park beside Bustos Dam to make it a major economic driver, make it relevant to the lives of the residents: thereby, sparking off volunteerism and love of environment towards sustainable development. One of the components of the proposal is the establishment of man-made forest, cleaning and greening of the riverside. Construction of adventure sports facilities i.e. High-V, wall climbing, buggy and zorb rides. Under recreational facilities the proposal wishes to build a port, a lighthouse, view decks and water sports facilities like kayaking, zip line and jet skiing. Provisions for floating cabanas for spa and massage services, floating restaurant that could accommodate 50-60 persons and small floating restaurants for 8-10 persons.

Municipality of Angat:

The Angat local government is planning to implement the Strategic Agricultural and Fisheries Development Zone (SAFDZ). Since it has no existing irrigation canal to supply water to agricultural land. The agricultural area is generally rainfed. However, some areas are irrigated in accordance with the program of the National Irrigation Administration. The barangays of Niugan and Donacion are the prime beneficiaries of the NIA program. Most of the municipal government's programs are livelihood based like agricultural production, livestock and poultry and backyard and commercial fish ponds.

Currently, they are developing a certain portion of Angat river in the up stream areas into a water recreation destination. The former quarry site is now utilized as a local tourism destination for water sports activities. Named as The

Environmental Water Sports Project which aims to promote Angat as an eco-tourism destination, located in Sitio Pugpog. Angat Mayor Gilberto Santos said the facility located in barangay Sta. Cruz, Angat town will be known as "Ganda Ko'y Silayan: Angat Water Park" and will include amenities such as water skiing, jet skiing, boating, kayaking, zipline, wakeboarding, floating restaurants, and fishing and picnic areas.

4.4 DESIGN QUALITY ANALYSIS OF CURRENT PLANS AND PROGRAMS

Most of the programs presented by the national government is very general and no specific action program was established considering that they are the implementimg agencies that suppose to be the one initiating such plans. According to their annual report in 2011, many of these new laws were impossible to be implemented or beyond the capacity of the forestry agency said **laws remained un-implemented to this date**. In spite of the designation and proclamation of many areas as mossy forests, protection forests, watershed areas, forest reserves, national parks and birds and wildlife sanctuaries for specific purposes and with corresponding prohibitions. Letters of instruction Nos. 917 and 917-A were issued for the proclamation of wilderness areas. Ecosystem Research and Development Bureau (ERDB).

Under the provincial government plans and programs, most are very traditional and not environmentally related development. Billions of pesos have been pledged to upgrade transport links, enhance education and health infrastructure and build

communications systems. Meanwhile, lack of investment in the fundamental element of humanity's economic prosperity: the trillions of pesos worth of ecosystem services that are critical to the functioning of the Earth's life-support system. If the provision of these services was not given 'adequate weight in the decision making process; current and continued future of human welfare may drastically suffer'.

'When you look at current trends in population growth and living standards, one realizes that we will be expecting our ecological infrastructure to provide even more ecosystem services in the future. Business-as-usual, which involves little investment in ecological infrastructure, is not an option (Bristow, 2009).

Dr. Bristow- CSIRO senior principal research scientist says nation-building must include investments aimed at restoring degrading ecological infrastructure and maintaining the resilience and regenerative capacity of 'undisturbed' ecological infrastructure in the case of future developments.

'We also have to find a way of enhancing the capacity of ecological infrastructure strengthening the vital links and enhancing resilience--if we continue to place ever-increasing demands upon it.'

The municipal level's plans and programs regarding environmental protection is directly anchored to the provincial planning development plans and proposal. However, several plans where executed with or without the provincial's permit each municipality has it's own interest in the resources the river will give them even if it compromises the river's basic function and uses.

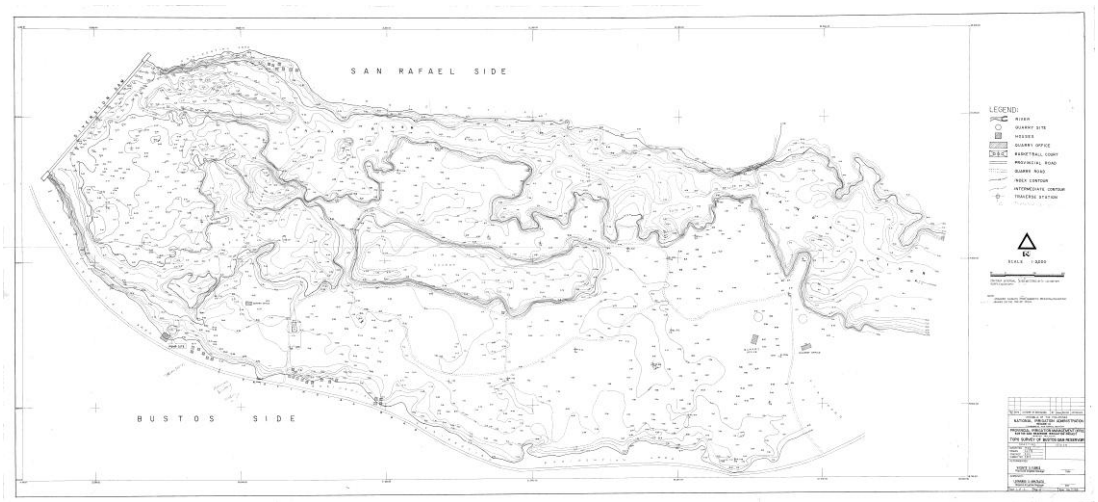
4.5 APPLICATION OF ECOLOGICAL INFRASTRUCTURE (EI) APPROACH

4.5.1 Establishment of EI

Because of the different plans and programs for the development of Angat River as a recreational and tourism destination, establishment and application of the ecological infrastruture framework shoud be applied. To protect the integrality of ecological system in Angat River, some key landscape processes must be considered: flood and storm water process, biological process, cultural process and recreational process. A master plan of EI should be made by uniting all these landscape patterns.

4.5.1 a. Flood and storm water security pattern

Bustos Dam lays on the upstream of Angat River. Because of the low-lying situation in the river bank areas, flat terrain, and poor surface drainage capacity, along Bustos Dam has repeatedly suffered from the floods and water logging in history. In recent years, with the damage to vegetation along upper reaches and increment of impervious area, this area has to face more flood risk and waterlogging problems. The establishment of flood and storm water security pattern is of respect for the natural surface runoff process. It would conserve enough retention and storage areas for flood and storm water, and use natural rivers, channels and ditches to link lakes, wetlands and ponds as a network, which could finally help to release flood and solve the waterlogging problems.(



Topo map of Bustos Dam *source: AMRIS*

The planning method of flood and storm water security pattern is based on runoff data from the NIA, PDRMC, MWSS for the flood submerging analysis, 10-year, 20-year, 50-year recurrence interval floods are used to delineate the potential inundant area, while in storm water submerging analysis, four levels of rainfall intensity, including 50 mm / d, 100mm / d, 200mm / d and maximum intensity in history, are utilized to identify the waterlogging vulnerable areas. The flooding map and vulnerability map from the Geo-Science Bureau was also used as baseline data. Below is a series of images of the site and the changes that have been made and occurred in the course of time. Fig. 4.2-4.6

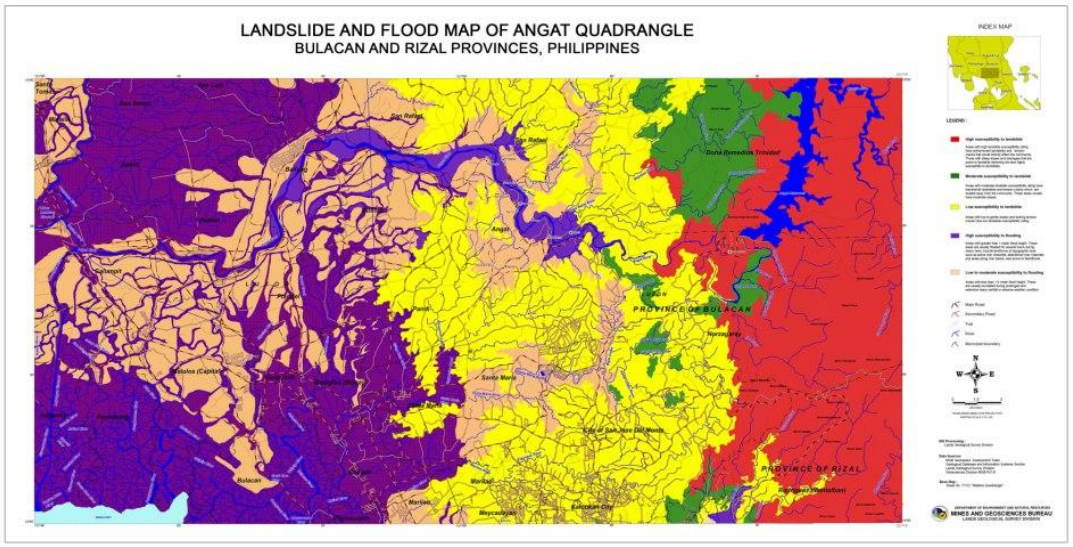


Image of the Bustos Dam in May 2002

Fig .4.1 source: Google Earth

Fig.4.2 Image of the site July, 2004 source : Google Earth

Fig.4.3 Image of the site in February 8, 2011

Fig.5.4 image of the site during dry season ,May 2011 source: Google Earth

4.5.1b Biological security pattern

Strategies for the biological security pattern are as follows: core areas of habitat should be protected strictly; buffer zone and continuous corridors should be constructed. Protecting biological security pattern is helpful to reduce disturbance to habitats and ensure the integrity of wildlife migration.

Firstly, the Indicative species of Bustos Dam are chosen; secondly, the key habitats for these species should be recognized in space as the "source". Based on these "sources", then comes the horizontal cost distance analysis which can find out the buffer zones, corridors and ecological strategic points. These are the biological security patterns of the indicative species. Finally, the integrated biological security pattern is established by uniting all indicative species security patterns.

4.5.1c Local cultural landscape security pattern

Studies and survey have been made to know how people utilized the river.The analyzing method learns from the surface analysis of GIS. Local cultural heritage and important linear cultural elements are chosen as sources, and the local culture experience is treated as some process of extending along linear elements. Finally the routes with the minimum cost come out as local culture experiencing corridors.

Below are the data gathered during an interview and survey conducted in the

neighborhood along Bustos Dam.

Table 1: RIVER RESOURCE UTILIZATION (50 respondents)

ACTIVITY USAGE	PERCENTAGE	REMARKS
Farming/Agriculture	29%	Irrigated agricultural land along the river banks
Drinking	22%	They thought that the source of their drinking water comes from the river
Laundry	21%	Water district services are high they opt to wash their clotheds in the river
Food Source	19%	Fishes coming from the river and also water vegetables (kangkong)
Income/Fishing	4%	Very few practices fishing because not enough fishes were caught
Gravel/ Sand	3%	Sand quarrying is already banned
Fish pond	1%	Not all fish ponds were in used some were eaten up
Waste dump	1%	Few dumpingof waste because the municipality provided a waste disposal collection.

Table 2. ***PROXIMITY TO ANGAT RIVER***

Proximity to River	Home Location
0.5 KMS	24.20%
1KM	20.20%
> 1KM	55.60%

TABLE 3. RESPONDENTS GENERAL VIEW OF THE RIVER

PERCEPTION	MEANS	VALUES	INTERPRETATION
Benefits	1.74	1-very beneficial 2-beneficial 3- none	Beneficial
Danger	1.64	1-no danger 2- dangerous 3- very dane	Slight danger
Water Quality	2.66	1-very clean 2-clean 3- very dangerous 4-dirty 5- very dirty	Slightly clean

The results would indicate that the respondents view the river as a potential source of benefits for their families. Those who live near the river are aware of its dangers but more so the potentials of the river. The respondents view the river as a potential economically not

adversary, which will threaten their life. The study also revealed the economic and financial difficulties the families are in. They are still using the river as a potential source of food and income. Fishing and agriculture are still viewed as a primary economic activity supported by the river. This would seem to indicate that the respondents are open and positive to any usage of the river might help them economically or financially. Their perception of the river as slightly clean indicates that they would be adverse to pollution of the river. When the indicated that they thought drinking water comes from the river and that they are doing laundry in the river, indicate that they would prefer to maintain a certain level of ecological balance in the river.

4.5.1d Recreational security pattern

Recreation also involves an experiential process. Recreational security pattern focuses on key landscape elements during the recreational process and its links. The influential factors include land cover, recreation route, historical and cultural landscape. In the scope of EI, the recreation means the natural elements for public to get fun of, such as woods, rivers, wetland, and so on. The method is also the same as that of local

cultural landscape security pattern. The difference is choosing cultural heritages and high-valued natural landscape elements as the source. Angat River and Bustos Dam has been a recreation and tourist destination ever since. Locals frequent the dam during summer season and river banks are also the playground for children living near it.

CHAPTER 5. : INTERGRATION OF EI DESIGN IN LOCAL PLANNING AND DECISION-MAKING

The use of ecological Infrastructure approach can be applied in maps to determine and identify existinganimals/ fauna for conservation and preservation. Mapping identified areas where these animals thrived can help planner protect their habitat and develop a system where they can be preserve and at the same time encourage the community to become aware of the importance of these wildlife. Historically, land use pattern in Angat River have resulted in substantial fragmentation of the river's lowland vegetation communities and assorted wildlife habitats. As a result, the most common type of ecological corridors within Angat river and surrounding are relatively narrow, linear corridors associated with water ways or steep lands.

A system in using hydrological history and identifying areas affected by 2, 5, 10, 50, 100 year flood level will drastically prevent unnecessary constructions on areas prone to flooding and subsidence.

5.1 CLUP

Ecological Infrastructure planning strategies can be applied in creating a comprehensive landuse plan of each municipality. Landscape planning is an inherently strategic activity. It strives to craft policies and actions that systematically address the trends and forces that shape and change landscapes. Strategic planning is driven by goals that are focused, linked with implementation, and presumed to be achievable. When strategic planning is informed by a landscape ecologically informed understanding of pattern: process dynamics, and is guided by appropriate spatial concepts, it may form a sound basis for plan development and implementation.

When the existing landscape supports the abiotic, biotic, and cultural

resource goals, a protective planning strategy may be employed. Essentially this strategy articulates the spatial pattern that is desirable and protects it from change. Conversely, it defines the areas in the landscape where change can be accommodated. The protective strategy is useful in relatively undisturbed landscapes and can often be applied at low cost. Ironically, it is difficult to promote politically because, by definition, it is used when the landscape is already functioning well. While landscape planners attempt to be forward thinking and anticipatory, human nature is often reactive. In this case, education and public awareness are useful to promote understanding of the issues and strategic options available.

When the existing landscape is already in a spatial configuration that is negatively impacting abiotic, biotic, or cultural resources, a defensive strategy is needed. This strategy seeks to control and arrest the negative processes of landscape change (i.e., fragmentation, dissection, perforation, or attrition) (Forman 1995). As a last resort, the defensive strategy is often appropriate, but it can also be described as reactionary and ineffective. By definition, a defensive strategy attempts to "catch up with" or "put on the brakes" against the inevitable process of landscape change. When the root causes of negative landscape change remain active, the defensive strategy will never be completely effective and best delays the inevitable change in defense of an ever-decreasing nature (Sijmons 1990).

In marked contrast with the defensive, the offensive strategy is inherently proactive in nature. It is appropriate when the landscape is already deficient with respect to supporting biotic, abiotic, or cultural resources. It promotes a "possible" future landscape that can be realized only through restoration. Since, by definition, it cannot be guided by an assessment of existing, resources, it must be based on a spatial concept crafted by a combination of rational and creative processes. The offensive strategy relies on knowledge from; landscape ecology, planning, and ecological restoration. It is costly and uncertain. This strategy is often practiced in Europe, where centuries of use have produced a cultural landscape with limited opportunities for protection or defense of desirable landscape patterns and associated processes.

Often landscapes contain unique elements or configurations of elements

that allow for landscape planning. These unique elements may or may not be optimally located, but represent positive opportunities, nonetheless. This strategy is dependent on the presence of certain unique landscape elements, which are often in the configuration of a corridor (e.g., abandoned railroad lines, transmission line corridors) or as a remnant environmental resource patch (Forman and Godron 1986). This strategy involves recognition of such special opportunities and integrating them with other planning strategies, often with the opportunistic strategy.

Planning official can also follow the Net Usable Land Area (NULA)Process. A planning procedure to identify all lands that are potentially available for development, after accounting for the spatial effects of ownership, regulation, and certain accepted ecological values and risks.

1. Already Developed, Protected or Regulated

•Rationale: By virtue of pre-existing development, ownership, or protection status , these lands are not available for potential development.

•Examples: Residential, Commercial, Industrial land, State and local parks, Regulated wetlands, Conservation lands

2. Critical Resources:

Rationale: These resources are unique, scarce or rare and represent significant values to society. Although they are removed from development consideration, they can be subject to appropriate use(s).

Examples: Aquifer recharge areas Prime agricultural soils, Sand and gravel deposits Endangered species habitats.

3. Hazards:

Rationale: Development of these areas results in hazards to individuals or to society (e.g. flood damage, excessive soil erosion, ground water contamination).

Examples:1% probability floodplain, Slopes over 25%, Soils with seasonally high water table, Soils with very poor drainage

4. Net Usable Land Area

Rationale: All remaining lands are considered potentially developable and are compared with other discretionary factors to generate alternative future landscape

5.2 CDP (Comprehnsive Development Plans)

5.3 BY LAWS AND ORDINANCES.

It is recommended that certain laws and ordinances should be written in order to protect the remaining natural ecosystem process in the river. Protection of wildlife and their habitats must be strongly preserve and conserve. Although the national government has written several laws and proclamation for the protection of the environment and it's resources, these laws are not properly implemented due to bureaucracy and red tape.

CHAPTER 6. RECOMMENDATIONS

River restoration is a complex process that requires a rethink of the current stormwater management practices and its implications on the design of urbanizing environments. Previously, the hard engineering approach provided specific, easily quantifiable solutions to focused drainage problems. This required a design approach that holistically integrates the landscape design with urban hydrology, environmental engineering and the arts.

The resulting vision was for the unused fishponds to be replaced with a naturalistic wetlands with no discernable boundaries where users experienced a seamless transition between park land and wetland. This called for a multi-functional approach to the design of wetlands and riparian corridors. The transitional zone can become a floodplain during the occasional storm events or a recreational area during the dry periods. The natural edge with the changing conditions encourages the proliferation of bio-diversity.

Habitat creation for promotion of bio-diversity

The remaining fishponds that were not in used is designed as a wetland area to recreate the loss habitat of fishes and other fresh water animals. It will serve as breeding grounds for fishes and native birds. Introduction of native plants were used with the aim of extending the range of flora and fauna found naturally in the neighboring buffer zone. While it is difficult to accurately recreate the plant palette found in our natural wetlands, the design strived to remain faithful to the look and feel of the environment of a natural wetland ecosystem. The density and "random" distribution of the plant mix deviates from traditional mass planting type design with clear separation between plant species. Areas were left open with only a mulch of wood chips to allow for natural colonization and succession to occur. Habitat logs and wood piles harvested from trees fell during the redevelopment were placed throughout the park and allowed to decompose naturally. These will provide habitats for insects and plants to colonize and propagate.

Bio-engineering for slope stabilization

In many Southeast Asian countries, the efficient conveyance of stormwater has been the design philosophy for past developments. This has contributed to numerous problems including flooding, pollution, land subsidence, habitat loss. These engineered stormwater canals are usually designed and made from concrete to quickly convey stormwater runoff directly to either the sea or nearest water body. However, these approaches are environmentally unfriendly and unsustainable, and results in issues such as downstream peak flows

stormwater runoff wastage, and compromised groundwater recharge.

Soil bioengineering uses natural vegetation in erosion control and slope stabilization. This takes advantage of the unique characteristics of plant growth and natural materials to retain soil and stabilize embankments. Various techniques have been developed that can be applied to a variety of different on-site conditions eg. gradients, water velocity, etc. The development of the root systems forms an extensive mat, holding the soils and rocks in place, increasing structural integrity and prevents erosion. Benefits include, providing habitats for wildlife, enhanced aesthetic, soil improvement, water quality improvement and reduction in stormwater runoff and improved integration between park and river.

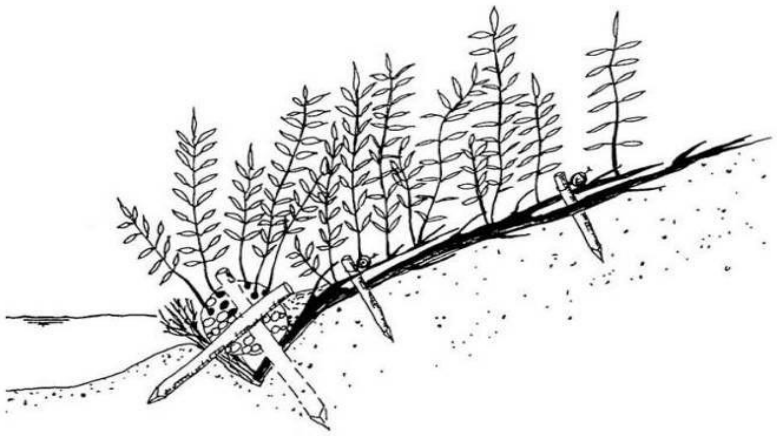


Figure 8: Section of Brush Mattress technique

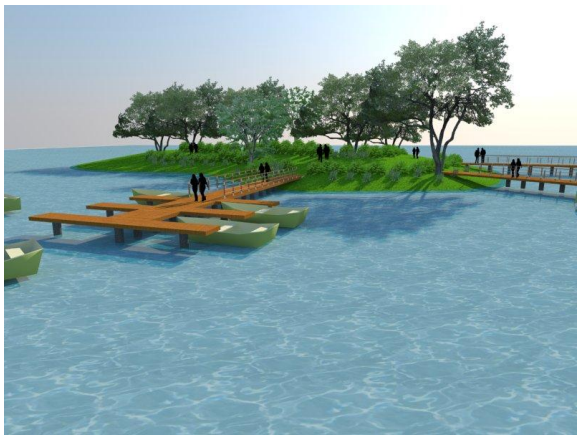
Water Cleansing using phyto-remediation plants

The existing system of marshes in Angat River where quarrying and domestic waste disposal is rampant suffer from poor water quality especially during prolonged dry and sunny periods. This is due to inflows of nutrient rich water that is left untreated. The new design will feature a cleansing biotope that uses the combination of plants and natural substrate to filter and remove most suspended, chemical and biological contaminants. Some of the plant species were specially selected to remove specific contaminants eg. Heavy metals. The aim is to reduce incidence of unsightly algae growth, contaminated water and unpleasant smell associated with sewage disposals from human settlements and industries. This dynamic interplay of wetland park and river will give Angat River a new unique identity, but even more, it will be the first demonstration

project in Bulacan that will give hope for healthy rivers far beyond the province.

Recreational activities that promote environmental awareness

The current plans and programs of the local municipalities are strongly geared towards tourism and recreational activities and facilities. Introductions of such facilities like viewing decks , pavilions , board walks and few active activities like boating and fishing will attract local and international tourist.



CONCLUSION (FOR REVISIONS)

Effective strategic planning requires moving away from conventional, technical water management approaches (built –infrastructure) towards more integrative landscape ecology-based approaches (ecological infrastructure). Native landscapes and ecosystems should be protected, managed, and restored through strong public and private partnerships.

Ecological infrastructure planning should be integral to a comprehensive landscape planning effort, including consideration of the development suitability, open space resources, wildlife habitat protection, and scenic resource management.

Ecological Infrastructure planning approach provides a positive alternative design to urban form and growth patterns and safeguards a sustainable ecosystem essential for the livability of the area , sustain air and water resources and contribute to health and quality of life in watershed areas such as Angat River basin.

'Evidence of a deteriorating ecological infrastructure will include increased salinity, acid soils, nutrient pollution, carbon depletion, changing patterns of runoff, recharge and river flow, and declining connectivity between floodplains and streams. Landscape planning is an inherently strategic activity. It strives to craft policies and actions that systematically address the trends and forces that shape and change landscapes. Strategic planning is driven by goals that are focused, linked with implementation, and presumed to be achievable. When strategic planning is informed by a landscape ecologically informed understanding of pattern: process dynamics, and is guided by appropriate spatial concepts, it may form a sound basis for plan development and implementation.

When the existing landscape supports the abiotic, biotic, and cultural resource goals, a protective planning strategy may be employed like in the case of Bustos Dam. Essentially this strategy articulates the spatial pattern that is desirable and protects it from change. Conversely, it defines the areas in the landscape where change can be accommodated. The protective strategy is useful in relatively undisturbed landscapes and can often be applied at low cost. Ironically, it is difficult to promote politically because, by definition, it is used when the landscape is already functioning well. While landscape planners attempt to be forward thinking and anticipatory, human nature is often reactive. In this case, education and public awareness are useful to promote understanding of the issues and strategic options available.

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