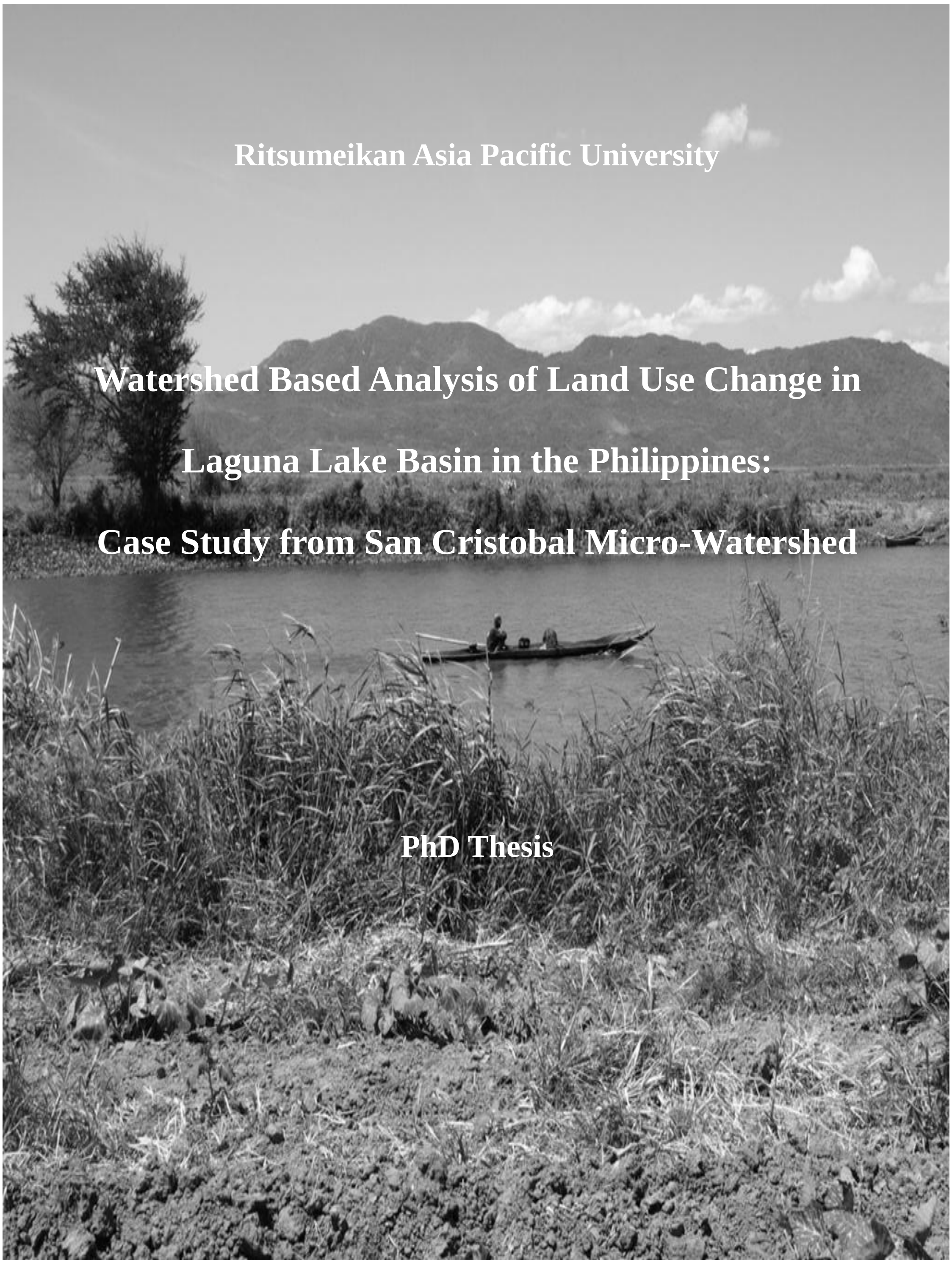

Ritsumeikan Asia Pacific University

Watershed Based Analysis of Land Use Change in Laguna Lake Basin in the Philippines: Case Study from San Cristobal Micro-Watershed

PhD Thesis

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List of Abbreviations

CCM	Component Cities and Municipalities
CDP	Comprehensive Development Plan
CLUP	Comprehensive Land Use Plan
DAR	Department of Agrarian Reform
DENR	Department of Environment and Natural Resources
DILG	Department of Interior and Local Government
DOT	Department of Tourism
DPWH	Department of Public Works and Highways
DTI	Department of Trade and Industry
HLURB	Housing and Land Use Regulatory Board
HUC	Highly Urbanized Cities
ICC	Independent Component Cities
IEMP	Industrial Environment Management Program
LGU	Local Government Unit
LGC	Local Government Unit
LISCOP	Laguna De Bay Institutional Strengthening and Community Participation Project
LLDA	Laguna Lake Development Authority
NGO	Non Governmental Organizations
PA	Provincial Agriculturalist
PPDC	Provincial Planning and Development Coordinator
PPFP	Provincial Physical Framework Plan
RA	Republic Act

Preface

The scale of the environmental system studied in this thesis is not very strictly confined to a scope of *regional* or *local* but refers to both. Still, a greater importance has been given to the local, but often with a reference to the regional. This is also important, I think, from the standpoint, that this type of an approach brings the problems and prospects of generalization, which every research is bound to do at some point, with reference to time and space. It is also important for me, who is not a native person to the Philippines to understand the problem with reference to an area greater in size, yet which is functionally related to the system studied and the main problem. The river basins are taken as the *functional spaces* because with altered land use, they become the pathways of environmental change in the lake basin, while the lake being its receptor. Therefore, my approach here is to study the land through the functional spaces and not the regional or the local, yet, they are referred whenever it was necessary (due to the nature of secondary data found on the regional basis). The aggregation of river basins, 24 of them, gives the identification of the lake basin. Furthermore, a river basin is considered as one of the vital features of addressing water resources, especially, fresh water resources. Without the river basins freshwater does not flow over the earth's surface in perpetual motion, and will also not curve the landscapes in such as a way that water is available for use in the human society, as rivers and underground aquifers are intricately related, without infiltration from the river basins, aquifers are not formed and sustained. The second of such functional spaces is the shorelands of the lake, the thin strip of land and water that make the littoral and extends to the epilittoral zones. Here, I have used the word shoreland rather than land water interface. This is because by definition the land water interface means the areas of land which goes underwater during the time of high water. They indicate a well defined area, like the river basins which have a definite boundary. The shorelands however, does not have a *definite* boundary and extends up to the epilittoral zones. It is due to its vagueness in definition that the shorelands has become my second area of exploration in studying landscape alterations. Also, it is to be noted here, that I have used Hutchinson's (1967) definition of lakeshore regions because of its comprehensiveness over Ostendorp's (2004) idea of calling it as riparian zone.

The functions that deteriorate or preserve the lake ecosystem are conceptualized as the social systems, this is because we, the humans are inside the society, therefore the assumed events of deterioration or preservation of the environment becomes a social concept. To elaborate on this a bit, it can be interpreted that the state of the environment we are in can be explained by two dichotomist concepts of environmental determinism and environmental possibilism that has revolutionized geography and environmental anthropology in the early 20th century until today. The state of the environment can be explained by environmental determinism, saying that the environment is actually guiding us in bringing the change; this makes the concept of sustainability a utopian one. If it is the environment, which is guiding us, then the environmental deterioration are also embedded in the society by the forces of nature. However, as human beings, we socially can separate ourselves to understand our impacts over the face of the earth, because this can be a method in itself to know ourselves, and through ourselves, put a lens to the world we act upon. Thus the theoretical lens can be the human society itself.

In the present work, I have used terms such as ‘carrying capacity’ often. The use has been applied not to measure it quantitatively, or argue about the notion, but the term has been used as a notion, to understand the ecosystem health with indications of the exceeding of the carrying capacities often in qualitative terms.

Acknowledgements

I owe my greatest debt to my supervisor, Professor. Fancisco Fellizar, Jr. for his guidance and support throughout the PhD program. I am grateful to Prof. Fellizar for his kind cooperation and support for the fieldworks in the Philippines. He has been a most resourceful guide in the academic matters as well as a mentor in life. Without his valuable inputs, this thesis would not have been possible to complete. For the fieldwork, I am deeply indebted to the support and hospitality of the Laguna Lake Development Authority members during the fieldworks in the Philippines, from helping and advising for data mining to accommodation during fieldworks.

I am deeply indebted to Professor Sanga Ngoie Kazadi for this research. It is for him that I, even not being a student of science, got interested in the study of land use changes, which I thought of implying in understanding the man-environment interactions in my chosen study area to analyze from a human geographical viewpoint.

Sincere thanks Ms. Oonk Emiko Tachikawa, my brother Mr. Abhik Chakraborty, and Mr. Max Caughron for the checking the English of my thesis. I would also thank Mr. Eid-Ul Hasan, Mr. Shantanu Saha, and Mr. Dhruv Anand for helping me when printing my work. I would like to express my thanks also to Ms. Julia Toteva for her efforts in making many charts and tables in the thesis.

Lastly, but not the least, I wish to thank my mother Mrs. Mitali Chakraborty, and my brother Mr. Abhik Chakraborty for their love and support throughout my life. My mother has always encouraged me to go out, and see the world to have my own interpretation about the events that are being played. It is for her enthusiasm that I, often not a native person have felt free in choosing the lands and people I study, even if they are geographically and culturally apart. My brother on the other hand, has always pushed me not only by critical discussions about methods or analysis, which have made it possible for me to understand them better and helping me edit my work, but also by supporting the household while I was writing the thesis.

Abstract

Integrated Water Resource Management has gained significance as a community based approach for sustainable management of water resources. However, the implementation of this notion has been problematic due to fragmented administrative structures, conflicting and contradictory sectoral decision-making process, disconnected local, regional, and national level decision-making and resource use activities at the catchment level. The present research seeks to understand the political-ecological processes that are involved in the use of land and water in a micro-watershed environment of the Laguna de Bay Basin, in the Philippines. The lake and its watershed has been of much concern for policy-makers, planners and scholars for constantly deteriorating water quality and diminishing fish catches due to rapid industrialization and urbanization in the watershed. The Laguna de Bay Basin has been regarded as a vital resource due to its productive fisheries, as source of irrigation, its role in local transportation and as a source of coolants for industrial power plants. The lake's deterioration in terms of ecological productivity in spite of the presence of a number of environmental organizations is a puzzle for planners, policy-makers and scholars.

Watersheds are hydrological units that play important roles in the management of lake environments. However, the majority of the works on water resource management in the Laguna de Bay Basin addresses the issue of environment through an assessment of water scarcity or water quality deterioration of the lake mainly and their implication on the people who are dependent on the lake for their livelihood. This research approaches the problem of the deterioration of Lake Ecosystem functions as a result of land use and changing land use patterns in the surrounding watersheds.

The thesis focuses on understanding man-environment interaction within a particular watershed of the Laguna de Bay Basin. The theoretical frameworks have been drawn from the review of literature about land use changes and water resource management and its evolution for the past 80 years. The research stems from observed serious deterioration of the lake ecosystem. The study involves the analysis of one of the least studied but most heavily converted landscapes of the San Cristobal Micro-Watershed.

It has been found out that the watershed of San Cristobal has undergone profound changes in its land use since the independence of the country to present. The most severely altered landscapes are forests and brushlands, and there has been an increase in agricultural and built up areas.

The effects of policies, their changes and overlaps have been explored and identified as major concerns for creating livable environments for the population of the lake basin.

Massive land conversion in the river basin similar to what took place in Manila in the 1940s created serious impacts to the lake environment. The political-demographic-economic factors shaped the landscape but these factors do not provide for sustainable natural and human environments in the lake basin. This happened in spite of the presence of one of the country's leading academic think tanks, and a number of institutions accountable for the management of land and water resources.

The main challenge for an integrated, sound management of land and water resources in the Laguna de Bay basin is in creating conservation spaces within the peri-urban areas. This is applicable especially to the lowland riparian areas of the Micro-Watersheds of the Laguna Lake, and the landscapes which are on their way to recovery from past land clearing activities. Involvement of locals for sustainable land use decision making is needed. Especially conservation practices are needed in the Eastern tributary watersheds which have not undergone massive land conversions like the San Cristobal watershed. It is argued that urbanized landscapes still have ecological value, and development policies in these regions must not allow indiscriminate conversions. This is to make sure that the present areas of biological hotspots in the lake's watershed continue to support the Lake basin ecology and the livelihood of the people.

Chapter 1

Introduction and methodology

1.1 On land use changes

Landforms continually change due to both ecological and economic forces. While the former is a long term process acting on geological timescale, the latter is human driven and has been increasingly intense in recent times. Economic forces are powerful and often impose sweeping changes on landscapes that had slowly evolved over millennia. A synthesis of these two forces is the ideal framework to understand the nature and management of ecosystems in the modern era. However, such a synthesis has often been found wanting where it is most needed. This is especially the case in developing countries where wealth and market forces have often subjugated the ecological integrity of landscapes rich in flora and fauna.

This research aims to analyze land use changes and their impacts on water resources management from a social-ecological perspective. Land based human activities tend to have most adverse impacts on the world's freshwater resources. According to Lambin & Meyfroidt (2010), land use transitions can broadly be divided into exogenous factors, consisting of socio-economic forces, and endogenous factors, consisting socio-ecological forces. Thus, a couple of general theoretical frameworks can be applied to understand human-environmental interactions. The first of these is a human ecological approach, which focuses on the endogenous or socio-ecological factors that change landscapes, while the second is a political ecological approach which concentrates on the role of exogenous or socio-economic factors in landscape changes.

The human ecological dimension of land changes stems from spontaneous and planned actions of human in their environment. Put simply, it explores how nature and culture are inter-related. From this point of view, humans are one of many ecological forces acting on the landscape. On the other hand, the political-ecological lens focuses on the effects of man-made systems or resources on the environment. Generally, the political ecological lens, therefore, is much more critical to the role of human actions on the environment and involves not only observation and interpretation, but also possible rethinking and regulation of human actions.

Both of these schools of thought have developed at intersections of various disciplines. The concept of political ecology is broader in scope compared to political economy as it addresses the interaction of human individual and the environment. A central insight derived from the human and political ecology standpoint is that unlike most of the creatures of planet earth, humans do not always depend directly on their immediate environment; and complex processes and factors such as division of labor and importance of technology weaken the link between humans and their immediate environment. These factors shape human demographic patterns and survival techniques (Hannigan, 1995) and in doing so, play a unique role in changing landscapes.

Consideration of these complex processes and factors gave rise to literature in latter half of 20^{th} century that saw non linearity emerge as a major attribute of environmental changes. One of the first propositions on using non-linear relationship in understanding environmental change came from the Annales School of History, as far back as in 1949. Braudel (1949) proposed that environmental change must be understood as a complex interaction of short term events, medium term processes, and long term structural processes. In this sense, the Chaos Theory provides a firm theoretical platform to understand the non-linear processes that drive environmental changes. Specifically, Chaos Theory proposes that sustained ecological balance may not be possible because of the chaotic relationships between the complex components of the ecosystem. Chaos Theory was adopted from Henri Poincare's treatises in mathematics going as far back as 1880 (Wolfram, 2002). A more direct approach using Chaos Theory to study the interaction between man and environment came from the works such as

Rappaport's (1967) study of the relationship between culture (rituals) and environment (management of local pig population)[1]. Rappaport's pioneering study shows that the relationship between man and the environment is nonlinear and can therefore only be understood using non linear dynamics.

Great advancement has been achieved in the study of changes in the land use and land cover in the last 4 or 5 decades. Meyer (1996) explained that land cover is the biophysical character of the land and its physical state. Therefore, land cover analysis provides an ecological understanding of the land. Land use, on the other hand, is the human or political ecological dimension of land cover,[2] as it refers to the action of humans on earth, as understood by the appropriation of land resources for economic reasons.

Several methods have been developed for understanding the temporal and spatial dimensions of land use and land cover change. Remote sensing projects including the BIOME 300, and HYDE 300, Millennium Ecosystem Assessment (MA), combined with the field of historical ecology have opened the door for assessing ecosystems, not only in long or short time scales but also over spaces, which may span

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[1] Roy Rappaport, in his study on Tsembaga tribes in the highland of New Guinea, studied to trace caloric flows through the village ecological system. Rappaport showed the importance of ritual cycles, to control the population of pigs, swidden agriculture, and even tribal wars with neighboring tribes.

[2] Note that human and political ecology has been put together as both can be treated as in the similar school of thought, i.e. putting ecological ideas in the social sciences.

from the local to the planetary. Remote sensing employs an array of tools and analytical techniques to gather data needed to assess land changes over a variety of geographic and temporal scopes[3]. Today, remote sensing has become one of the most common methods for scientifically analyzing man-environment interactions.

Whereas remote sensing techniques are useful in understanding shorter term land use changes, the field of historical ecology, on the other hand, involves a much longer time scale, ranging from years to even centuries, producing methods to understand long term changes in the landscape. However, historical ecology lacks generalization, as it is most effective in studying the local landscapes. With remote sensing's advancements in methods and scopes, and its integration with historical ecology specific projects like BIOME 300 and HYDE 300 have been developed, which address the landscape changes in both long timescales of approximately 300 years over and large spatial areas that is continental to planetary in scale (Goldewijk, 2001; Goldewijk & Ramankutty, n. d). The Millennium Ecosystem Assessment uses a combination of remotely sensed as well as ground data producing information on land use changes for several decades with a global to regional focus (Alcamo & Bennett,

[3] Remote sensing has advanced to study the planetary geology by even analyzing the atmosphere and geology of other planets, thereby addressing the uniqueness and importance of biological processes of the earth. Such an understanding has given support for the Gaia hypothesis, and development of ideas such as 'spaceship earth'.

2003). Both the MEA and BIOME techniques integrate data through remote sensing and empirical observations. Historical Ecology, true to its name, tries to understand human influence over the earth for several centuries to several millennia. Although historical ecology focuses on the human dimensions of environmental change, the field sees human actions more as force acting within the ecosystems. Thus it treats human systems as integral parts of ecosystems.

Since the 1980s quantitative modeling approaches to understand the land changes have become more numerous. Some of the important quantitative land use studies have included both economic (Michael, 2004, Newbarn et al., 2005; Michael et al., 2008; Irwin, 2009; Vandelen, 2010; Wallace, 2010) and non-economic (Batty et al., 1989; Ludeke et al., 1990; LaGro & DeGloria, 1992; Flamm & Turner, 1994; Veldcamp & Fresco 1996; Anderson, 1996; Clarke, 1997; White et al., 1997) modeling approaches to understand the effects of economic, social or environmental variables on the changes in land use. Others have tried to establish land use change characteristics from the context of regionalism, or locale (Blacksell & Glig, 1981; Helmsing, 1986; Pacione, 2002; Patsey, 1988; Kivell, 1993; Stanilov, 1998). It is important to investigate how the non-human environment interacts with human-generated processes and this requires that land use studies are contextualized in the form of case specific investigations. This is because environmental problems are the result of complex interactions unsuitable for making universal generalizations, (Swanson & Johnston, 1999; Kueffer, 2006).

There is probably no single theory which can account for all changes in land use patterns over time as land use varies over space and time due to a range of economic, social, and ecological factors. Changes in land use can be explained by the particular forces or events that alter the environment in a specific way (Vayda, 2009). The idea of explaining landscapes through 'event ecology', as Vayda puts it, does not need any particular theoretical lens to explain landscape changes. Vayda's theory of no theory supports the perspective that nonlinear relationships define the land use of a given region. The event ecology approach to land changes explores why such events occur in a given area in an inductive manner rather than employing an overarching general theoretical framework, or a preconceived notion held by the researcher. (Vayda, 2009; 139-142). Event ecology does not disregard the explanatory usefulness of the political or human ecology approaches, but provides a open-ended and wider lens to understand the processes in global change studies.

1.2 A River basin and its characteristics:

The present research explores the social-ecological characteristics of land changes in a micro watershed located within the Laguna de Bay basin. The definition and understanding of a river may be different according to our interaction with the landscape. A river is a morphological force which, coupled with mass wasting and erosion, tends to balance erosion and deposition in a given area. When a river achieves this equilibrium, then it is said to be in a graded state. Mackin (1948) states that,

> A graded river is one in which, over the period of years, slope and channel characteristics are delicately adjusted to provide, with available discharge, just the velocity required for the transportation of the load supplied from the drainage basin. The graded stream is a stream in equilibrium; its diagnostic characteristics are that any change in any of the controlling factors will cause a displacement of the equilibrium in a direction that will tend to absorb the effect of the change. (Mackin, 1948; 471)

This implies that a river's grade is a slow but powerful process capable of significantly changing a riverine landscape through time. This also implies that once an environmental change has occurred it will likely remain a long term characteristic of a given stretch of river for a considerable period of time, and the river tends to absorb the change in its new hydrologic regime, which now shifts into a new equilibrium state. In addition to changes in Grade, river systems respond to environmental change through complex and non linear ways both geologically (Schumm, 1977; Morisawa, 1985), and biologically (Chadwick et al., 1986; Gore & Johnson, 1980; Yount & Niemi, 1990). This implies that, anthropogenic impacts on the rivers and their basins are complex and have responses which are non-linear. Planning river restoration policies and projects without addressing the target areas' land use history may lead to unrealistic goals (Wohl, 2005). In this sense, often, the most common indicators used for the assessments of river degradation are chemical, biotic, physical, hydrological, and landscape based ones (Gergel et al., 2002). However, human experiences are also powerful tools to assess changes in a river's steady state. Findlay's (2002) work on stories of families living by the threatened Lachlan River in the Murray Darling system in Australia shows how human experiences and memory can be sources of vital information for understanding a river's unique nature. This is also because locals often see the river and its biotic communities as 'fellow living beings'. This philosophy is quite different when compared to planners and policy-makers who use more technocentric approaches to river management (Kada, 1999).

Human use of a river basin changes the patterns of gradational characteristics of that river. These changed gradational characteristics are called riverscapes[4]. Cutting irrigation channels, building large dams, increase in pollution; all of these bring changed patterns to the gradational characteristics of a river and make it shift from its 'natural' state. The changes in channel characteristics through irrigation canals and dams use the

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[4] 'Riverscapes', (after Haslam, 1991), implies involvement of human activities in riverine landforms. The term may be thought in contrast with terms such as 'fluvial landforms' which is a geomorphic term exclusive of human actions.

gradational characteristics for production. On the other hand, pollution added into the channel uses the gradational characteristics for creating sinks for the byproducts of consumption. Furthermore, the case of pollution introduces the question of human consumption patterns as a factor of land use change in the river basin, which impairs the gradational characteristics of the river.

1.3 Rationale of the research

The functions of a river basin are in a state of dynamic equilibrium (Newson, 1997) at any given time. This equilibrium is the result of regulation functions and exploitation functions[5]. Regulation functions help the exploitation functions to keep the 'dynamic equilibrium' of a river basin to be in balance. Often river systems, under increased human modifications, cause disturbances in natural regulation functions leading to changes in exploitation functions. This change in the exploitation functions has often been the cause of resource depletion and rising human conflicts between groups competing for river resources (Ibid). As lakes constitute the base level of erosion of the surrounding watersheds, they provide a useful case in environmental changes

[5] Regulation functions include a rivers natural ability to maintain or to move back to its original steady state following a change, whereas exploitation functions are those which are used by humans.

with the associated causes, pathways and receptors[6]. For example, deforestation in the steep upland areas of a watershed may increase the sediment load in a river which acts as a pathway to carry the sediments into its receptor, the lake. Since the basin area of a lake is by definition smaller than the large river systems which drain into the seas it represents an optimum geographical space to study the above phenomena. Furthermore, it is possible to divide lake watersheds into geographical subdivisions such as region: landscape, stream corridor, streams, and reaches. These subdivisions make it possible to give both in-depth analysis and generalizations.

The target lake for this case study is the Laguna de Bay Basin in the Philippines. With an area of 90,000 hectares (Santos-Borja & Nepomuceno, 2006), it is the second largest lake basin in Southeast Asia after Tonle Sapin Cambodia. The Laguna basin has a high population density with an estimated 6 million inhabitants (Santos-Borja & Nepomuceno, 2006). This high population density makes it an ideal lake basin to explore the problems and prospects of integrated land and water resource management (IWRM) in the context of Asian lake basins. In addition, research on lake environments with high population density is relatively scarce, and the majority of such

[6] The 'causes' are the source of environmental changes, 'pathways' are the systems through which this environmental change moves and 'receptors' are systems which are influenced by the environmental changes through the pathways. Thus, industries, rivers and sea are respectively the examples of causes, pathways and receptor of marine pollution.

studies are concentrated on lake environments in Africa (Lamberts, 2006), and this research derives its significance from this background as well.

1.4 Analysis of human-environment interactions in the Laguna de Bay Basin

The Laguna de Bay basin is a bioregion with a phenomenal productivity which sustains the Philippine's largest urban agglomeration. It is the largest lake in the Philippines and one of the largest in Southeast Asia. The lake basin consists of 14 cities, 49 municipalities, and 66 local governments spread over 6 provinces. The diversity of different institutions in the basin, associated land conversions, and political forces working behind them are major concerns for sustainability in this bioregion (Kelly, 2003).

The lake ecosystem provides a range of livelihood opportunities to the local communities. It has a heavily urbanized basin due to the proximity of Metropolitan Manila, which serves as the main trading and business center in the country. The Lake basin has a total area of 3820 sq.km, of which about 2920 sq.km (77%) is belongs to its tributary watersheds (See Figure 1.1) (Santos-Borja & Nepomuceno, 2006). The lake is severely polluted by international standards, its water unsafe for consumption and its shores are a virtual garbage dump for the Manila conurbation. The garbage mixes with the lake during the high tides and the wet season, and the severity of the lake's pollution load increases in the process. This tragic situation is compounded by poverty and corruption, both of which remain high in the Philippines. Such characteristics provide an interesting background to investigate how politico-economic factors impact resource governance in a typical Southeast Asian Country.

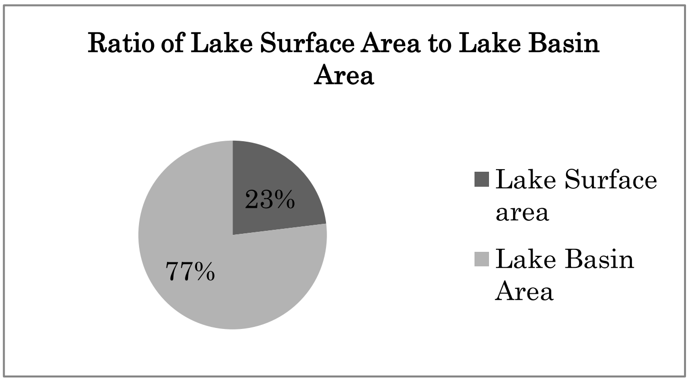

Figure 1.1: The ratio of the lake surface area to its total watershed area

The land immediately surrounding the lake plays a dominant role in the long term sustainability of the lake's ecosystem. The 24 tributaries of the lake reflect the characteristics of the lands they traverse, and these characteristics influence the ecosystem of lake. Therefore, to understand the state of the water resources in a region an assessment of the land based activities is needed at the particular spatial scale.

The San Cristobal, the river basin chosen in this study poses a special case for research. With an area of 14,100 ha, the San Cristobal is a relatively small watershed which allows the researcher to carry out fieldwork throughout its area. Although the San Cristobal watershed contributes only 5% of the total runoff to the Laguna Lake, it is one of the most polluted in the region. Its watershed is situated at the edge of Metropolitan Manila. Rural areas begin from the San Juan River Basin, situated to the south of the San Cristobal; indicates that urbanized spaces of the San Cristobal watershed are relatively new. Furthermore, the close cohabitation of urban and rural spaces allows us to understand the interaction between the ‘urban’ and the ‘rural,’ and associated processes of human interference on the landscape. Based on this geography, this research assesses of change through ‘space’ in San Cristobal river watershed which feeds into the Laguna de Bay bioregion, and through ‘time’ by carrying out a historical study of land use change in the river basin. The shoreland regions where the tributary rivers meet the lake are the most ecologically complex landforms in the basin. These regions are situated between the littoral and the epilittoral zones of the lake. Freshwater input to the lake originates in the 24 tributary channels, which flow through this important ecologic zone. Saltwater environments, on the other hand, are influenced by tidal inflows from the Manila Bay through the Pasig River.

There have been numerous studies on the relationship between land use changes and the state of water resources. Scientific projects, beginning in the 1970s, address issues of natural resources in crisis. This crisis has been caused by several factors including explosive growth of human population in the 20th Century, changes in human consumption patterns based on occupational specialization[7], increase in the gap between the rich and the poor, along with emergence of consumption patterns increasingly governed by market forces at all levels of the society, which increases the total consumption of resources. Despite this increased knowledge on ecological issues there is little interaction between science and policy (Bocking, 2004). The dynamic between science and policy needs further study in the context of water resource management in urbanized lake basins. The main problem of urbanization is the degradation of natural resources. However, urban areas can be beneficial, as they can shelter the poor and can offset stresses in the vulnerable ecosystems by conservation efforts. In fact the idea of conservation grew from urban regions (Tarn, 1985). In the context of the present research, the Laguna de Bay Basin; is surrounded by a complex environment of urban, peri-urban, rural and forested areas which give the water environments their present character. This gives ample scope to understand how policies and natural resource management are related to each other locally, what are the relations

[7] as the former is a quantitative increment, the latter is related to resource use in qualitative terms, setting the outputs to a maximum while spending lesser and lesser man power

between local and the regional land changes, how the functions of resource complexes are changing, and how social processes are related in general to land and water resources in the area. A more systematic account of the main inquiries studied in this research follows.

The research is centered on understanding the land use changes in a lake basin, and tries to identify their relationship to the related social phenomena through literature review, field observations and interviews.

The principal inquiries made in the research are:

- What are the general characteristics of land use in the lake basin? How can changes in land use be interpreted ecologically?
- How did urbanization change land use in the basin? What role does urbanization play in promoting sustainability of the lake basin? How can change in land use be interpreted sociologically?
- Which areas in the lake basin are under the most rapid transition and what are the possible ecosystem values of these spaces that urbanization replaces?
- What role do policies have in the land use changes in the basin? What are these policies and how are they affecting the lake basin? Are there policy gaps and overlaps? Who and how are decisions made? What are the social

and environmental effects of rapid land use changes?

1.5 Assumptions, methods and framework:

1.5.1 Assumptions

The present research stems from pragmatic knowledge claim, which means that the main inquiry of the research is generated directly from the problem. The pragmatist knowledge claim approach is derived from the works of, Rorty (1983), Murphy (1990), Patton (1990), and Cherryholmes (1992). According to Creswell (2003), pragmatist inquiries lay the foundation of multiple research methods. In this type of inquiry, the researcher is more concerned with the research problem and uses pluralistic approaches to answer the research questions. Creswell further defines following characteristics of the pragmatic research approach;

- The researcher is free to choose the methods, needs and procedures he/she thinks as appropriate that best fits the purposes.
- Pragmatism applies to mixed method research and is not committed to any one philosophy.
- Pragmatism looks to many approaches to collect and analyze data rather than describing the world in only one way.

- Pragmatists believe that truth is what works as a satisfactory explanation at a certain time. Following this general philosophy the researcher thus mixes different research methods to best answer the research problems above.
- Pragmatic researchers look at the 'what' and 'how' questions more in the research. However, a purpose for mixing the different research methods needs to be established:
- Pragmatists acknowledge that research takes place in different contexts, social, historical, political or any other, meaning that a research may need a theoretical lens that is reflexive of social justice and political aims.
- Pragmatists believe that we must stop asking questions about reality and the laws of nature.

(After Creswell, 2003: 12)

The present research is a response to the problem of deterioration of watershed functions in a tributary watershed of the Laguna de Bay Basin. Taking this problem as the most important research inquiry, methods are mixed to understand its causes and consequences. The research, therefore, takes a multi-methodological approach with a mixture of qualitative and quantitative techniques in both desk and field research. Desk research is done with literature reviews of works on Laguna de Bay and other of Asia's densely populated lake and river basins, and analysis of data from secondary and primary sources; while field research includes observation, information collection, individual interviews and field surveys. Therefore, it can be said that this research follows a mixture of different qualitative methods and descriptive quantitative statistics in an overall qualitative framework. The qualitative framework in field research gives the researcher a comprehensive perspective (Babbie, 2001). A qualitative framework is included into the research as purely quantitative methods will not allow the researcher to understand many of the underlying mechanisms and the drivers of land changes (Young et al., 2006).

The study attempts to keep the research methods as open as possible in the initial information gathering stage. Information was gathered from Laguna Lake Development Authority with some key in-depth interviews with the officials. This was done to understand the current understanding of the lake, its general land use, and the particular ecological problems it is facing. The second stage examines the processes of rapid changes in the upstream areas of the river basins. A river basin has been chosen which has undergone urban changes and is situated between the urban and rural interface. In the next stage, inquiries were made to understand changes in the downstream parts of the river basin. The researcher also ventured to other river basins, to understand the processes better, with particular emphasis on understanding the processes of urbanization. This is because urbanization spans to the rural areas and the spaces of natural conservation.

The respondents chosen for in-depth interviews[8] included officials from environmental organizations that are accountable for the management of the lake and its ecosystems, villagers, farmers, village captains, and other local residents (such as tricycle drivers, boatmen etc) and students. In the course of the research a total of 46 respondents were interviewed[9].

The research objectives were:

1. Describe the patterns of land use changes in the San Cristobal Micro Watershed in the greater context of land use changes in the Laguna de Bay Basin;
2. Identify the different policies, actors, and activities in the basin and their relation to the past and present land uses;
3. Describe and explain the nature and level of integration between policies, and the development projects as far as the sustainable utilization of watershed land use is concerned;

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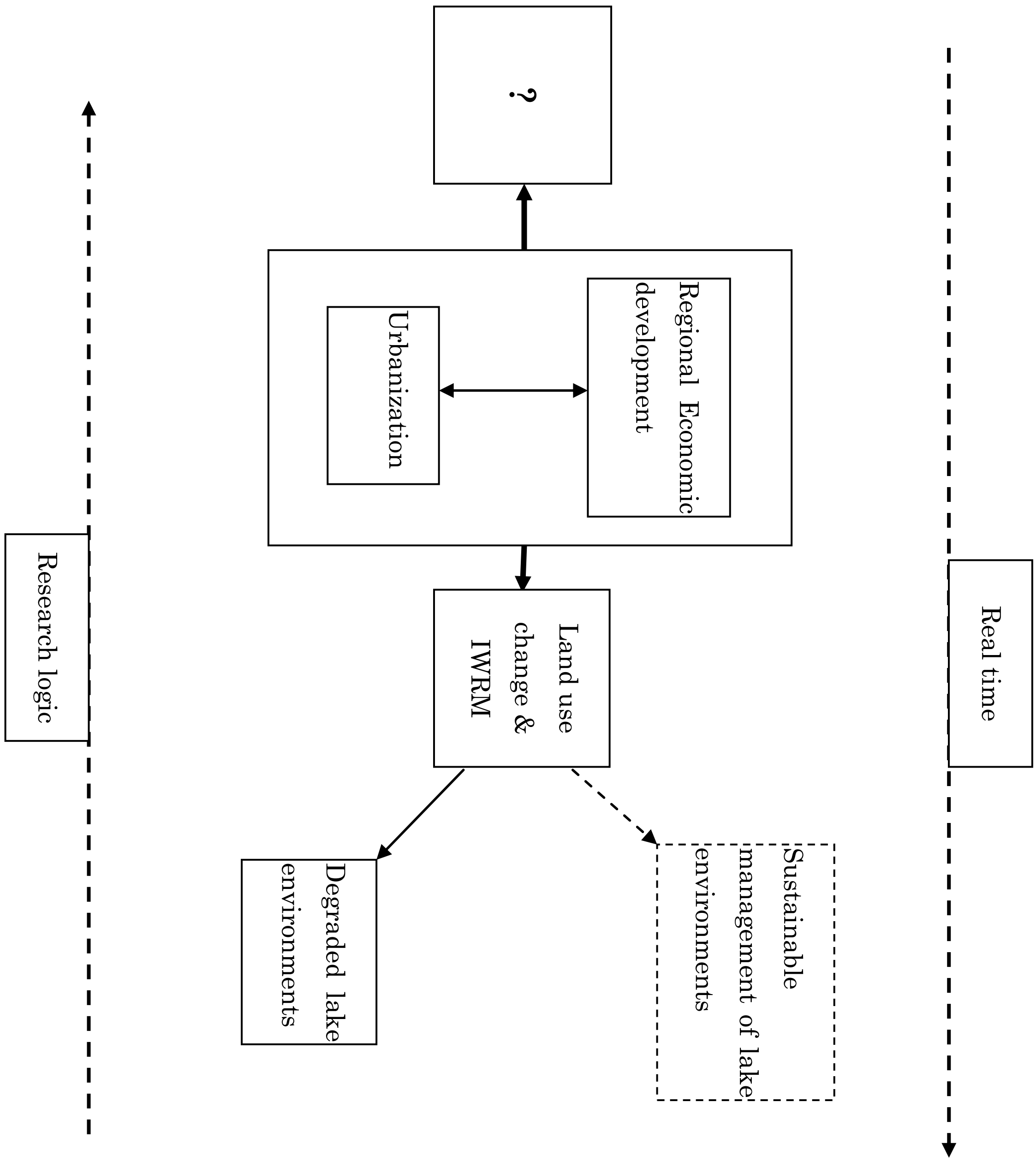
8 See appendix 2 for details.
9 For a more detailed description of respondents, see Appendix 2.

4. Describe the pattern of integrated land and water resource management in the Laguna de Bay watershed;
5. Identify mechanisms for policy integration;
6. Provide recommendations for integrated land and water resource management focusing on politico-administrative integration.

The assumptions and the logic on which the research is based are given below: The flow chart represents the assumed situation of the lake environments. At present we observe degraded landscapes in the lake basin. As economic development and urbanization have played a dominant role in shaping the landscape due to the proximity of the lake basin to Metro Manila, these are taken as intervening mechanisms. The main inquiries therefore are: what caused these mechanisms to take shape, which induced land use changes in the lake basin, and what are the consequent impacts on the sustainable waters resource management in the region?



?
Regional Economic development
Urbanization
Land use change & IWRM
Degraded lake environments
Sustainable management of lake environments
Research logic
Real time

Figure 1.2: Research logic

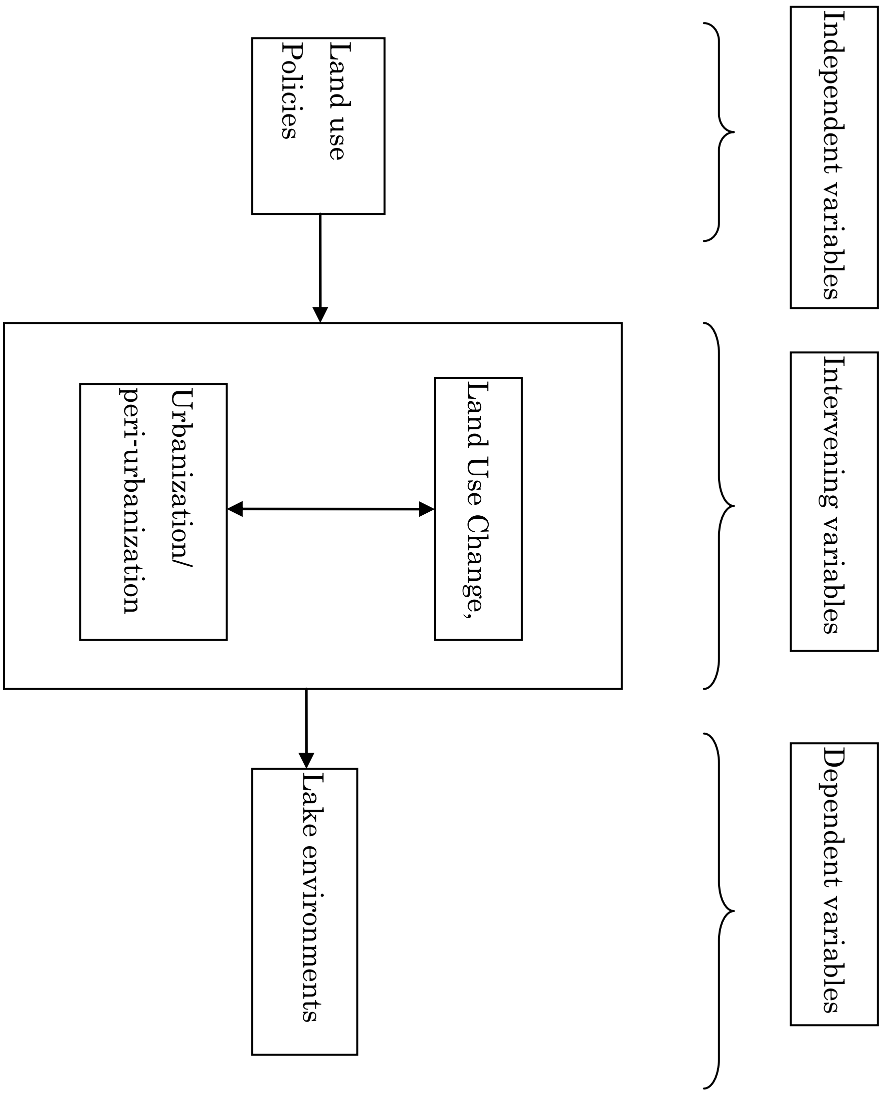


Figure 1.3: Diagram showing different variables in the research and their relationships.

1.5.2 Research questions:

This research raises six specific questions which are provided below;

1. What major changes in the land use have taken place in the selected study area of the Laguna de Bay watershed for the past 59 years[10] (1944-2003).
2. What are the mechanisms of changes of changes in land use and what kinds of landscapes have been adversely affected?
3. How are the social and economical processes related to the alteration of land uses? How are the land use policies related to these land use patterns?
4. How is land and water resource management internalized in the land use policies of the region?
5. To what extent does integration of policies relate to sustainable land use decision-making in the selected watershed?

[10] This research looks at land cover change across time in the study area. Two sets of data were found to be most reliable in this relation. One, the maps produced by Corps of Engineers of the U.S. Army in 1944. These maps were the results of compilation from other maps (Luzon 1:31,360 in 1940; Commonwealth of the Philippines 1:200,000 in 1939; Communication Map of Philippines, 1:400,000 in 1927; Mobil Oil Road Map, 1:1,100,000 in 1942; and Stereo Compilation by USGS from oblique photography in 1944). The integration of spatial data with Aerial Photogrammetric Mapping gives these maps greater accuracy among the old maps. Second, the 2003 land use map done by LLDA from SPOT 5 data of 2003, which gives high resolution images implying greater accuracy. As I am not an expert in directly compiling maps from raw satellite images, I have taken the help of secondary sources (described above) to combine data, which gives a medium term perspective of land use changes with optimum accuracy.

6. What are the challenges regarding integration of land and water resource management in the region? What issues remain unaddressed in the present case?

1.5.3 Fieldwork design and data analysis methods:

The surveys were conducted in two phases. First, to concentrate on the main problem areas, a quasi-governmental organization responsible for management of the ecosystemic services of the watershed was chosen as a key informant for the study. The Laguna Lake Development Authority was chosen in order to identify the main problems that the lake basin is facing today. This organization also has long term involvement with changing environmental and developmental processes occurring in the Laguna de Bay Basin. A detailed and descriptive background study of literature was made regarding changes in land use, and the experiences of water resource management in relation to land use changes. The main aim in this phase was to understand the present status of integrated land and water resource management in the lake basin.

In the second phase, a case study approach (exploring two cases) on land changes in the San Cristobal Watershed and the lakeshore regions was taken in order to conduct in-depth investigation of the key processes that change the functional integrity of the lake basin's social and ecological systems. These changes are expected to alter socio-economic and ecological conditions of the watersheds. The case study approach was chosen over other qualitative method such as ethnography, grounded theory or narrative approaches because of it allows the researcher to understand in depth the events, activities and processes in action (Creswell, 2003). As Punch (1998) also notes,

> The Basic idea is that one case (or perhaps a small number of cases) will be studied in detail, using whatever methods seem appropriate. While there may be a variety of specific purposes and research questions, the general objective is to develop as full an understanding of that case as possible. (Punch, 1998; 150)

Coupled with the results of phase one, the main aim of the analysis is to explore how the past and present land uses are related to the changes in land use practices. The evidences of these changes were drawn from both primary and secondary sources. Secondary data sources include literature on land use and its change and socio-economic development pathways in the study area. Literature was gathered from published and unpublished government documents, as well as academic journals. Field surveys were carried out rather informally, using open and semi-structured interviews to the respondents on a cross-sectional basis, and are supported by field observations. Less structured questions were preferred as the main aim of this initial phase was to understand the present socio-ecological problems in the lake's tributary watersheds. It was found that these tributary watersheds were some of the least studied spaces in the lake basin. Less structured questions were used as they helped researcher identify key causal mechanisms (Axin & Pearce, 2006). Two main data collection tools were information collection through open interviews and observations, often supported by photographs, to explore causal reasoning. The main aim of the field research is to bring out the degree to which social processes influence the ecosystem services the tributary river basins.

In order to understand land use changes in the San Cristobal watershed, it was assumed that counting of the areal extent of the land changes was not explanatory enough to explain the effects such changes. Therefore, types of landscapes (assessed through land use and land cover types) were chosen as the primary basis of analysis. These types of landscapes, sampled through a cross sectional basis, were then compared to the regional ecological history of the area as understood through changes in vegetation cover. The meaning of changes in vegetation cover has been investigated through various sources.

Inquiries were often cross checked by moving out in space (through field interviews and observation) and time (through secondary data) towards regions of similar geographical characteristics. These characteristics include landscapes produced by retreating or advancing natural processes, and landscapes produced by the interaction between land and water. Moving the spatial scope to a different location and analyzing different spatial samples became necessary as the areas covered by the cases under investigation have changed considerably through time. This was done by cross-checking with existing literature of previous land use practices and comparison with landscapes in other locations which retain the characteristics that were once present in the target area. This chapter presents the analysis of information collected from secondary sources and field observations.

Characteristics of land use changes in the riparian areas of the Laguna Lake were determined through analysis of the government documents including satellite imageries, land use planning maps, land use planning reports, and photographs taken from the field. These were supplemented by unstructured interviews with government officials, local residents and traditional resource users. The interviews followed an open design because of the exploratory nature of the inquiry and to understand the mechanisms of land conversions in the lake's land water interfaces. Fieldworks were done in the shorelands of San Cristobal, San Juan, and Calauan watersheds. Results are presented through descriptive statistics and qualitative interpretations of the materials mentioned above. Although by definition, the land-water-interface region refers to the geographical zone where the land and water meet, which, in this case, would be a zone at very close proximity to the lake. However, the term 'shoreland' used in this research refers to a much broader area where the presence of the lake can be felt in the livelihoods of the people as well as in the ecosystem they depend on. We use this term because the lake is functionally and biologically connected to the surrounding wetland areas which are inundated, low lying, and are inhabited by several species of fishes and mollusks.

The assessment of land use in the San Cristobal watershed is carried out by using two series of maps.

1. The 1:50,000 topographic maps of Luzon Island published by the United States Army in 1948[11].
2. The 1:50,000 land use map of Laguna de Bay basin prepared by the Integrated Water Resource Management Division of the Laguna Lake Development Authority in 2003[12].

The topographic maps published in 1948 were the result of previous topographic maps of Luzon coupled with revisions from vertical aerial photography; and, the 2003 land use maps of the Laguna de Bay Region are the result of land use

[11] These maps show land use of 1944.

[12] In the case of retrieving data from the land use maps prepared by Laguna Lake Development Authority, it was not necessary to delineate areas under different land cover types as they were already delineated. Furthermore, as LLDA used the topographic maps by National Mapping and Resource Information Authority (NAMRIA), of scale 1:50,000, it was not necessary to rescale the two maps.

classification from SPOT 5[13] data.

The following equation was used in calculating the area of different land cover types in hectares,

N/4 x100

Where, N = number of grid squares on a centimeter graph paper[14]

The watershed of the San Cristobal River was delineated[15] by roughly joining the interfluves of the watershed that lie between the San Juan River in the south and Cabuyao River in the north, since the two types of maps used different projections[16].

1.5.4 Identification and coding of land uses from topographical maps

A topographic map models the general geographic features of the land under

[13] SPOT 5 (Satellite Pour I'Observation de la Terre) was launched in May 4 2002.

[14] 2 centimeters equal 1 km in a map with a representative fraction of 1:50,000. Therefore, dividing the number of total grid squares of respective land cover categories by 4, gives the areal extent of land covers in km^2. As 1 km^2 equals 100 ha, a multiplication of areal extent of land areas in km^2 by 100 converts the land areas into hectares. Areas under respective land covers were delineated for preparation of the land use analysis for the year 1944, and the respective land cover categories were transferred to a tracing paper for quantifying the areal extent of each land use types in the watershed. This was done by overlaying the tracing paper on a centimeter graph paper. The delineated land use categories are then calculated by counting the grids, each one of which represents 1 km^2 area.

[15] It was necessary to delineate the San Cristobal watershed in the topographic Maps of 1948.

[16] The maps by Corps of Engineers, U.S Army used Polyconic Projection; whereas the maps by LLDA referred topographic maps by NAMRIA for the map coordinates using Universal Transverse Mercator (UTM) Projection.

consideration. A land use map, on the other hand, is a thematic map that shows different landscape with certain theme(s) in mind. The topographic map used in the present study is used for explaining the following land use categories in the watershed of the San Cristobal River:

1. Woodland
2. Bamboo
3. Grassland with scattered tree
4. Banana or Abaca
5. Tropical Grass
6. Rice Field

Marshlands have not been included in the map legend, though their presence can be found in the lake perimeter. Quantitative assessment of the areal extent of built up areas was done by defining such areas under the following definitions:

1. Areas having both the attributes of human habitation represented by associations of buildings and regularly or irregularly maintained roadways.
2. Associations of closely attached buildings even without existence of roadways.

Therefore, roadways alone have not been regarded as built-up areas in this study, neither are scattered lots of houses[17].

1.5.5 Limitations:

One of the main limitations of the analysis was dependency on the cross sectional analysis of the landscape. It is assumed here that a landscape of change analyzed cross-sectionally has the major attributes of the changes that have occurred there in the past. Thus it cannot provide information on the particular rates of changes in different landscapes through time.

Linguistic and cultural differences are major limitations of the surveying process. As the researcher is not from the Philippines, it was not possible to give an insider's viewpoint on many contentious issues. The problem of language was a major concern while carrying out interviews during the fieldwork.

Unavailability of micro level (village level) data in time series and unavailability of key maps placed a further limitation on the understanding of social change in the chosen municipalities. Due to this, the researcher had to rely on cross sectional analysis of the land use plans.

[17] It is to be noted, that the traditional houses of the Philippines were used to be built with woods, with village houses built with woods, bamboo and nipa (a species of mangrove ideal for making roofs of the village huts), depending on the economic situation of the owner. In either case, although the areas are *built up* however, they cannot be put with the areas of similar status now. For more, refer to Wernstedt and Spenser's (1967) book, *The Philippine Island World: A Physical, Cultural and Regional Geography.*

1.6 Thesis Outline and Structure

This thesis is organized as follows; it starts with two introductory chapters dealing with the conceptual framework, the literature review and the methodological frameworks. The third chapter is concerned about general geography of the study area. Then four subsequent chapters follow with the main argument of how landscapes are altered in the study area as an interaction of human activities. The results are compared and discussed in the last two chapters with main conclusions of the research.

Chapter One provides the introduction of this work. This chapter emphasizes on the different concepts that have been used in the thesis. Short review of definitions of particular terms has been provided. It conceptualizes the changes in land from a perspective of human intervention in the landscape reviewing literature with the scope of understanding social aspects of land changes. The methodologies and knowledge claim of the research has been introduced in this chapter.

In Chapter Two, a broad idea of the social, economic and environmental conditions of the Laguna de Bay Basin have been provided, gathering information from topographic and present land use maps, and various other literature sources.

Chapter Three basically constitutes the review of present literature about the notion of integrated water resource management. This chapter shows how the process of water resource management has evolved from issues with water resources only to issues related with both land and water resources. A special emphasis is been given to the argument of water and water resources. We often come with the examples of *green water* or *blue water*. However, status of water talked here is not about its state but its function. Accordingly, inquiries are made about the regional water resources through land use. This is because the land and the water are functionally connected.

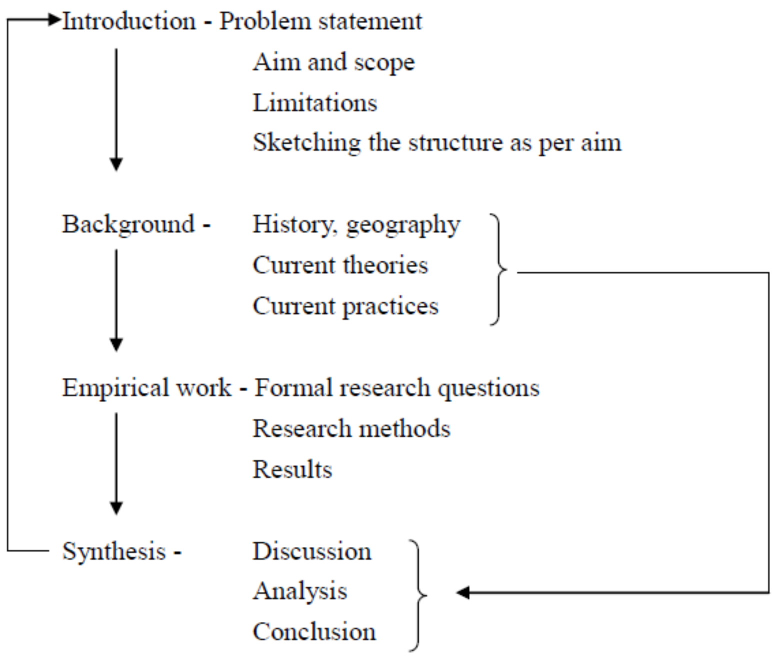
Chapter Four presents a study to understand how human influences change the general landscape of the Laguna de Bay Basin. An account of such changes in landscapes has been given in the background of landscape changes in the Philippines, exploring the trajectories of human influences on the landscape. The analysis has been based primarily on the vegetation patterns in the Lake basin. An account of the changes in the landscape in San Cristobal Micro-Watershed has been given in this chapter. The San Cristobal is a Micro Watershed in the peri-urban area. The argument of landscapes of alteration and recovery has been explored in a micro scale with this watershed as a spatial sample, thereby addressing the human influences in a hydrological unit to understand the state of land and water resource management.

Chapter Five is a study of the processes of urbanization in the shoreland regions of the Laguna Lake, which is another spatial sample used in the research. The ecological significance of the lakeshore regions for sustainable human environment has been explored. An account of the shoreland regions has been given which are more peri-urban rather than rural. The status of the lakeshore regions in the background of land use policymaking in the regions has been explored.

Chapter Six gives an account of the main driving forces of land changes in the Laguna de Bay Basin with references drawn from the analysis of the previous chapters. Spatial sample for this chapter includes the municipality of Calamba and Cabuyao. How the land use policy processes trickle down from the national to the local policies has been explored with analysis of their consequences in the land use.

Chapter Seven, describes the main conclusions of the thesis.

The general structure of the thesis is as follows:



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Chapter 2

General Geographic Features of the Laguna de Bay Basin

2.1 Introduction and objectives

This chapter provides a general geographical background of the Laguna de Bay Basin. Special attention is given to the characteristics and present land uses in the 24 tributaries of the Laguna de Bay Basin to provide a sufficiently broad picture of the human activities reflected through the landscape. Furthermore, the basic functions and ecology of the lake with some of the present ecological problems are described. This section is based on the results of literature reviews, interpretation of land use and topographic maps, and maps available online.

The online, topographic, and land cover maps, used for interpretation, are shown below:

Open source maps	Google Earth Google Map; Map feature Google Map; Terrain features Google map; land cover feature
Topographic maps (Produced by NAMRIA)	Manila; 1:250,000, 1954. Daet; 1:250,000, 1954 Baras; 1:50,000, 1992. Quezon City; 1:50,000, 2001 Muntinlupa City; 1:50,000, 2001 Manila; 1:50,000, 1995 Calamba; 1:50,000, 1993 San Pablo; 1:50,000, (n.d.) Paete; 1:50,000, (n.d.)
Land cover maps (Produced by LLDA)	Laguna Lake Development Authority, LISCOP II

2.2 Topography:

The Laguna Lake depression is a large caldera that resulted from multiple eruptions in two phases, about 1 million years and 29,000 years ago respectively. Much of the caldera is now occupied by the shallow Laguna de Bay, or Lawa ng Bay in local dialect. Although mountains and hilly tracts dot the landscape, about 80 percent of the land has gentle slopes, whereas steep to very steep lands occupy only about 20 percent of the land total surface area (See Figure 2.1).

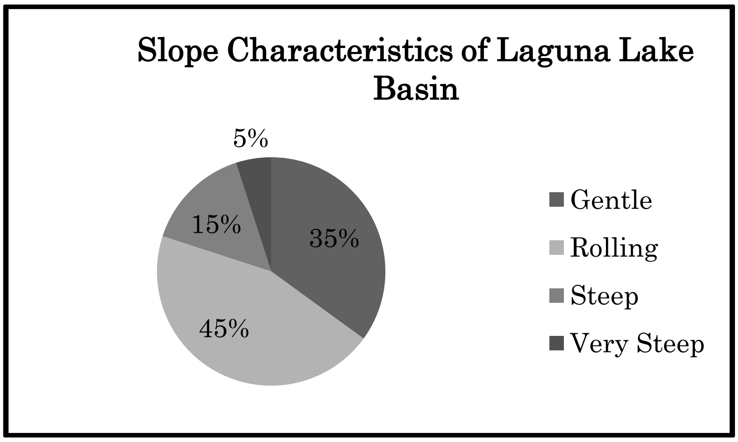

Figure 2.1: Distribution of slopes in the Laguna de Bay Basin (Lansigan & Navarette, 1989)

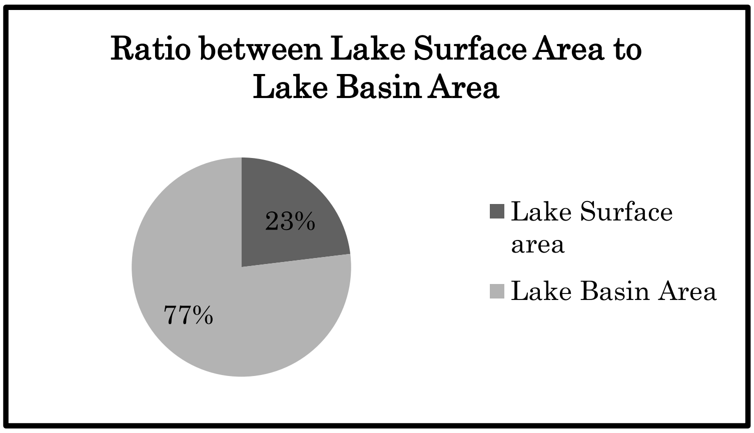

Figure 2.2: The Laguna de Bay Basin has a large land area draining to the lake.

Although about 80% of the Laguna de Bay Basin is gently rolling hills, the landforms of the basin can be divided into the following categories.

Uplands and mountains: The northern side of the watershed is characterized by peaks including Mt. Cayadlas. Mt. Danes, Mt. Irid, Mt. Minalunad, Mt. Payacin, Mt. Domire, Mt. Puno, Mt. Matapad, Mt. Yabang, Mt. Kanumay and Mt. Tanauan. The eastern side is characterized by extension of the Sierra Madre and on the south by Mt. Cristobal, Mt. Banahaw, Mt. Atimba, Mt. Nagcarlan, Mt. Lagula, Mt. Bulalo, Mt. Maquiling and Mt. Sungay. The mountain forests are degraded, even in the reserve forest areas. However, the montane forests of the basin still have a wide floral and faunal diversity.

Plains: Level to gently sloping or rolling plains run in narrow belts around Laguna Lake. These narrow plains are located in extremely low lying areas which can become completely submerged during extreme rainfall events and due to tidal actions. These flatlands become extremely narrow, often confined only to the lakeshore regions; due to the proximity of Sierra Madre Range on the Northeastern side of the lake. To the south and southeast of the lake, the considerably larger watersheds of Pagsanjan, Sta. Cruz, Calauan, and San Juan have created flatlands which are much broader than those near the lake's perimeter. These flatlands provide some of the finest agricultural lands in the region due to abundant nutrients from the rich volcanic soils eroded from the uplands. Most of the uplands in the southern part of the lake are extinct volcanoes; they do not produce ranges which are the characteristics of the Sierra Madre region in the Northeastern areas. The low lying areas in the southern uplands, however, are often occupied by volcanic lakes.

2.3 Soils:

The prime agricultural soils in the lake basin are found in the lowland areas around the lake, where rice is the main agricultural crop. The character of the soil changes with elevation and distance from the lake, as mainly in-situ shallow soil dominates the upland micro-watersheds.

Table 2.1: Principal soil types of the Laguna de Bay Watershed

Principal Soil Types	Primary subcategories	Secondary subcategories
1. Soils of the marshes		
2. Soils of the plain lands	a. Soils of the narrow piedmont zones	i. Quingua series ii. Carmona series iii. Guadalupe series iv. Novaliches series v. Marikina series
	b. Soils of the Wider plains	i. Binangonan series ii. Bay series
3. Soils of the uplands and mountains	a. The Lipa series b. The Tagaytay series	
	c. The Antipolo series	i. sandy loam: Mt Sungay, Talim Island ii. Clayey loam: Mt Cristobal, Mt Banahaw

A short account of the major soil characteristics of the Laguna de Bay Basin is given below.

1. **Soils of the marshes**: Hydrosols are present in narrow belts from Calamba in Laguna Province to Angono, Cardona and Morong in Rizal Province. These are seasonally or permanently wet soils of the river mouths of the Eastern tributaries surrounding the East Bay of the Laguna Lake. The hydrosols of the marshes are not used for agricultural purposes. Marsh soils are particularly predominant in the

riparian areas of the lake and the watershed. Once dominated by perennial grasslands of the land water interface regions, much of these areas are now occupied by human settlements.

2. **Soils of the plains**: The soils of the plain-lands can be divided into two subcategories:

   (a) Soils of narrow piedmont zones

   (b) Soils of the wider plains

   The soils of the plains extend from the north of Calamba in Laguna Province to San Pedro, San Mateo, Binangonan and Morong. These soils stretch to narrow piedmont zones in the Teresa, Binangonan, and Morong and comprise of Quingua series (Laguna), Carmona series (Laguna), and Guadalupe Series (Rizal and Laguna). The Novaliches series (Rizal), Marikina series (Rizal), Binangonan series (Rizal) and Bay series (Laguna) comprise the soils of the wider plains. The soils of the plains have a heavier texture compared to their upland counterparts. The Quingua series is characterized by fine sandy loams. Not heavily textured, they are generally found on the riverbanks of San Cristobal and San Juan except in the shore lands of Cabuyao, Sta. Rosa, Binan, and Laguna.

3. Soils of the uplands and mountains: The upland soils can be divided into three

subcategories,

(a) **The Lipa series:** The Lipa series of soils are made from the decomposition of volcanic tuff, it is dark brown in color and the soil profile extends to a depth of about 30 cm. These soils can be found in Sto. Tomas, Tanauan (Batangas), Cabuyao uplands, Sta. Rosa, Binan (Laguna), and Carmona (Cavite) regions.

(b) **The Tagaytay series:** The Tagaytay series extends 12 to 30 cm downwards into the soil profile, and is dark brown to black in color. This soil type can be found in parts of the Tagaytay City, and Silang (Cavite).

(c) **The Antipolo series:** The soil profile of the Antipolo series extends from 20 to 90 cm downwards into the soil profile, is reddish in color and found extensively in the Antipolo, Montalban, Baras, Tanay, and Pililla in Rizal Province. The soils of the higher mountain areas vary between clayey to sandy loam which is described as below;

i. Mt.Sungay: Sandy loam

ii. Mt. Cristobal: Clay loam

iii. Mt. Banahaw: Clay loam

iv. Talim Island: Sandy loam.

Most of the upland soils are very fragile in character. They are fertile due to their volcanic nature, which explains the great floral and faunal diversity that remains in the region[18]. However, they are fragile in the sense that most of the soils in the uplands are easily eroded by strong runoff and overland flows which occur every 6 months during the typhoon season.

Figure 2.3: Physiography of the Laguna Lake Region (Courtesy: Google Map, 2009)

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18 In 2004, a new mammalian species have been discovered in the Mt. Banahaw forest area just 50 miles away from Manila. This is a quite interesting fact as the areas of intense human activities on the landscape are not very far from this forest. Also if we take the whole lake basin as a bioregion, which is pretty heavily urbanized, this discovery shows that biodiversity may still thrive in well protected areas of even an urbanized bioregion. Lawrence and Heaney (1998), in their book *Vanishing Treasures of the Philippine Rain Forest*, have said that the island of Luzon is one of the most biologically diverse in the world.

2.4 Climate:

The climate of the Laguna de Bay Basin area is characterized as a tropical marine type with distinct wet and dry seasons. The wet season lasts for 4 months, from June to November, and is characterized by typhoons which strike the Luzon Island from early June until September. The 6 month long dry season lasts from December to May. The average yearly temperature is 27 degrees centigrade.

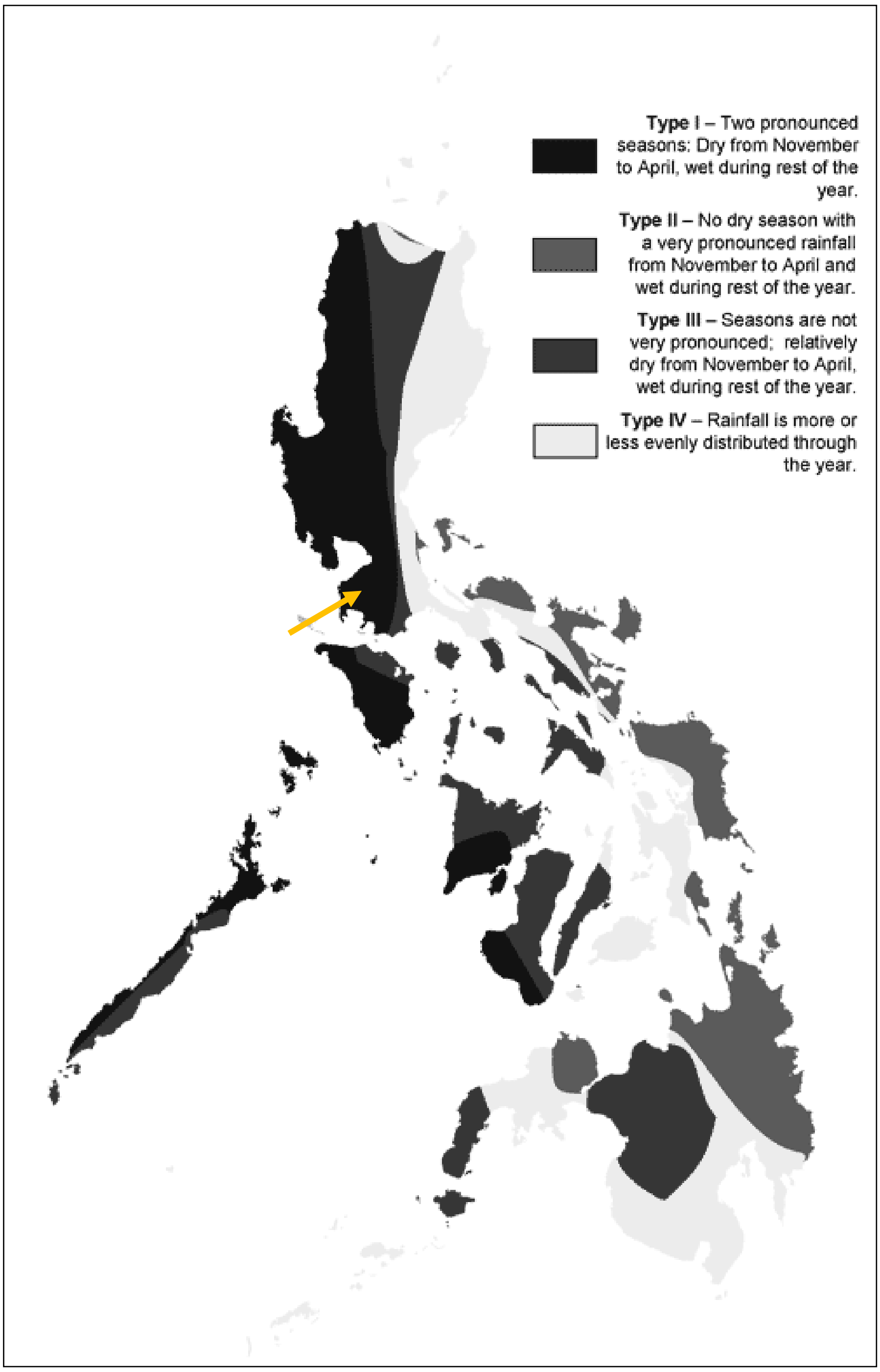

Figure 2.4: Agro climatic zones of Philippines. (The arrow points to the Laguna de Bay region) (*Source*: http://mapsof.net/philippines/static-maps/png/philippine-climate-map).

The climatic characteristics of mean monthly temperature, rainfall, and occurrences of typhoons are given below. Strong positive correlation can be seen between the typhoons and temperature which suggests the importance of these storms in the runoff systems of the Laguna de Bay Basin. The considerable decrease in the rate of evapotranspiration coupled by runoffs generated by effective precipitation, causes annual flood conditions in the basin.

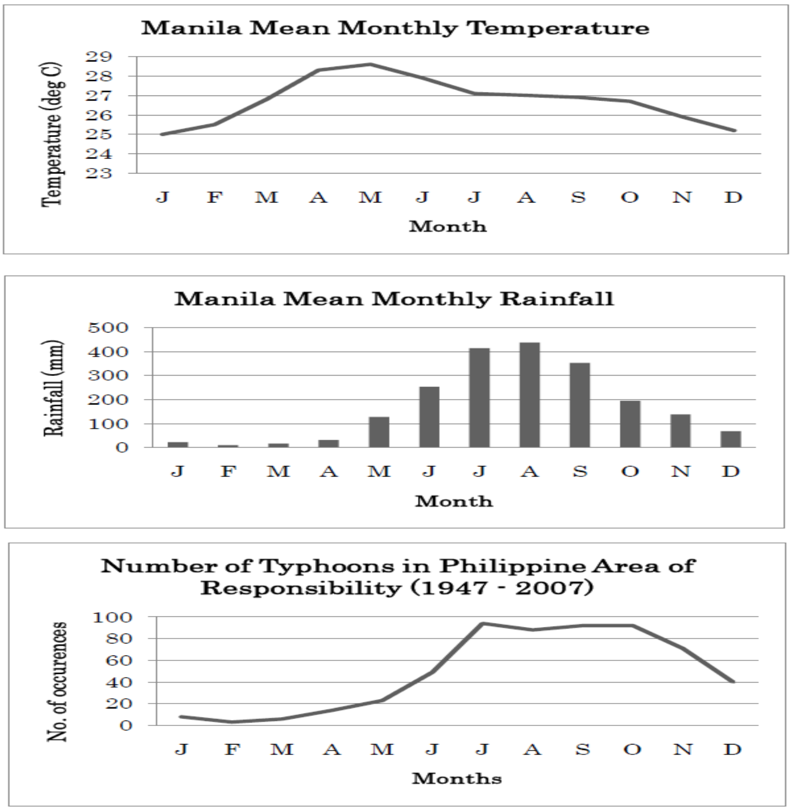

Figure 2.5: The Number of typhoons in Philippines, along with temperature and rainfall patterns suggests that almost half of the year is dominated by strong storms that dump huge amounts of rains within a very short period of time, resulting in floods. This climate pattern plays a significant role in the dispersion of pollution loads in the lake as we will discuss in greater detail in chapter 6.

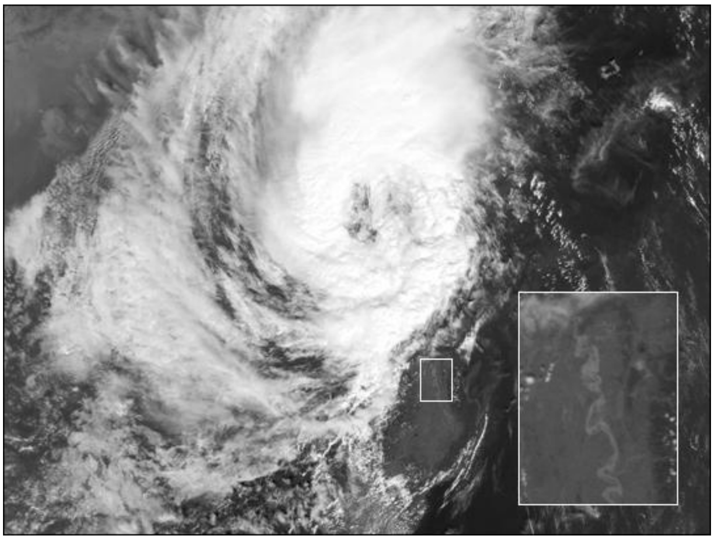

Figure 2.6: Image of Typhoon Melor over Luzon Island, taken by the MODIS on 2nd November 2003. The yearly rainfall distribution follows the occurrences of typhoons. The rainfall increases steadily from April and decreases from September and October (Source: NASA, Visible Earth Catalogue).

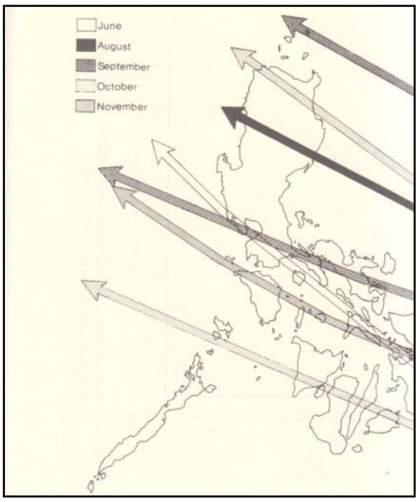

Figure 2.7: Paths of typhoons over Philippines. (Source: Brosius, 1990)

The basin receives ample annual precipitation of 1900 to 2000 mm in average, varying according to the terrain, and proximity to the sea. The eastern part of the lake basin receives 100 mm to 500 mm more rainfall annually than the lake basin's average annual precipitation (the eastern margins of the lake receive a rainfall of over 2400 mm annually). The municipalities of upper Pagsanjan (including Mt. Banahaw reserve forest area) Caliraya, Pangil, Sta. Maria, and Marikina River basins receive the highest rainfalls; and the lowest rainfalls levels in the basin are recorded in the extreme western margins, in the municipalities of San Cristobal, Cabuyao, Binan, San Pedro, and Muntinlupa, where average annual precipitation is less than 1900 mm to 2000 mm. The highest mean annual runoff are generated in four places in the basin, these are:

(i) The Extension of Sierra Madre in the upper Marikina River Basin and upper Sta. Maria and Siniloan River Basin.

(ii) The Banahaw mountain region in the upper Pagsanjan River Basin

(iii) The Mt. Makiling mountain region with upper Los Banos watershed

(iv) Tagaytay Highlands in upper San Cristobal watershed

All these areas except Tagaytay Highlands have considerable forest cover, (with substantial areas of closed forests in the Banahaw mountain region, and the extension of the Sierra Madre) which helps retain the soil moisture and produces sustained runoffs throughout the year. The Tagaytay Highlands were once well forested with plantation agriculture in the 1950s, but currently grassy terrain predominates the area; with both intercropping and mixed cropping agriculture, and residential settlements. The changes in land use means that, the area is vulnerable to the type of sheet and gully erosion which is also present in the upper reaches of San Pedro, Binan, Cabuyao and San Cristobal Rivers. The northeastern, eastern, and southeastern highlands have negligible amount of sheet and gully erosion as considerable portions of their highlands still remain forested. However, these forests are of secondary type, with the exception of the Mt Banahaw Reserve Forest and forests of the Sierra Madre range.

2.5 Population:

The Laguna de Bay region is characterized by densely populated urban and peri-urban areas. The megacity of Manila is fed by the San Juan, Pasig, Mangahan, Paranaque, and the lower reaches of the Marikina River watersheds. The city is situated outside the natural watershed of the Laguna Lake. Of these river systems only the Marikina and Mangahan fall inside the Laguna de Bay watershed.

The peri-urban areas are located in the western margins of the lake basin and are covered by the watersheds of San Perdo, Binan, Cabuyao, and San Cristobal. These represent zones where urban and rural land use activities are juxtaposed, leading to land uses that have transitioned from rural to urban. The areas are characterized by large and small scale land conversion process (as described in detail in subsequent chapters) particularly on the western margins of the lake basin. The regions of higher population density are also the industrial growth centers, or corridors of such growth areas. Table 2.2 shows the municipalities and watersheds that represent peri-urban landscape in the lake basin. However, the degree of urbanization differs according to the distance from Metropolitan Manila, with population more densely clustered and efficient flow of goods and services available nearer to the urban center.

Population in Rizal province has increased by a factor of 16 since 1948; while the population in Laguna has increased by a factor of 6. This shows a much stable population increase in Laguna compared to that of Rizal. A notable feature of greater lakeshore occupation is the ratio of municipalities which have rapid population increase. For instance, in the province of Laguna, the number of municipalities that have had a rapid population increase since 1948, is just 5 out of 30, whereas in Rizal, 7 out of 14 municipalities have undergone such a rapid population increase (Table 2.5). Such rapid population increase can be observed in the municipalities of Antipolo, Binangonan, Cainta, Rodriguez, San Mateo, Tanay, and Taytay. This has happened with the extension of urbanization of Metro Manila in the west. In the Province of Laguna, municipalities of rapid population increase were, Binan, Cabuyao, Calamba, San Perdo, and Sta. Rosa.

These areas are the peri-urban areas of the western side of the Laguna de Bay watershed.

Table 2.2: Situation of peri-urban areas in the western margin of the Laguna Lake.

Watersheds	Municipalities	Provinces
San Pedro	San Pedro, Carmona, Silang, Tagaytay city	Laguna, Cavite
Binan	Binan, Carmona, Silang, Tagaytay city	Laguna, Cavite
Cabuyao	Sta. Rosa, Cabuyao, Silang, Tagaytay city	Laguna, Cavite
San Cristobal	Cabuyao, Calamba, Silang, Tagaytay city	Laguna, Cavite

Table 2.3: Total population and population growth rate in different provinces of the Philippines. *Source*: NSO, 2007.

Region	Total Population (2007)	Growth Rate (1995-2007)
Philippines	**88,566,732**	**2.16**
NCR	11,566,325	1.71
CAR	1,520,847	1.63
I. Ilocos	4,546,789	1.51
II. Cagayan Valley	3,051,487	1.56
III. Central Luzon	9,709,177	2.67
IVA. Calabarzon	11,757,755	3.56
IVB Mimaropa	2,559,791	1.95
V. Bicol	5,106,160	1.40
VI. Western Visayas	6,843,643	1.43
VII. Central Visayas	6,400,968	2.07
VIII. Eastern Visayas	3,915,140	1.27
IX. Zamboanga Peninsula	3,230,094	1.94
X. Northern Mindanao	3,952,437	1.79
XI. Davao	4,159,469	1.99
XII. Soccsksargen	3,830,500	2.52
XIII. Caraga	2,293,346	1.40
ARMM	4,120,795	4.78

Figure 2.8: Laguna de Bay Basin with, the provinces, and municipalities, and jurisdictional area of LLDA. (Source: Integrated Water Resource Management Division, LLDA, 2009)

Table 2.4: Population increase in the province of Laguna from 1948 to 2000. (Source: NSO, 2000)

City/ Municipality	1948	1960	1970	1980	1990	2000
Laguna	**321,247**	**472,064**	**699,736**	**973,104**	**1,370,232**	**1,963,872**
Alaminos	9,518	13,860	16,649	20,615	27,412	36,120
Bay	7,395	11,416	16,881	22,960	32,535	43,762
Binan	20,794	33,309	58,290	83,684	134,553	201,186
Cabuyao	15,206	20,618	32,117	46,286	66,975	106,630
Calamba	36,586	57,715	82,714	121,175	173,453	281,146
Calauan	9,180	13,618	19,747	25,259	32,736	43,284
Cavinti	6,193	8,297	10,462	13,222	15,131	19,494
Famy	1,569	4,163	4,651	5,241	7,928	10,419
Kalayaan	3,817	5,007	6,957	10,247	13,118	19,580
Liliw	7,977	11,064	14,638	17,436	21,911	27,537
Los Banos	10,954	21,519	32,167	49,555	66,211	82,027
Luisiana	6,883	8,746	11,494	12,199	14,241	17,109
Lumban	7,516	9,719	13,289	17,360	19,773	25,936
Mabitac	2,700	4,316	6,377	8,543	11,444	15,097
Magdalena	3,733	5,559	7,650	10,433	13,450	18,976
Majayjay	7,753	9,906	12,316	13,699	15,875	22,159
Nagcarlan	15,335	18,227	25,057	30,637	37,696	48,727
Paete	5,546	7,443	11,601	16,383	20,579	23,011
Pagsanjan	9,282	10,691	14,556	19,489	25,024	32,622
P akil	3,055	4,765	7,229	9,048	13,438	18,021
Pangil	4,156	5,364	8,118	10,519	15,212	20,698
Pila	13,606	11,156	15,551	20,962	27,467	37,427
Rizal	3,901	5392	6,539	7,510	9,501	13,006
San Pablo City	50,435	70,680	105,517	131,655	161,630	207,927
San Pedro	9,063	14,082	32,991	74,556	156,486	231,403
Sta. Cruz	22,534	32,850	47,114	60,620	76,603	92,694
Sta. Maria	3,851	8,378	12,575	15,744	20,525	24,574
Santa Rosa	17,259	26,583	41,335	64,325	94,719	185,633
Siniloan	5,450	9,149	12,413	17,220	22,759	29,902
Victoria	No Data	8,922	12,741	16,522	21,847	29,765

Table 2.5: Population increase in the Province of Rizal from 1948 to 2000. (Source: NSO, 2000)

City/ Municipality	1948	1960	1970	1980	1990	2000
Rizal	**104,578**	**173,958**	**307,238**	**555,533**	**977,448**	**1,707,218**
Angono	5,255	7,093	12,127	26,571	46,014	74,668
Antipolo city	7,604	21,598	26,508	68912	205,096	470,866
Baras	2,745	4,454	7,166	11,196	16,880	24,514
Binangonan	20,422	31,274	52,296	80,980	127,561	187,691
Cainta	3,692	6,803	20,714	59,025	126,839	242,511
Cardona	8,134	12,476	16,880	24,503	32,962	39,003
Jala-Jala	2,429	5,223	8,115	11,945	16,318	23,280
Morong	10,035	13,694	18,970	24,858	32,165	42,489
Pililla	6,067	9,021	15,052	23,222	32,771	45,275
Rodriguez	5,257	9,648	20,882	41,859	67,074	115,167
San Mateo	6,811	12,044	29,183	51,910	82,310	135,603
Tanay	8,627	13,955	23,247	40,443	58,410	78,223
Taytay	14,144	21,747	46,717	75,328	112,403	198,183
Teresa	3,356	4,928	9,381	14,781	20,645	29,745

2.6 A description of the river systems and their associated land uses

Laguna Lake has a water retention time of 8 months. This means the combined runoffs from the micro-watersheds of the Laguna de Bay Basin replenish the lake with fresh water every 8 months. The micro watersheds are thus immensely important in maintaining the health of the lake ecosystem.

The micro-watersheds of the Laguna de Bay Basin can be broadly divided into two classes.

1. Those not having clearly defined main stream

2. Those with a clearly defined main stream.

The watersheds of Mangahan, Angona, Taguig, Muntinlupa, Jala-Jala, and Los Banos which have several streams of equal length which flow parallel to each other, into the lake, which makes them members of th first group of streams. The watersheds of Marikina, Baras, Tanay, Pililla, Sta. Maria, Siniloan, Pangil, Caliraya, Pagsanjan, Sta. Cruz, Pila, Calauan, San Juan, San Cristobal, Cabuyao, Binan and San Pedro represent river systems where a single dominant stream network can be observed which controls the hydrological network of its watershed. They fall in the second group of streams.

With a basin area of 534.8 sq. km (53480 ha), the Marikina is the largest micro-watershed draining to the lake. Situated to the north of the lake, the Marikina catchment drains through the highlands of the Sierra Madre Mountains. Much of the water flow from the Marikina River is controlled through the Napindan Hydraulic Control Structure, the operation of which is given in the next section. The river's watershed includes the municipalities of Rodriguez, San Mateo, Antipolo, Tanay in Rizal Province and municipalities of Marikina, Pasig, and Quezon City in the National Capital Region. The catchment area of the Marikina River has some forest cover, especially in the municipalities of Rodriguez and Antipolo. This is among the last remaining stretches of closed forests in the upper Marikina watershed. These closed forests are surrounded by more open forests and brush-lands, which are the areas of re-growth in the previously cleared forest areas. Pockets of coconut and banana plantations can be seen in the brush-lands. In the middle course of the river however the land cover changes to plantation agriculture, mixed with brush-lands with some remaining small pockets of forests. Grasslands are common in the built up areas in the eastern part of Antipolo Municipality. In the lower reaches, the landscape has drastically been converted into urban land use. The river enters an urban and peri-urban landscape after traversing vast stretches of open grassland in the municipality of San Mateo. In the municipalities of Marikina, and Pasig, the river flows through landscapes where built up areas are the dominant land use type. The river turns 180 degrees at Mangahan Floodway before it joins with the Pasig River about 5 km further downstream.

The Mangahan Micro watershed covers the municipalities of Marikina, Pasig, Cainta and Taytay, which are all heavily built up with urban and peri-urban areas. A large portion of the urban areas in the Mangahan micro-watershed is the result of conversion of the previous rice lands originally present in the 1950s. In fact the rice lands extended from the west of Marikina River to the municipality of Teresa, and included San Isidro, Baranka, Marikina, Santolan, Mapadan, Rosario, Cainta, and

Pasig.[19]

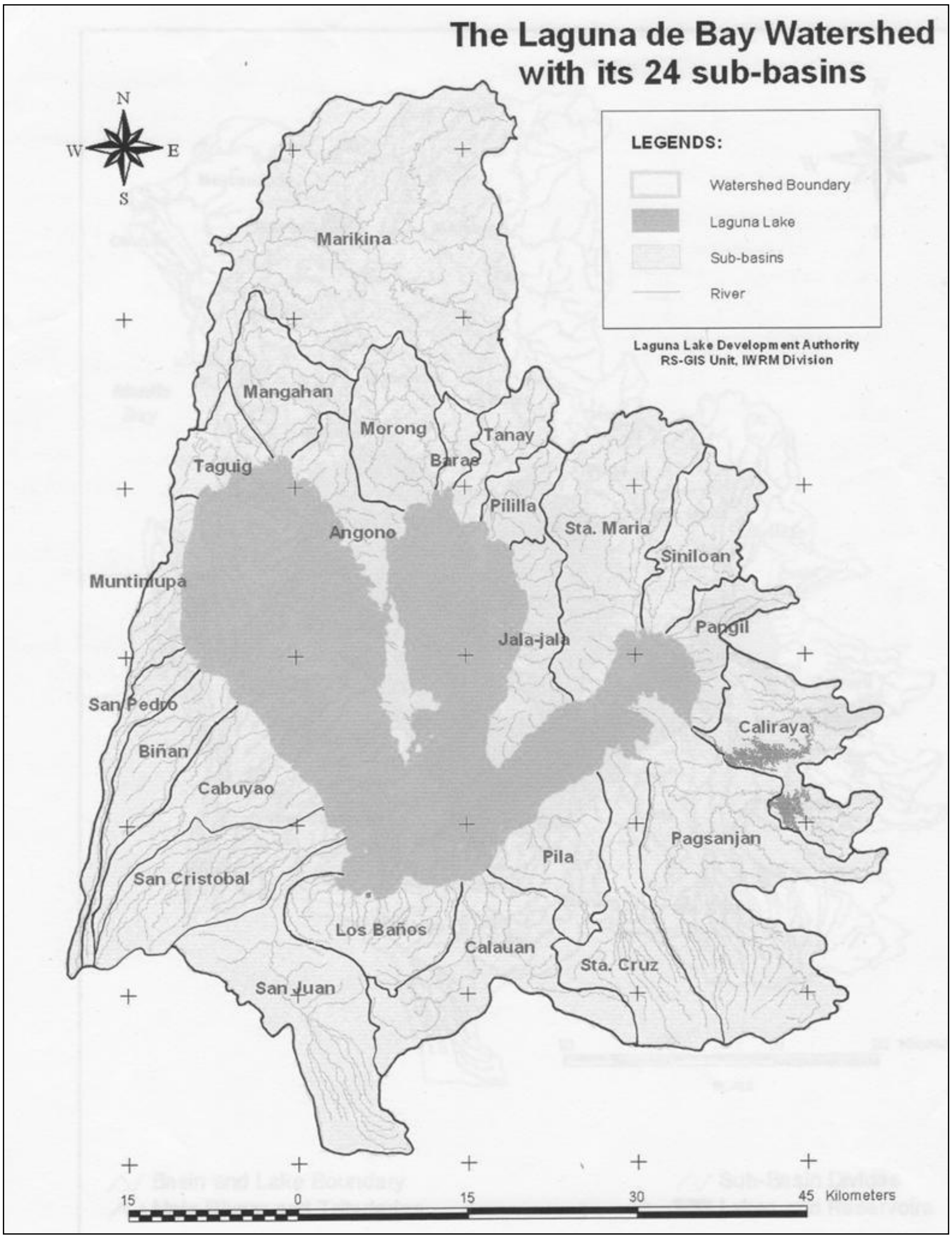

Figure 2.9: Laguna de Bay Basin with its 24 tributary watersheds. Note: The Urban watershed (not shown here) is situated to the west of Marikina River. (Courtesy, IWRM division, LLDA)

19 The Mangahan River was called Manga River at that time.

Much of the land use in the **Morong micro-watershed** resembles the land use patterns that were dominant 50 years ago in the Mangahan River watershed. The Morong watershed has an area of 70 sq.km, and is characterized by landscapes that are characterized by rice lands, with some built up areas such as in Teresa and Maybancal. The peri-urban areas are located in the highlands whereas rice is cultivated in the lowlands. According to a 1991 Laguna Lake Development Authority study Morong plays a significant role in the eutrophication of the Laguna de Bay in its northern section, due to runoff from nearby hog farms. In 1994 the LLDA, together with the Local Government Units of Morong, Teresa, and Antipolo recovered loads of garbage from the riverways and cleared a nearly 3 km stretch of waterway clogged by water lilies (Manila Bulletin Publishing Corporation, 2004).

The Baras micro watershed is the third smallest watershed in the Laguna de Bay Basin (after Pililla and Pangil). The watershed has an area of nearly 52 sq.km, and is regarded by many as a sub system within the larger Morong micro watershed, and thus is referred to as the ‘Morong-Baras Micro Watershed’. Baras has a much diverse landscape than Morong. The northern and southern sections of the sub-basin are characterized by rice cultivation mixed with settlement areas whereas the middle section of the river is covered by brush-lands and plantation agriculture.

The **Tanay** micro watershed is characterized by brush-lands, plantations and open grasslands. This watershed has an area of 53.44 sq. km and is characterized by open grasslands located in the upper catchment areas, whereas the mid and lower reaches are dominated by brush-lands and plantations. The brush-lands, like the upper Marikina micro watershed, are those areas in the Laguna de Bay Basin where forests are on the way towards natural regeneration.

With just 41 sq.km area, the Pililla micro watershed is the smallest of all in the Laguna de Bay Basin. The upper catchments of Pililla are forested, and these forests are of regenerative type. Land use nearer the Laguna Lake is characterized by strips of rice lands. Pililla represents a watershed where the brush lands extend right up to the lake's shore. However, these brush lands have been degraded in the lowland areas near the lake, being replaced by clearings undertaken for production of charcoals, slash and burn or *kaingin* agriculture, expansion of settlements, and plantation agriculture. Pililla is situated at the gateway to the Jala-Jala peninsula from the north. The Jala-Jala is a somewhat ill-defined watershed, as several streams of equal length flow in to the Laguna Lake from the central ridge of the peninsula forming a parallel drainage pattern in the north of the watershed and radial drainage pattern to the south. The lake fringes of the Jala-Jala watershed are settled mainly by the fishing community. Rice lands are located adjacent to these settlements in the lakeshores. More than 90% of the Jala-Jala watershed was forested in the 1950s but the forests have been cleared in subsequent periods. The present day brush lands, with the plantations and grasslands in Jala-Jala represent areas which were previously forested. Although much degraded, the brushlands produce runoffs that are relatively unpolluted. Bottled water is made from the streams of Pililla and is supplied to urban regions downstream.

The Sta. Maria River has a considerably large watershed of 205 sq.km and is third only in terms of area, after the Marikina and Pagsanjan River basins. The watershed has distinctive dissected hill tracts in its upper and mid reaches, and gently rolling plains in its lower reaches, where rice is cultivated. The western part of the Sta. Maria watershed has a degraded forest cover, which extends to Jala-Jala. The low lying eastern part of the watershed is dominated by rice lands. The watershed has considerable tracts of patchy forest cover in its upper and mid courses, however logged-over areas have created brush lands and plantations that have pushed the forests to the much dissected extreme upper part of the watershed.

The Siniloan micro watershed has an area of 71 sq.km and covers the municipalities of Sta. Maria, Mabitac, Famy, Siniloan, and Pangil. The watershed has patches of degraded and fragmented forests intermingled with brushlands and plantation agriculture. It is speculated that *kaingin* agriculture, and charcoal making with illegal logging activities are a matter of great concern in the remaining forestlands of the watershed. This is also the case with the highland areas in all tributary basins in the western margin of the Laguna Lake. As the river enters it lower reaches, settlements start at the fragmented forest fringes followed by rice lands which extend to the lakeshores.

Pangil is another small watershed with a land use similar to that of Siniloan, with brush lands, plantations and forests mixed together in the upper and middle reaches. Rice lands extend from the lower mid courses to the lakeshores. Areas of settlements are located between the plantation and rice lands. The micro watershed of Pangil covers the municipalities of Pangil, Pakil, Paete, and Kalayaan.

Table 2.6: The Laguna de Bay tributary sub basins and their respective basin areas.

River sub-basins	Basin Area (sq.km)	Number of Rivers
Marikina	534.80	34
Mangahan	87.61	10
Angono	86.86	26
Morong	70.21	18
Baras	51.88	-
Tanay	53.44	8
Pililla	41.19	7
Jala-Jala	72.13	17
Sta. Maria	204.91	19
Siniloan	74.31	8
Pangil	51.14	13
Caliraya	97.01	14
Pagsanjan	311.77	27
Sta. Cruz	148.35	13
Pila	90.55	7
Calauan	154.87	12
Los Banos	102.73	74
San Juan	191.77	15
San Cristobal	140.66	17
Cabuyao-Sta. Rosa	120.13	10
Binan	75.55	12
San Pedro	56.57	-
Muntinlupa	43.51	9
Napindan	45.00	-

The **Caliraya** micro watershed, with its 97 sq.km area, covers municipalities of Kalayaan, Lumban, and Cavinti. The area around Caliraya is a popular tourism destination for Manila's elites. This lake is actually a manmade reservoir, built by the US Army in the 1930s and then rebuilt by the Japanese during the Second World War. The region became more popular and easily accessible with the construction of concretized roadway and hydro electric power plant. The power generation is supported by three power plants, Caliraya, Botocan and Kalayaan. The total capacity of the grid is728 MW, and all power produced is supplied to Metro Manila[20]. As far as land use is concerned, the micro watershed is characterized by brushlands and coconut plantations in its upper reaches. Settlements in upland areas are in the vicinity of the Caliraya Lake in small clusters whereas linear settlements can be located along roadways. The areas of rice cultivation in the watershed follow the lakeshores in a thin strip.

The Pagsanjan River (also called Pagsanjan-Lumban River) **Basin** is one of the largest fluvial systems in the Laguna de Bay Basin with an area of 312 sq.km; second only to the Marikina Basin. The Pagsanjan covers the municipalities of Lucban, Luisiana, Majayjay, Magdalena, Cavinti, Sampaloc, Pagsanjan, and Lumban. Two tributaries, Balanac and Bombongan, join in the lowlands to form the Pagsanjan main flow at the municipality of Pagsanjan to the south of San Isidro. The Balanac originates from the Mt. Banahaw volcanic mountain (2169 m.) in the municipality of Lucban, at 2,158 m. above sea level. The river is said to be a major tributary contributing 35% of the surface recharge to the lake (Lasco & Espaldon, 2005). This is because its large catchment area is still heavily forested. Much of the land above 1000 meters in altitude

[20] The Caliraya power plant was called CBK power plant until it was taken over by Sumitomo Corporations Electric Power Development Co. Ltd. www.jpower.co.jp/english/news-_release/news/

is forested in the Pagsanjan catchment. However, between 900 to 700 meters, the landscape is mixed with cultivation of upland rice in small pockets, and opened forests mixed with brush and grasslands. Coconut plantations start below 700 meters extending up to the lowlands, where irrigated rice is cultivated. The Pagsangan Delta extends to the East Bay of the Laguna Lake with rice cultivation in the inner delta and squash and corn cultivation in the outer delta which floods during the rainy season.

Mt Banahaw de Lucban (1875 mts), is a strato-volcano to the East of Mt Banahaw which recharges the Balanac river with runoffs from its still forested uplands. Banahaw de Lucban is not a protected reserve forest and the canopy has been cleared in many places. Banahaw de Lucban's land cover is characterized by open forests and brush lands in the uplands, and coconut plantation from roughly 700 meters elevation. Rice cultivation in the upland takes place at about 500 meters altitude from Lucban to Galalod. According to Laguna Lake Development Authority, the Pagsanjan pollutes the lake considerably as it contributes a large volume of water discharge. The river is said to have high total coliform concentration coming from Majayajay piggeries, which is the major pollutant in the Pansanjan River.

To the west of the Pagsanjan River flows the **Santa Cruz River,** with primarily coconut plantations and pockets of rice cultivation in between. The river originates from

Mt Banahaw and covers the municipalities of Liliw, Nagcarlan, Magdalena, Pila and Sta. Cruz. The total area of the basin is 148 sq.km. Landscape in the extreme upper reaches is forested and falls in the Mt Banahaw reserve forest area. The lower Santa Cruz is characterized by irrigated rice cultivation much the same way as the Pagsanjan, however its lower reaches are much more populated than Pagsanjan due to the Santa Cruz urban area, which is a major city in the Laguna Province. Two picturesque volcanic lakes, Pandin and Yambo are similarly located in this river basin. The two lakes are a part of a chain of seven volcanic lake range known as 'the seven crater lakes'. The other five crater lakes are in the Calauan and Makampongo micro watersheds. Of these the Makampongo watershed falls outside the Laguna de Bay Basin system.

The **Pila** micro watershed covers a 91 sq.km area and its catchment originates from Mt Nagcarlang and Mt Atimba, both of which have been planted with coconuts and bananas. The upper parts of these low and extinct volcanoes have some brushland and grassland with some plantations. Rice cultivation starts from about 40 m. of altitude. Victoria, the capital city of Pila municipality is a notable urban center, and is surrounded by lakeshore rice lands.

The **Calauan** micro watershed traverses through the municipalities of Rizal, San Pablo City, Alaminos, Calauan, Victoria and Bay. The watershed has an area of 155 sq. km, which makes it roughly the same size as the Santa Cruz Micro Watershed. The Calauan watershed stretches through a wide area from east to west. Half of its catchment originates in the Mt San Cristobal area, while the other has its origins in the Mt Makiling region. The upper reaches of the eastern tributaries show a land use pattern similar to that of Sta. Cruz River, with brush lands in the extreme upper catchments and plantations of coconut and banana in the middle altitude range. The western catchments have rice cultivation in the lowlands, which cover the southern part, while the northern part is somewhat forested in the uplands near the vicinity of Mt Makiling. The narrow lower reaches are characterized by irrigated rice cultivation from the lakeshores to 5 to 6 km inland.

The **Los Banos** watershed (103 sq.km), which encompasses the Mt Makiling reserve forest, has the largest area under forest cover among the Laguna de Bay micro watersheds. This watershed is one of those whose principal stream cannot be easily delineated. Several parallel streams flow towards south from Mt Makiling's highlands, meeting the Laguna Lake in its southernmost tip. The Makiling Reserve Forest is the last stretch of the old growth forest cover in the basin apart from the Banahaw mountain region, and the upper reaches of the Marikina watershed in the Sierra Madre range. The reserve forest, owned by the University of Philippines' College of Forestry, is a living laboratory of the region as it possesses a vast amount of genetic resources. The reserve forest has 2089 species of plant species, classified into 1060 genera, 34 species of mosses, 67 species of fungi, 29 species of fern and 34 species of liverworts.

The **San Juan** micro watershed has an area of 192 sq. km. This mostly consists of rice lands with linear types of settlements along the provincial roadways. The lower reaches of the river basin is heavily urbanized where land has been converted from rice paddies into urban settlements. The river basin covers the municipalities of Santo Thomas, Malavar and Tanauan in Batangas Province and Calamba city in the Province of Laguna.

San Cristobal shows a land use similar to the landscapes found in San Juan micro watershed, except the fact that the San Cristobal still has some denuded forest cover in the upland in the Tagaytay Hills. The landscape in the uplands is a highly mixed type with four types of land covers: brush lands, grasslands, plantations, and built up areas mixed together. The middle reaches of the river are characterized by rice lands and urban and industrial land uses, while the lower reaches are characterized by rice paddies. Plantations of pineapple can be found over wide areas, with plantations of coconut in the uplands of San Cristobal. It should be noted that the uplands of the river has *in situ* soil with a depth of 20 cm to 1 m. which is highly erodible. Pineapple plantations in the uplands of the watershed exacerbate soil erosion, as soil in between the rows are kept bare and open to erosive forces. The upland cultivation of, coconut, pineapple, banana, coffee, and corn are sold to local and overseas tourists. Apart from Tagaytay hills, a tourism spot in itself, the region is a gateway to reach the popular destination of the Taal Lake region. According to the locals there are some old growth forests in the Tagaytay Hills between the villages of Tartaria, Lumil and Kabangaan. However, others say that the forests no longer exist, and only some remaining stands from a previously logged area with an areal extent of only about 10 ha are left standing. Industries making semiconductors, beverages, and fast food, populate the mid courses of the basin along with residential areas. Rice cultivated in the lowlands is delivered to local consumers and to Metropolitan Manila.

The Cabuyao-Sta. Rosa River traverses through a 120 sq.km basin with agricultural areas separated by large areas of urban landscapes. The Cabuyao originates from the Tagaytay Highlands in the municipality of Silang in Cavite Province; the upper reaches of the river are characterized by a narrow basin. The river basin covers the municipalities of Cabuyao, Sta-Rosa, and Silang.

The micro watersheds of **Binan**, **San Pedro, Muntinlupa** and **Taguig** rivers have urban and peri-urban components extending from Metro Manila. The Muntinlupa and Taguig watersheds fall within the National capital Region. Of these rivers, only the Binan has brush lands mixed with grasslands and plantation agriculture in its upper reaches. Sta. Rosa city, a principal urban center, has a population density of 3,417 per sq.km with 50% of its population falling within the reproductive age of 15 to 40 years. The annual natural population growth rate is 6% to 8%, which is more than three times the Philippine national average. Peri-urban areas with high population density and growth rate characterize the shoreland regions of the lake basin. Industries are the major economic force in these watersheds. Industrial estates like the Laguna Technopark, Santa Rosa Business Park, Meridian Industrial Complex, Greenfield Development, and car manufacturing industries like Ford, Toyota, Nissan, Honda, Columbian Motors, and Star Motors show the growth of industrialization in the region.

The general feature of land use in the Laguna Lake's surrounding watersheds is as described in detail above. The eastern part of the lake basin is characterized by watersheds which are much more rural and the waters of which are much less polluted in both physical and chemical terms. Large industrial estates are absent in the watersheds of the eastern tributaries which have considerable areas of logged forests, and plantations. The western tributaries are much more industrialized and urbanized with the conversion of previous agricultural lands of the lake basin for urban uses.

2.7 Ecological characteristics of the Laguna Lake

The Laguna de Bay Basin is drained by 24 micro-watersheds of varying area. The lake is connected to the Manila Bay by the Pasig River, whose flow is reversed towards the lake during high tide bringing salt water from the Manila Bay. During low tide, however, the normal flow towards the Manila Bay resumes and water from the lake flows back into the Bay. The Pasig River acts as a natural outlet to the Manila Bay. The flows of the Pasig and the Marikina Rivers are controlled by the Napindan Hydraulic Control Structure (NHCS) through the Napindan Channel and the Mangahan Floodway. The NHCS is situated at the confluence point of the Marikina Pasig, Napindan and Taguig Rivers. The NHCS is closed when the water level of the Marikina River rises. When this happens the flow is diverted towards the lake through the Mangahan Floodway to decrease the impact of flooding in the downstream of Pasig-Marikina River system. During heavy rains when the lake gets too much water, the excess water is released through the Napindan Channel into the Pasig River and further into the Manila Bay by opening the NHCS. The NHCS can also be closed to stop the intrusion of salt waters from Manila Bay into Laguna Lake.

The Laguna de Bay is a unique hydrological system due not only to its size but due to its shallow average depth of 2.8 meters (Santos-Borja & Nepomuceno, 2006).

These characteristics create of high turbidity and murky water. Second, the low water levels make ideal environments for aquatic vegetation to flourish, especially in the peripheral regions of the lake. This latter condition makes favorable habitats for demersal fishes like the snakehead murrel (*dalag*) and Salmon catfish (*kanduli*) in addition to benthos which includes snails, clams and insects (Santiago, 1993). It was estimated in 1964, that the lake had about 80,000 tons of fish stocks and 240,000 tons of benthos (Rabanal et al., 1964, in Santiago, 1993). The high benthic population is due to the caharacteristscs of shore vegetation in the lake's ecosystem.

Table 2.7: Areas and mean maximum depths of Asia's major lakes (Source: ILEC, 2006[21])

Name of Lakes	Country	Area (sq.km)	Average Depth (m.)
Danau Toba	Indonesia	1,103	529
Tonle Sap	Myanmar	2,500 – 16,000	Varying; 1 – 10
Laguna de Bay	Philippines	900	2.5
Lake Dianchi	China	7.5	2.5
Lake Chilika	India	1,165	Varying ; 1.4 – 3.4
Bhoj Wetland	India	36	6
Lake Biwa	Japan	670	43
Xingkai/Khanka	China	4,510	4.5
Shongkhla	Thailand	8,020	Varying ; 1 – 2

The Lake has a total estimated volume of 2.7 x 10^9 m^3 and the annual water recharge from the tributary watersheds is 3.8 x 10^9 m^3 (Rabanal, Acosta, & Delmendo

[21] Moedojo et al. (2006), Matsui et al. (2006), Santos-Borja & Nepomuceno (2006), Xiangcan et al. (2006), Ghosh & Pattnaik (2006), Kadarkar & Mukherjee (2006), Ide et al. (2006), Xiangcan & Pingyang (2006), ARCBC (2009). See references for details.

1964). This means that the lake water is replenished in about 8 months (ILEC, 2006). Furthermore, a notable feature of the lake is its rapid eutrophication due to the conversion of surrounding lands from forests into agricultural land, settlements and industries. In the 1930s, the lake was plagued by blue green algae, and was classified by European researchers as a eutrophic lake. Santiago (1993) notes:

> ...the mention of blue-green algal blooms and fish-kills in the 1930s puts the lake in the category of eutrophic lakes (rich in nutrients and food), commonly associated with man-made pollution. …. We are talking of conditions 58 years ago when I believe the human population in the watershed was less than one million. The basin had a good forest cover, and there were few industries in the watershed. Should we then assess the lake as being polluted by man's activities? If not, then these events are natural happenings. The question is what factors trigger the lake to show peculiarities identified with man-made eutrophication? (Santiago, 1993; 102).

According to Santiago, since the researchers were European, the Laguna de Bay was judged according to European limnological standards, which may not be appropriate to tropical lakes. The Napindan Hydraulic Control Structure regulates the inflow of marine saltwater into the lake and thereby reduces nitrogen intrusion in the lake, which is considered to be the main cause of eutrophication. In doing so, the NHCS may have deteriorated the lake's natural hydraulic and nutrient regime and the intrusion of saltwater into the otherwise turbid waters of the lake leads to flocculation, a process by which suspended sediments react with the saltwater, coagulate and eventually settle at the lake bottom. The flocculation process makes the water transparent to sunlight, which allows photosynthetic activity for phytoplankton growth. Because phytoplanktons are the primary producers of the lake, all other organisms in the lake depend on it, which becomes the ecological base for a healthy fish population. However, with the saltwater going out of the system, the turbidity returns, and primary production is consumed rather fast, disrupting the ecosystemic cycle. The FAO measured the Lake Phytoplankton boom in 1977, showing this oscillation in primary productivity within a year (Figure 2.10).

In addition to the eutrophocation and saltwater intrusion, overfishing is one of the most pressing problems that have altered the lake's ecosystem. In the years 1961 to 1964 the average yearly fish catch ranged from 80,000 to 82,000 tons, however, in the year 1968 it decreased to a mere 39,000 tons (ARCBC, 2009). The overfishing in the lake is attributed to changing fishing practices which use faster motorized boats using drift nets, and nets with finer meshes to catch even smaller fish. These practices have decreased the population of the future breeders thus depleting the total stock. Faster boats, drift nets, and finer fish nets have weakened the stability of fishing activities in the lake. In 1968 it was noted that much of the catch was used as animal feed, thus the mechanized fishing system decreased the fish that had good market value for human consumption, to the disadvantage of the fishermen using more traditional techniques.

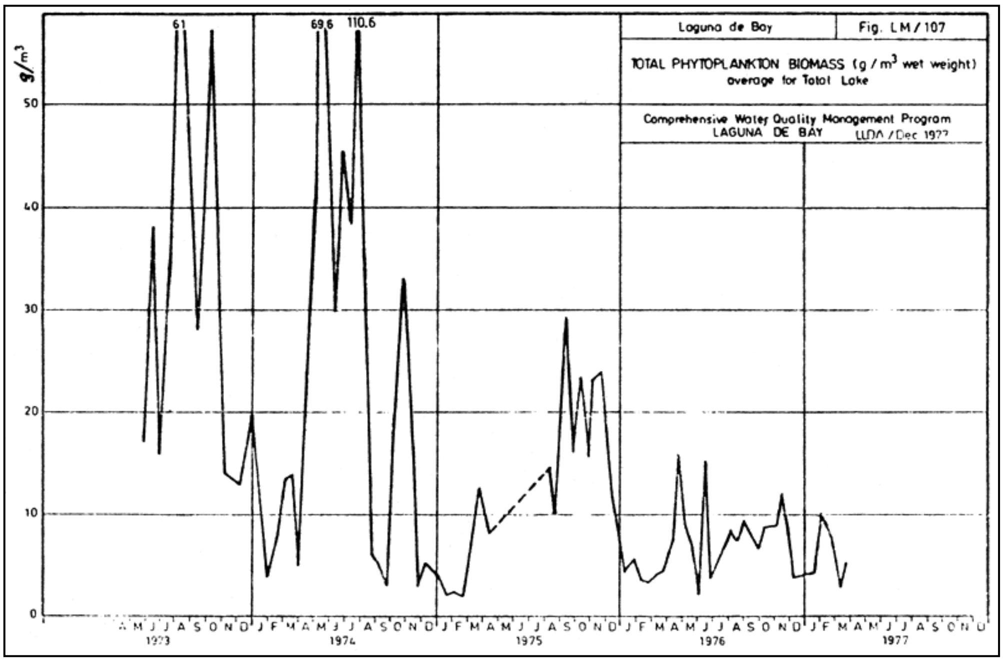

Figure 2.10: The annual oscillations of the phytoplankton population in the Laguna Lake ecosystem. The larger oscillations between years may be part of another larger cycle beyond the scope of his research. The Vertical axis represents phytoplankton concentration in g/m^3, while horizontal axis represents years.

Source: http://www.fao.org/docrep/008/ad794b/AD794B43.gif

In an effort to solve the worsening fishery situation, the Laguna Lake Development Authority came up with the idea of introducing fish pens to promote culture of the milkfish in 1970. The project was successful to a fault and the LLDA eventually asked the same fishermen it had targeted to reduce this practice as it came to cover nearly a third of the lake’s surface. As of 2011, the Laguna de Bay produces an annual fish harvest of 132,000 tons of milkfish from these pens as shown in Figure 2.11 below.

Figure 2.11: Large portions of the Laguna Lake are still covered by fish pens. Without the fish pens the catch from the lake will be much lower than its present production. As of 2011 the mean annual fish catches are about 132,000 tons. (Photograph by the researcher. February 10 2010).

Lake Basin	In-lake						Basin origin						Regional/Global		
	① Unsustainable fishing practices	② Introduced faunal species	③ Salinity changes	④ Weed infestations	⑤ Nutrients from fish cages	⑥ Loss of wetlands	⑦ Excess sediment inputs	⑧ Non-point source nutrients	⑨ Agro-chemicals	⑩ Water abstraction and changes in run-off	⑪ Effluents and stormwater	⑫ Industrial pollution	⑬ Atmospheric nutrients	⑭ Atmospheric industrial contaminants	⑮ Climate change
Aral Sea			→			→				→					
Baikal							↓				↓	→		→	
Baringo	→						↓			↓					↓
Bhoj Wetland							→	→	→		→	↓			
Biwa				→		↓		→	→	↑	↑				↓
Chad						↓	↓			↓					↓
Champlain								↑			↑			→	
Chilika Lagoon			↑	↑			↓	↓	↓	↓	↓				
Cocibolca/Nicaragua							↓		↓		↓				
Constance		↓				→		→	→		→				
Dianchi					↑	↓	↓	↓	↓	↓	↓	→		→	
Great Lakes (N.Am.)		↓						↓	↓		↑	→		→	
Issyk-Kul		→					↓	↓	↓			↓			↓
Kariba Reservoir					↓			↓			→				↓
Laguna de Bay	→	↓	→	→	↓		↓	↓			↓	→			
Malawi/Nyasa	↓			↓			↓	↓	↓	↓	↓		↓		↓
Naivasha	↑	→		↑		→	↓			→	↓		↓		
Nakuru							→	→		↓	↓				
Ohrid	→	↓				↓	↓	↓	↓		↓				
Peipsi/Chudskoe	↓			→				→			↓	→			
Sevan	↓	↓				↓	↓			↓	↓				
Tanganyika	↓						↓				↓	↓			↓
Titicaca		↓					↓				↓	↓			
Toba	↓	↓		↓	↓	↓	→	→	↓	↓	↓		↓		
Tonle Sap	↓	↓					↑				↓				
Tucurui Reservoir				→			→								
Victoria	→	↓		↑		↓	↓	↓			↓	↓	↓		
Xingkai/Khanka	↓					↓	↓		↓		↓	↓			
Total	12	11	3	9	4	11	21	16	12	11	23	12	4	4	7

Figure 2.12: State of the Ecosystem of the Laguna de Bay Basin. Arrows projected downward mean deteriorating conditions, arrows projected upwards mean improvement in the prevailing conditions, arrows projected horizontally mean no major changes in the prevailing conditions. (*Source: ILEC, 2007)*

The Laguna de Bay is plagued by a complex set of problems especially point and non-point sources of pollution of the lake, alteration of the lake's natural ecosystem by invasive species, increasing sedimentation of the lake by the tributary watersheds and overfishing in the lake for the sustainable use of its fisheries (ILEC; 2007). Many of the environmental problems in the lake basin are not problems of the lake itself but are associated with the vast area of land that drained by its tributaries. Conversely, forests in the tributary watersheds have a positive impact upon the water quality of the lake; this correlation is evident in the case of clear waters of the eastern tributaries. However, these closed forest areas are rather isolated from each other, and remain only in three large pockets in the basin: the Sierra Madre Range in Marikina Basin, the Mt Banahaw region in the Pagsanjan Basin and Mt Makiling region in the Los Banos watershed area. Of these forests perhaps the most denuded is the Mt Makiling region, as the western and northern parts of the reserve forest are depleted. Urban land uses have given rise to dense settlements starting from the lowlands and extending further into areas that had forest cover even a generation ago. Presently there are a number of resorts and real estate establishments inside the protected area. Adding to the urban sprawl, illegal logging activities, and charcoal production often take place inside the reserve forest. As Mt Makiling is surrounded by urban land use it is difficult to protect the remaining forestlands, and the present command and control mechanisms taken by the Department of Environment and Natural Resources (DENR) and University of Philippines have fallen short in this regard. Much of the protected forests are no longer closed forests but are increasingly open with plantation and cleared areas in between primary forests.

The extension of Sierra Madre range and the associated forests which are found in the upper Marikina, Tanay, Pililla, Santa Maria and Siniloan Basins are not protected by command and control and have an age old forest land use culture known locally as *kaingin* in which traditional forest uses such as slash and burn agriculture, charcoal making and hunting of wild animals, continue. These activities have also resulted in a degradation of the forest resources in the lake basin, finally resulting in the degradation of natural ecosystems of the Laguna de Bay Basin. The region has a number of indigenous peoples (IPs), who are said to be associated with the *kaingin* land use practices. How a typical landscape in the Sierra Madre looks like can be exemplified through the account of a researcher from LLDA's Laguna de Bay Watershed Environmental Action Planning Program, according to one the researcher:

> "… (At barangay Cuymbay) we saw charcoal makers that indicate how the people get their livelihood and its implications on our resources…the road leading to the *barangay* is so steep although 2-3 km (away) only from the main highway. What is ironic here is that along the major highway, a well paved road, there is the Sierra Madre Hotel and other rest houses, but when you enter this *barangay* road, there is this niche of a community that is about, say, 50%-60% IPs (Indigenous Peoples). There is no electricity, only generator sets. There is

> only one elementary school….

The same report states again:

> ...and then, amazingly, we chanced upon makeshift stands that sell monitor lizardsfor P150 (US$xx 150-250 and tickling (white breasted swamp hen) for P 40-50 (US$ xx) depending on the size. [This indicates] that Tanay is still biologically rich and that in terms of biodiversity.

The team again notes about the existence of illegal mining activities:

> "…We were surprised to discover black marble mining. Together with LLDA, we went there [to doko doko] yesterday and they were also surprised to see the mining area because supposedly, the operators must apply for a permit with the LLDA because it [the land it mines] drains to the Laguna Lake
>
> (Unknown, n.d.) .

The case of Banahaw Protected Area is different from Sierra Madre, where nature and humans interact, and few command and control mechanisms are available for minimizing human impacts. Banahaw's surroundings are different from the Mt Makiling region described above. Banahaw remains untouched by the urban and profit-making activities. The majority of the visitors to the area are pilgrims who hike the mountain to celebrate a local ritual marking the attaining of adulthood. The mountain is said to be the dwelling place of God, Catholic saints and even some of the 19th Century Philippine national heroes.

Banahaw de Lucban is a secondary lava cone on the eastern slopes of the

Banahaw. Its rugged terrain keeps areas converted to agricultural and settlement purposes restricted to its lowers slopes. Mt San Cristobal (locally known as Devil's Mountain) is neither a sacred area nor a protected park. Therefore the mountain is much less forested and has mixed landscapes of brushlands, grasslands and plantations.

As a whole, the types of land uses around the Laguna de Bay Basin mix urban and the rural influences as well as Filipino and indigenous practices. For the most part, the urban lifestyles are confined in resorts and holiday homes with resources of the industrialized world available in these places. Outside this luxurious domain lives a poorer community who is perpetually dependent on living directly from the dwindling land and water resources. However, the resource use options for the indigenous peoples are based on age old cultural practices which are difficult to change. Hunting wild animals in the forests of Philippines, for example, may be as old as the history of human settlements itself. This is also true for slash and burn agriculture and collection of fuel wood from forest vegetation. In tropical forest regions, these more direct uses of the land can be sustained with low population densities, or healthy forests, but are not sustainable practices with high population density or degraded forest conditions.

Another notable feature is the land use change in the extension of Sierra Madre through forest cutting and development of upland plantations. The conversion of forest areas through large scale forest clearing and the establishment of upland horticulture plantations is a major threat to the lake's ecosystem, especially in the fringes of Sierra Madre fronting the lake (Top, 2003).

One viable option for protecting the environments and raising livelihoods of the people here is to increase tourism activities in the region to provide alternative sources of income. However, tourism does not always pose an opportunity to save the environment and raise the livelihoods of the people using traditional methods (Wells, 1992; Christ et al., 2003; Lamorski & Dabrowski, n.d.) The UPLB regularly closes all climbing activities in the region at certain times due to pollution from the solid wastes produced by the climbers. Tourism can also cause a diversion of money away from the local communities to the outside infrastructure developers and businessmen. This seems the case in the present tourism activities in the extension of Sierra Madre range in the Laguna de Bay watershed. The high-income lifestyles of the gated resorts, with a poor indigenous community kept outside the tourism industry's gains, widens the social and economic gap in the local culture.

In addition to diverting funds, and placing a wedge in the society, tourism can also bring the ill effects of drugs and alcohol and may lead to the deterioration of environment. The case of Aeta people[22] of the Sierra Madre Mountains is an example of this. Top (2003) asserts that with increasing exposure to alcohols and drugs, indigenous inhabitants allowed people to penetrate and open logging activities in their ancestral land. In doing so, the Aeta's ancient culture and the forests that they depended on for more than 4000 years were degraded considerably. Tourism activities can also bring social vice such as sex tourism and child prostitution (Niu, 2000). Such activities actually were (and still are) associated with tourism activities in the Pagsanjan River area.

Despite these very real potential pitfalls associated with tourism; there are social and environmental benefits of applying tourism based strategy for reviving the region. Tourists from the urban areas also take part in the preservation of nature, as the influx of tourists put an existence value for nature for its aesthetic beauty and a nature which is away from the urban. In doing so, tourism activities may play a role in preserving biodiversity in the region.

Tourism might also generate alternative income sources and help to get rid of destructive practices such as slash and burn agriculture. The quintessential aspect of slash and burn cultivation is the return period after the cultivation. A shorter fallow

[22] Also called as Agta, Agay or Ata

period tends to degrade the forest cover over time (Boserup, 1965; Seavoy, 1973; Cramb, 2005). This can happen for several reasons, including: multiple cropping in the same plot; a shorter return period; the 'shading cycle' due to either lesser cultivable area; or greater population density in the community leading to a much larger area of land per year for cultivation.

If tourism can help preserve the integrity of the ecosystem then it can contribute to preserving the lake basin environment for the long term, and is certainly something to look at seriously as a policy solution, albeit with a careful eye to the potential social problems associated with it.

2.8 Summary

The Laguna Lake has existed long before humans inhabited the Philippine Islands. The dynamic interaction of the land and the sea has shaped the past and present conditions of the lake. The lake basin environment is characterized by its rich fisheries and fertile soils in the low lands that are ideal for rice cultivation. However, the upland soils are not suitable for agricultural practices due to their *in situ* character, which makes the soils highly erosive. In the past few decades, the peri-urban areas of Metropolitan Manila have expanded into the western margins of the lake basin through the San Pedro, Binan, Cabuyao and San Cristobal watersheds. The eastern tributaries, on the other hand, are dominated by more rural landscapes with ample vegetative cover. These areas also have cleaner rivers in the lake basin which contribute positively to the health of the lake water ecosystem.

The function of the Laguna Lake ecosystem has been impaired in two ways; one, through the operation of the Napindan Hydraulic Control Structure; and second, through the deterioration of the micro-watersheds. The lake's floral and faunal populations and the water quality level optimum for their survival is linked with Manila Bay. However, the NHCS has artificially altered the natural process of saltwater intrusion in the system, creating problems for lake and the organisms relying on it. The micro-watersheds of Laguna together discharge 3.8×10^9 m^3 of water into the lake. Thus, freshwater in the lake is replenished approximately every eight months. Therefore, changes in the watersheds are reflected in the lake's conditions within a year. This particular feature coupled with its average depth gives Laguna de Bay a unique character. Thus, it is both urgent and imperative to assess the conditions of the micro-watersheds and the social ecological factors and processes that may cause further degradation of the lake ecosystem.

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Chapter 3

From 'Water Resource Management' to 'Land and Water Resource Management'

3.1 Introduction:

The notion of integrated water resource management (IWRM) is widely debated among politicians, planners, and naturalists. However, failure in managing the resource that is sometimes referred to as "blue gold", as a resource for the global and local common goods reflects the problem of conceptualizing the dynamism of IWRM. The notion of IWRM has been developed over time, and is recognized in academia as having quite a long history. During the time in which the development of the idea has taken place, there have been significant changes in thinking and ongoing debates. Some have stressed the importance of formal mechanisms in implementing IWRM while others have emphasized the vital function of informal sectors in the realization of IWRM. Others still, have argued for a mixed approach, taking account of both formal as well as informal sectors according to the region to which the concept is applied. However, it is only very recently that the "IWRM package" has been recognized as non linear, dynamic, diverse, and complex. (Saravanan, 2006).

This chapter is directed towards understanding the evolution of the concept of IWRM, as well as the ideas of feedbacks and adaptiveness that emerged from this work, before assessing the present position of the IWRM rhetoric, as expressed through its evolution. It is argued that a major reason for the failure of this idea in the implementation stage is, a stress on *maximum* ecosystem services, which is dominant even in relation to the idea of maximum *sustained* ecosystem services. The concept of IWRM, as emerged in the literature, is seen through the notions of human ecology. This chronological review suggests that in each stage of the development of the notion, as well as in its implementation, externalities arise accordingly. These externalities suggest a complex, as well as a compound, relationship between the human and ecological systems, whereas the internalizing of many frameworks that were previously thought of as external conditions are regarded as characteristic of adaptiveness and resilience in the management of water resources in an integrated manner. Special attention is given to the processes of basin governance, and its effectiveness in patterning the ecological processes and feedbacks, in such a way as to minimize the energy used in the planning process.

3.2 Integrated water resource management: A Historical Perspective

Much of the terrestrial landscape has been shaped by water over millions of years. The unique characteristic of water that it is able to exist in solid, liquid, and gaseous forms in the temperature range of the earth–atmosphere system makes it a wonderful "tool" with which nature has been able to shape landscapes over space and time. Water affects these landscapes in both direct and indirect ways; directly through its hydrological action, and indirectly through water's potential to influence the metabolism of all living organisms. These organisms, and their complexes, such as biomes, which depend directly on water for their survival, shape their immediate landscapes as well as the earth–atmosphere system, thereby influencing the livable steady state conditions of the earth's life supporting systems. Water, thus, is at the very heart of the Gaia hypothesis as presented by Lovelock (1979). However, with the domestication of plants and animals around 13,000 years ago somewhere around the arid Middle-East (better known as the "fertile crescent") (Diamond, 2005), humans increased the importance of the relationship between water and landscape significantly. Since they now depended on plants for their survival, which in turn needed water for their survival, humans started changing the landscape by creating the necessary conditions for the "domestication" of plants. What followed was a population explosion in the perennial river basin regions, with increased specialization in resource use. These specializations in resource use gave rise to large hydraulic civilizations, in the sense that all the resources utilized within a river basin were patterned by hydraulic structures, such as dams and other irrigation systems. Some hydraulic civilizations were successful in achieving comprehensive management of their land and water resources, as exemplified by their lifestyles and the time scale (several thousand years) over which they remained as hubs of technological advances and international relations through trade (Kenoyer, 1997; Yoffee, 1995). The success of these civilizations as far as long–term resource use is concerned, suggests that they must have had a plan based on the interconnectedness of the land–water systems. Based on these facts, it is presumable, that an integrated approach for land and water resource uses in this sense is older than the idea itself.

The notion of IWRM as an academic discipline came much later. Perhaps the earliest roots of IWRM can be traced back to the 1930s, with the commencement of Multi–Purpose River Valley Projects (MPRVPs) such as that of the Tennessee Valley Authority, which marked a new era of integrated resource management. Although the main aim of these projects was to use the then rapid technological advances to extract the maximum possible yield from the watersheds, nevertheless, they did try to include "water systems" with other ecosystems and a knowledge of both terrestrial and aquatic ecosystems, as erosion and pollution control, etc., were necessary (Mukhtarov, 2007). However, as this approach looked at resource management for maximum possible yield, it looked at natural systems objectively, and human systems were considered to be beyond this sphere. Later, the works of White (1961), Simon (1957) and Wolpert (1964) brought the characteristics of decision-making processes for resource management into focus. White (1961) showed that culture and resource management institutions had a greater influence on decision-making than the immediate physical environment. Simon's (1957) and Wolpert's (1964) works showed that decision-making for resource management was based on imperfect knowledge, rather than perfect knowledge (Hooper, 2003).

The search for a compromise that was reflected in an integrated approach to land, water, and ecosystems started around the 1960s. This integrated approach (also conceptualized as "second generation IWRM") took shape in response to widespread negative consequences from misuse of interactive land and water systems mainly reflected through the declining quantity and quality of available freshwater (de Jong et al., 1995). This new concept took some time to develop a stronghold in academia, finally becoming established in the 1980s. The idea of water resource management as an interaction between land, resources, and the environment was put forth by Burton (1984) in his article: *The Art of Resource Management.* Burton argued for a land–use appraisal of resource use. However, even at this time, integrated management of water resources still meant *maximum* possible human uses. Biswas (2004), following a review of literature from the last 60 years, identified many elements of the related frameworks that constitute the IWRM rhetoric. A summary list of these elements is given below:

- Economic efficiency, regional income redistribution, environmental quality, etc.
- Water supply and demand
- Surface and groundwater
- Water quantity and quality
- Rivers, aquifers, estuaries, and coastal waters
- Wastewater
- Water projects
- Urban and rural water issues
- Water institutions
- Public and private sectors
- Government and NGOs
- Legal and regulatory frameworks related to water
- Economic instruments for water management

- National, regional, and international issues
- Intrastate, interstate, and international rivers
- Bottom–up vs top–down approaches
- Centralization and decentralization
- National, state, and municipal water policies
- National and international water policies
- All social groups
- Gender–related issues
- Climatic, physical, biological, human, and environmental impacts
- Present and future generations
- Present and future technologies
- Water development and regional development

(Biswas, 2004).

However, the implementation of this broad, all–encompassing concept has been far from successful. Biswas suggests that the main reason for this failure is the increasingly reductionist approach to the different "epistemic frameworks" provided by the indicators of the integrated water resource management. These include different disciplines, together with their theories and institutions, including water, environment, economy, society, communication, technology, geography, and many more. Together, they form such a vast field of knowledge that mastering all of them is quite impossible (Biswas, 2004). Therefore, the potential allocation of equal importance to each of these criteria is an impossible task, rendering the concept of *integration* a utopian ideal.

One of the most significant contributions to the IWRM rhetoric, as far as the problem of reductionism of ideas is concerned, has been the work of Mitchell (1991). As Hooper (2003) found, Mitchell's approach was focused primarily on ecosystem–based natural resource management principles, however, his emphasis was on the use of *specific* components, based mainly on stakeholder knowledge, for an integrated approach to resource management. The concept of IWRM had been under development for a long time, gaining momentum with the new environmental movements of the post 1970s, which promoted wide-scale reductionist ideas in the name of comprehensiveness. Mitchell's work tries to address this problem with a strategic approach based on stakeholder knowledge as a means of achieving holism. Mitchell's approach enables effectiveness at the implementation stage, unlike the comprehensive approach. One of the greatest drawbacks of his idea, however, was that although it was based on an ecosystem approach, human systems were not included, being regarded instead as external boundary conditions.

The different stages in the development of the IWRM concept are shown below. They indicate a trend in thinking from *maximum possible ecosystem services* to *maximum sustained ecosystem services,* given the same exemplary externalities.

Table 3.1: A literature review of the IWRM rhetoric.

WRM in the past	**Planning Procedure**	**Emerged externalities**	**Literature**
Prior to 1930s	Single purpose	Organization of ecological processes in the human system extremely dispersed. Objective view of nature. Lack of linkages between human system and the ecological processes. Culture	White, 1998
1930s – 1960s	Multi-Purpose (First Generation IWRM)	Organization of ecological processes in the human systems is still dispersed. Objective view of nature. Lack of linkages between human system and the ecological processes. Culture	Water Projects for maximum possible yield (TVA, Aswan, DVC).
1960s – 1990s	Land, water and ecosystem based management (Second generation IWRM)	Lack of linkages between human system and the ecological processes. Culture	Simon, 1957 White, 1961 Wolpart, 1964 Burton, 1984
Post 1990s	SES	Information flow pathologies, Unsustainable utilization of human behavior	Lee, 1992 McGovern, 1988. Gleick 2000, Mitchell 1991, GWP, 2000

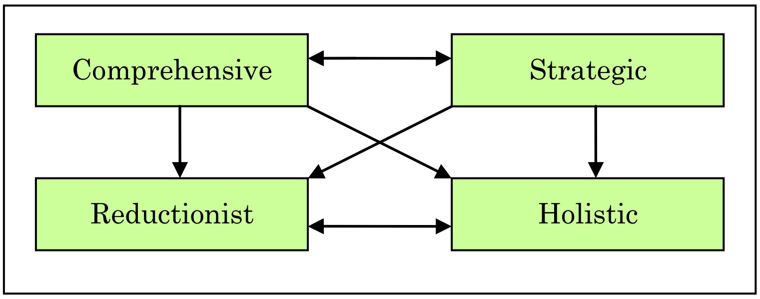

Figure 3.1: The four problem modules with IWRM (Source: Author)

Based on Table 3.1, we can find four problem modules for the conceptualization of IWRM (see Figure 3.1). These four problem modules are also associated with all other natural resource management practices. They reveal two major dichotomies, the first arising between comprehensive and strategic approaches, while the second is between reductionist and holistic approaches. The existing literature suggests that a comprehensive and holistic approach requires such a lengthy time frame that it is a near impossible task. Comprehensive approaches have thus tended to become reductionist, because it is much easier to draw knowledge from the pockets of expertise that exist within different elements of natural resource management, for example, elements concerned with water management listed earlier. The strategic–reductionist approach has perhaps been the most widely implemented one for the management of water resources. This constitutes a direct utilitarian concept, reflected in structural management methods such as dam building and irrigation expansions, and by single – sector approaches such as river basin management practices prior to the 1930s. Gleick (2000) suggests that IWRM indicates a transition from a directly utilitarian concept of better utilization of resources that were thought to be of unlimited quantity to an indirect utilitarian concept involving better utilization of *finite* resources. External boundary conditions (meaning conditions that do not have a direct influence on the system) arise in each of these cases, giving rise to negative environmental externalities, with the outcome being both quantitative and qualitative deterioration of resources at the receptor level. This is most prominent in the case of the strategic–reductionist approach as exemplified by White (1998). Before White's work, culture was a major external boundary condition, for example, in either the strategic or the integrated approach to the management of natural resources. However, nowadays the attribute of culture is being reconsidered in any natural resource management rhetoric, especially the rhetoric associated with adaptive management, which is at the heart of human–environment or social–ecological systems discourse. Likewise, in water resource management prior to the 1930s, where the trend was towards single–purpose approaches, certain purposive management practices such as dam building viewed irrigation as the sole internal boundary condition. Processes such as recreational use or biodiversity conservation in the riparian states were external to the management of the system in this sense. With the emergence of MPRVPs following the

1930s, internalization of many attributes became possible, but in general they continued to concentrate on strategic interests, while the vital parameter of *interactions* between different strategic interests were not taken into consideration. Thus, in this phase, interactions were not included as external boundary conditions in the water resource management system. The internalization of interactions between land, water, and ecosystems came with the second generation of IWRM, especially following the 1990s, from when water resource management began to be seen as integrated land and water resource management (ILWRM).

An essentially human ecological approach to the management of river basins has been adopted in recent years, especially since the 1990s. This trend has followed the main criteria of basin management, with human systems seen as integral to natural resource management. This has seen the establishment of the notion of the social–ecological system (SES), and this concept (as it relates to IWRM) is described in the following section.

3.3 Social-ecological systems and the causes of their collapse:

The interactions between resource pools and human systems are not separate phenomena. Thus, the criteria of integration in its broadest sense are related to the interactions between the human, or social, and the natural or ecological systems. Together, they form social–ecological systems (SES) (Anderies, Janssen & Ostrom, 2003). The importance of these two components, which are at the heart of IWRM, has also been described by Jonch-Clausen and Fugl (2001). In contrast to the objective view of nature, which focused on optimum resource use and thus profit maximization, the notion of SES allows resource managers to take a subjective view of nature whereby the social systems are seen to be embedded within it. Thus, it is, in essence an indirect utilitarian concept. This relationship is represented by a simple feedback system as shown in Figure 3.2 below. However, this simple relationship is not likely to be realized in reality, where the prevailing condition is more likely to be a complex–compound relationship (see Figure 3.3).

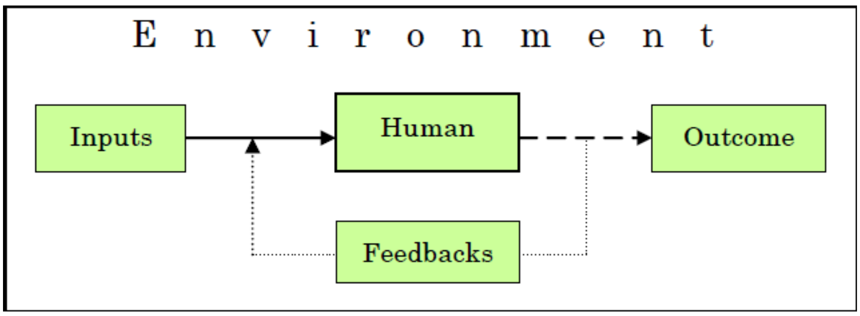

Figure 3.2: The relationship between Human system and the Environment. (Source: Author)

Complex–compound relationships involve an array of different sources, pathways, and receptors for social–environmental outcomes. This explains the non linearity, diversity, and dynamism of the IWRM rhetoric, and this kind of relationship gives the whole system more resilience because the collapse of certain components does not necessarily lead to the collapse of the whole system (Anderies, Janssen & Ostrom, 2003), an attribute that makes social–ecological systems adaptive to change. For IWRM, the natural system is given by the resources available at the land–water systems, the mutual interaction and evolution of which tend to maintain SES. A decomposition of human systems, on the other hand, provides the analytical frameworks of all the different stakeholders and their activities as expressed through their use of the land. These different land uses can be taken as characteristics of the human system influencing the collapse or sustainability of natural resources.

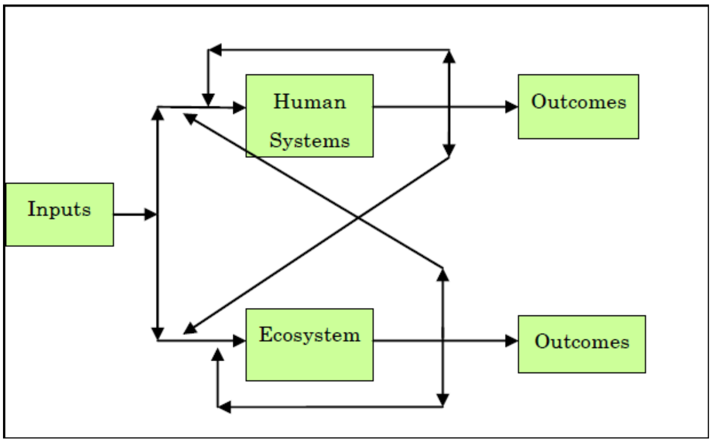

Figure 3.3: Complex compound relations in a Social-ecological system (Source: Modified after Harvey, 2007; 454)

A foundational study of the factors of mismanagement which can lead to the overuse and eventual collapse of resource systems was done by Garrett Hardin (1968) in his work: ‘The Tragedy of the Commons’. In this work, Hardin showed that an increase of a positive component can lead to the degradation of the ‘commons’. For example, in the case of a pastureland (a ‘common’ resource); an increment of a cow leads to an increment of the negative component of overgrazing. While a ‘positive utility’ of an additional animal is +1 unit, the negative utility associated with overgrazing is smaller than –1 unit. This occurs because the effects of overgrazing are shared by all the herdsmen using common pasture land. These two factors encourage the pastoralists to maximize their ‘goods’, which in this case is the services from the animals as quickly as possible. But because resources are finite unlike the growing population, the rate of population growth is the primary factor that leads to resource depletion.

The concept of common pool resources or CPRs is at the center of Hardin’s argument and laid the foundations for resource economics. CPRs define those resource types which do not have clearly defined property rights. Grazing lands, irrigation systems, lakes, rivers, and fisheries constitute the most common examples of such CPR resources. The ever increasing power of human economic activities and the inputs they require; combined with the finite resource pool, creates a vicious cycle of exploitation exceeding natural resource regeneration leading eventually to resource depletion. Based on this logic it follows that the sustainability of common resources is directly related to the state of the CPRs and therefore that in the longer term human populations are also reliant on the maintenance of common resources. In the long run, conditions are more likely to move towards resource collapse as there are no restrictions for actors to exploit a particular common resource. Becker and Ostrom (1995) argue that common-pool resources are defined by two factors: exclusion and subtractibility. These two factors determine the 'tragedy of the commons' phenomenon relating to the governance of common-pool resources. Exclusion means deterring others from using a resource. In simple terms it is about placing restrictions on use. Most commonly exclusion is created though property rights and is violated by 'free riding' of some actors who make use of the resource without paying for its cost. Most natural resource managers call for an exclusion through some form of property scheme, their main aim being to internalize the 'free riding' described above. In practice however, more often than not, these schemes have failed to achieve their purpose, in worst cases deteriorating the ecosystem health further or creating a wider gap of resource inequality within the community (Runge, 1981).

The second factor influencing CPRs is subtractibility which is the diminution of a resource's value due to usage. Subtractibility leads to increasingly uneven distribution of resources over space and time. Other defining characteristics of common-pool resources include the mobility or storage traits of a resource and whether the resource is physical or biological in nature (Becker & Ostrom, 1995). In case of water resources, flowing water and stored water require completely different management practices and have different end uses for both human and ecological purposes. For example, water generating electricity though a dam's turbine is a physical resource; whereas water in a fishery is not. Water is therefore neither an inherently physical nor biological resource but often has characteristics of both, with the same water serving different purposes for different users simultaneously. These multi-purpose attributes of a common-pool resource make water governance challenging as far as long term sustainability is concerned as compared to other natural resources which have fewer uses for fewer actors.

Apart from Hardin's classical idea, and the second generation of ideas that evolved from Hardin's framework, like those put forward by Becker and Ostrom, other scholars, like McGovern et al. (1988) concentrated on information–flow pathologies as some of the main forces behind sustainable social organizations, which tend to affect the sustainability of SESs. According to McGovern et al., lack of or flawed information flow may occur for several reasons, such as over–generalization of information available within one type of ecosystem, applying one ecosystem management model to manage several ecosystems, managerial detachment from the resource–user communities such as agriculturalists, inadequate observation, ideological beliefs (Lee, 1992), and moral and ethical considerations by the managers. These problems then give rise to formal solutions, which result in less than favorable outcomes and make the social–ecological systems less resilient to necessary changes for long–term resource use. The degree of divisibility of the different resource categories is another attribute that affects the management of natural resources. The notion of unsustainable utilization of human behavior is actually quite old. Zimmerman (1951) and Firey (1960) were the main proponents of this idea. They proposed that the perceived values of certain ecological processes affect the behavior of individuals and communities. These values, according to Firey, must be internalized, and must be recognized by the society as gainful to both the individual and society (Firey, 1960). Conservation of ecological processes by local farmers is an example of internalization of ecological values. Furthermore, the internalization of ecological values is related to culture and traditional knowledge, as expressed by White (1998), as discussed above. The interaction between the common–pool resources and the resource users is, therefore, shaped through an array of social decisions that constitute the meta–system of human–environment interactions. Unfortunately this has so far been inadequately addressed by both the market and state institutions (Carpenter, 1998).

The following section addresses the process of institutionalization of the ecological processes through understanding the feedback patterns and building resilience in human institutions, both of which are actually an attempt at "co-adaptation" with the changing circumstances of a social–ecological system. Here reorganization of the IWRM thinking is proposed from the macro scale, based on the theory of evolution, to the meso scale, based on the different natural resource management approaches, to the micro scale, based on the interaction of human institutions with the natural environment as a means of achieving long–term resource use.

3.4 Basin governance as 'complex adaptive strategies' for ecosystem homeostasis

Natural resource management practices tend to arise from efforts aimed at controlling certain environmental characteristics of a given region for human consumption. This utilitarian nature of management practices has been at the heart of ecocentric management, such as conservation of biological diversity. The main question raised by such practices is, "If we cannot protect other species from human–induced extinction, can we protect ourselves from the same?" In the case of IWRM, this conservationist thinking can be related to the concept of maintaining environmental flows with a view to maintaining ecosystem health. This indirect utilitarian concept is easily distinguishable from the direct utilitarian concept which holds a purely objective view of nature as expressed through technocentric thoughts.

3.4.1 Co-adaptation, co-evolution and ecosystem homeostasis:

The framework of basin governance of any natural resource management program can be divided into three stages, according to the scale of inquiry. The broadest is the macro scale, which originates from the theory of evolution. The notion of IWRM through basin governance falls within the domain of social–ecological systems, which constitutes the efforts of human beings to make them and their activities “fit” with the surrounding environment for the long–term use of a particular natural resource. Thus, if the environment changes, then human activities and therefore resource management practices must also change, to make them fit with the surrounding environment. This “changing together” and “fitting together” has been recognized as co-adaptation and co-evolution (Martin, 2001). Natural resource management requires planning at different levels of decision-making. As human society composes a system that interacts with the environment, through either collective or individual decision-making, natural resource management must address this process of decision making. Dakin (1963) stated that planning is “a careful balance between efforts to draw energies together.” The “energy” in Dakin’s explanation is nothing other than the complexity that arises as a result of collective human actions within the environment. These collective human actions need to be held together in some *way* to “reduce the entropy and increase organization within an environment” (Burke & Heaney, 1975). The importance of such organized behavior is to make human actions fit with the environment with minimum energy spent. This energy minimization can help reorganize the system according to the feedback it gets, both from the inputs drawn from nature and outputs to nature. The reorganization leads to changes needed to make the social system fit with the environment. Thus, the human systems make them adaptive to the environment in response to the changes in that environment.

3.4.2 Natural resource management for ecosystem homeostasis: managing feedbacks

At the meso scale of IWRM thinking, the various natural resource management practices can be taken into consideration. Natural resource management practices are actually ways of understanding the feedback provided by ecological processes in response to naturally or anthropogenically induced interventions. Natural resource management practices can be divided into three broad paradigms; adaptive management, ecosystem–based management, and community–based management (Bocking, 2004). Adaptive management refers to the efforts of human institutional systems after regional development or environmental preservation projects have been implemented. Environmental impact assessment is the most common example of adaptive management. Ecosystem–based management, on the other hand, refers to the priority given to nature, which is mainly seen as objective, for human consumption. This type of management can be further subdivided into three categories, i.e. management through species-based inquiry, through the array of different possible activities, and an array of different goals that may or may not be achieved as far as a common resource is concerned. Each category of ecosystem–based management has its own drawbacks. Management through species-based inquiry is easily carried out, and requires much less effort and time to understand the state of the ecosystem. However, it does not provide any information about the state of other species within the ecosystem, such as an increase or decline in their population due to management practices. The *real* state of the ecosystem, therefore, is never known. The state of the ecosystem as judged through the array of different activities that can be carried out concerning a common resource, as well as goal–oriented ecosystem management, take a primarily objective view of nature, concentrating mainly on how much can be extracted from it. The question is therefore, how much consideration in real terms is given to the state of the ecosystem?

The third management paradigm involves community–based attempt to make human systems fit into the natural systems. This approach is concerned with resource management through local community effort, and with acknowledging the importance of local knowledge in determining resource use. To the extent of whatever spatial and/or temporal scales they apply to, these management practices are actually an effort to fit the current production at the primary, secondary and tertiary levels to the environmental circumstances in which they are situated, and also to some extent to the possible future circumstances in which they may find themselves. Furthermore, this attempt to make human activities fit the natural circumstances asks for resource use on an optimum scale. The biggest drawback of community–based natural resource management practices is that it requires the use of community's knowledge. Traditional knowledge regarding long–term resource use is not a unidirectional phenomenon; there are many other attributes that are involved. Diamond (2005) has provided a detailed description of such attributes in his popular book *Guns, Germs, and Steel: The Fates of Human Societies*. He argues that the collapse or sustainability of human societies is a factor of the environment itself. The main aim of management practices such as those outlined above is to increase the knowledge base of the resource managers, in both the formal and the informal sectors, to better cope with the dynamism and complexity of the environment.

3.4.3 Human institutions and resource user communities for resource use: Patterning ecological processes through resilience

At the micro level, different resource management institutions come into play when it comes to resource use. These institutions may be either formal or informal in nature. It is the combination of these institutions and their decisions which makes resource use possible in a given river basin. These resource management institutions tend to combine social decisions in a collective way for resource governance. The aim of the resource-governing institutions is to give a *pattern* to the ecological processes in order to build resilience. The dichotomy between the words "governance" and "government" is worth mentioning here. The words "governance" and "government" are often used interchangeably where management of natural resources is concerned, but they are substantially different. The latter is associated with "official" control over a tract of land or country, while "governance" is different in the sense that it is associated with the "activity" of controlling or managing a tract of land or a country. Therefore, the essence of it is related to different actors or stakeholders at various levels of society. The collapse or sustainability of natural resources is thus strongly related to both terms, the governance of the natural resources as performed by all the stakeholders, and/or the official control of the resource by a few. Social systems tend to find and use a pattern to utilize natural systems. This is referred as "institutionalization of ecological processes" (Lee, 1992). There is a growing literature mentioning the importance of institutional reforms (Bandaragoda, 2006; Ferragina, Marra & Quagliarotti, 2002) and regarding either stakeholder involvement taking a participatory approach for resource management (Moigne, Xie & Subramanian, 1994; Newson, 1997; GWP, 2000) or market–based instruments such as water pricing (Dinar, ed, 2000). The main aim of the resource–governing institutions is to draw the necessary energies together for efficient resource use, in other words, to institutionalize the resources for better management. Furthermore, these institutions may fail to include all of the resource–user communities that have a substantial impact on the resources. Here, adverse situations arise when there are externalities between the resource management institutions and the unaccounted resource–user communities in land–use decision-making. Furthermore, these externalities may come into play with either a lack of or incomplete information (McGovern et al., 1988) about the local environment and changes in it; or they may be the outcome of unsustainable utilization of human behavior (Firey, 1960). As stated above, information patterns play a vital role in the feedback loop of the complex–compound relationships of social–ecological systems. This may lead to unsustainable utilization of human behavior, an example of which can be seen in land use practices such as removing of climax vegetation cover on the steep slopes for agriculture. These practices have a direct negative effect on the resilience of the whole system.

3.5 Summary

It is not feasible to reach a unique and holistic solution that addresses all the problems related to sustainable use of land and water resources. A major drawback for the realization of the IWRM concept has been a stress on maximum ecosystem services rather than sustained ecosystem services. It is primarily due to this that pockets of expertise have evolved with limited relation to each other as identified by Biswas (2004). Thus the goal to integrate social-ecological processes into IWRM has not been achieved. Nevertheless, resource governing institutions can improve their robustness by building resilience in the system as put forward by Ostrom (1995), Millington (1999), Mitchell (1991) and Burton (1984). Ostrom defined boundaries, active monitoring, conflict resolution mechanisms, accountability, resource tenure rights, and violator sanctions, regarding common resource use; as areas where institutions can be more robust whereas Millington and Mitchell stressed the importance of strong knowledge and community awareness, creating a cross sector approach involving all possible natural resource issues, combined with strong legislative frameworks suitable for the existing situation. Burton has argued for a land use appraisal for water resource management in an integrated manner. Governance of natural resources, thus, is a complex process. This is due to several reasons. First, awareness of the interaction between different components of the natural resource systems is still evolving, which affects long term decisions. Second, as social decision making systems evolve, as represented in resource governing institutions, coupled with the complexity of the resources they tend to utilize for human consumption, they become capable of making themselves fit to the interaction between human and nature for long term resource use. This may be achieved through internalizing the externalities as experienced through the feedbacks from the ecological processes. This makes the social decision making systems employ adaptive mechanisms for sustained resource use. This is exemplified by the ongoing trend towards a paradigm shift in the IWRM discussion. However, problems often occur in the implementation stage due to information flow pathologies, unsustainable human behavior and the conditions of exclusion and subtractibility. Thus, resource governance can be seen as a set of complex adaptive strategies with the resource governing institutions functioning as complex adaptive systems. The efficiency of these complex adaptive systems for fairly equitable and long term resource use should increase with their potential to internalize the possible externalities and thereby reduce the energy expended to a minimum.

Human relationships with nature are complex. Some of our behavior and actions deplete resources at a faster rate or impair their quality considerably. This is why it is almost impossible to achieve a holistic solution to the management of resources; and the case of water resources is no exception. But even as it is impossible to achieve a totally holistic solution to the management of water resources, resilience in decision-making can be increased by identifying vital functions between human beings and ecosystems. The ideal scale for this is in the micro level of the IWRM application where resource governing institutions and resource users act upon the environment directly. This is important for achieving holistic solutions for better management of natural resources through strategic approaches. These strategic approaches are not all encompassing as they work with particular aspects of the man-environment relationships. These include information-sharing, identifying which human behaviors and/or decisions are unsustainable and so on. These are considered vitally important for identifying patterns in the ecological processes and adding resilience in land use decision-making.

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Chapter 4

Land Use Changes in Laguna de Bay Basin with Reference to The San Cristobal Micro-Watershed

4.1 Introduction and objectives

This chapter gives an account of the human induced land use changes in the Laguna de Bay area. Examples are also obtained from other parts of the Philippines in order to understand and compare the land use changes in the study area relative to other areas, as well as for cross checking, validating and analyzing the data for greater accuracy of interpretation. The ecological history of the landscapes in the Philippines, as reflected by vegetation characteristics, was also reviewed. Fieldworks were conducted in the study area aimed to identify landscapes which are under transition due to social-ecological forces.

The analysis seeks to explore the following:

1. Type and direction of environmental changes
2. Drivers of change, both human and non-human
3. Environmental context in which such changes occur

4.2 Some features of land use changes in Laguna de Bay Basin

There are four major terminologies that need to be clarified for a better understanding of land use changes in this chapter, namely; 'landscape', 'landscapes of recovery', 'transitional landscapes', and 'landscapes of alteration'. 'Landscapes' refer to landforms and land covers resulting from human activities (Jackson, 1994; Cosgrove, 1998). The term 'Landscapes of recovery' (viz. Flinn & Vellend, 2005) refers to land covers developed under natural succession, without any major human interference. 'Landscapes of alteration', (viz. McIntyre & Hobbs, 1999) on the other hand, represent land covers that are altered toward more consumptive use by economic and social forces. 'Transitional landscapes' (viz. Redman & Foster, 2008) fall between 'Landscapes of recovery' and 'Landscapes of alteration', in that the land covers cannot be distinctly defined towards recovery or alteration. They can take either form depending on the type of anthropogenic impacts they have encountered.

The Laguna de Bay Basin is characterized by a large expanse of lowlands adjacent to two large bodies of water represented by Laguna Lake and Manila Bay. The basin is of immense environmental value considering the economic activities and the sheer number of people it hosts, due to its proximity to Metro Manila, one of the biggest urban agglomerations in Asia. Economically, the region records a gross regional domestic product of about one hundred billion pesos[23] (Santos-Borja & Nepomuceno, 2006). The forests that extended to the shores of Laguna Lake were opened during the 1950s and 1960s by transnational logging companies. The areal extent of forest cover was 23,236 ha during 1966 (Sierra et al., 1990), and has since decreased to 17,689 ha in 2004 (Tachikawa et al., 2004). The forest cover continues to diminish to the present, and has been replaced by brushlands and grasslands (regenerative type land covers), open areas, built up areas and agricultural lands.

It is difficult to find accurate estimates of land use changes in the Laguna de Bay basin since the 1960's (when quantitative estimation of land use data in the basin become more available in various literature). This is because existing land cover change data causes confusion regarding the areal extent of different land uses. There are two reasons for this confusion. First, the areal extent of the total watershed as recorded in various documents is not the same. The total basin areas, according to a variety of literatures, range from 392,000 ha (Lansigan & Navarette, 1989) to 370,000 ha (Pacardo, 1993) and 382,000 ha (Haribon, n.d.). Assuming from the more current literature that the total lake basin area is 382,000 ha with the lake surface area as 91,000 ha, this leaves about 291,000 ha as the watershed area draining into the lake. This discrepancy

[23] 1 USD = about 43 PHP (as of April 11, 2011)

in watershed area estimates makes analysis of temporal changes for all individual land use types extremely difficult.

The second reason is the presence of mixed land uses. Main land uses like plantation agriculture and cereal production take place with mixed forestlands or mixed grasslands and brushlands. So it is often difficult to define a landscape with a single dominant use. In some cases a single dominant use is expressed when in fact there is a mixture of landscapes. In other instances, a mixed land use type may be expressed. This inaccuracy and fluctuation in descriptive terminology make time series assessment of land use from the existing literatures rather unfeasible. As forests are destroyed, grasses and brushes become the dominant vegetation in the landscape. Forests are replaced by these grasslands, which are then used for either agricultural or urban land uses. The process of continuously opening up lands and subsequently replacing landscape is multi-layered, with one type of landscape constantly being embedded with another. However, these embedded landscapes have important spatial characteristics, and they represent landscapes where both man-made and natural processes act together.

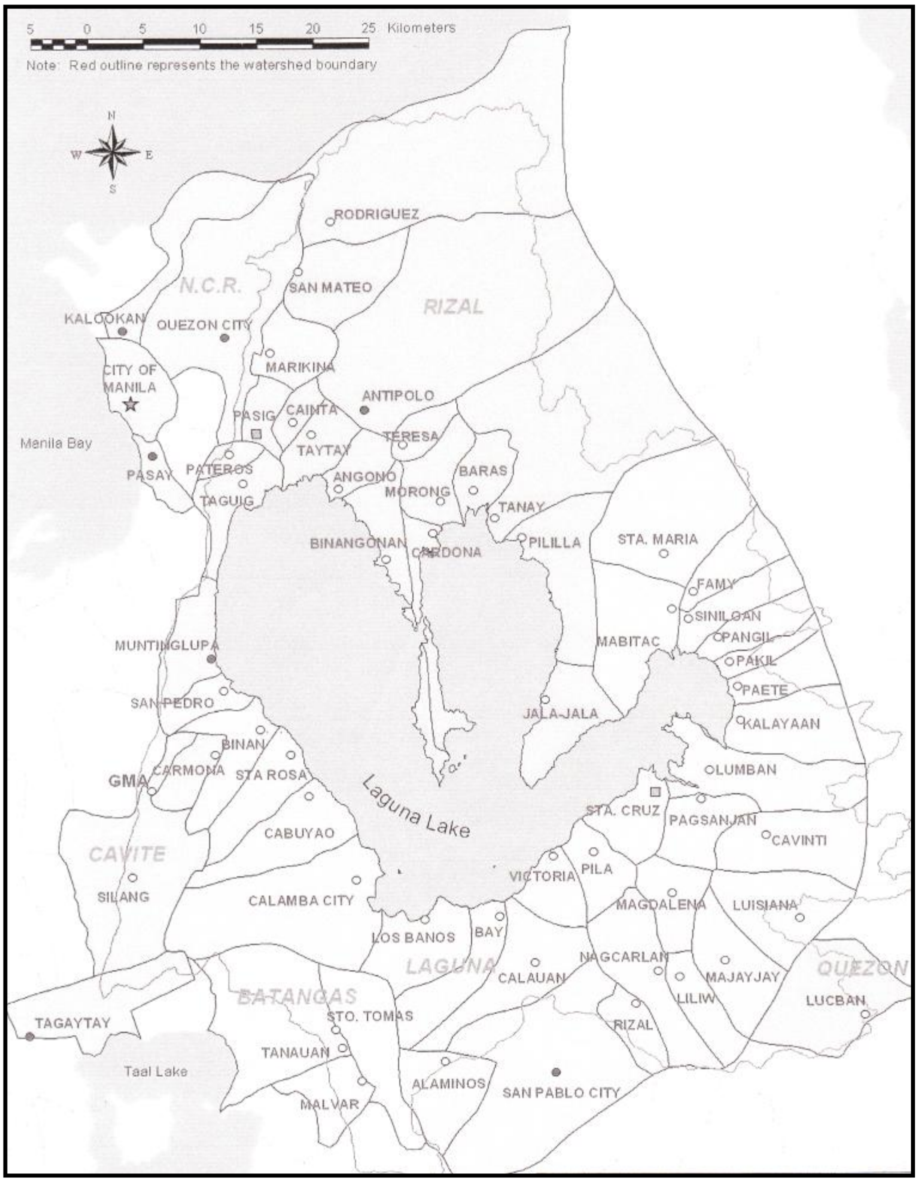

Figure 4.1: Administrative map of Rizal and Laguna Provinces (Image: Courtesy LLDA)

Table 4.1: Population trends in the provinces of Rizal and Laguna from 1903 to 2000 (Courtesy: NSO 2000).

Province of Rizal		**Province of Laguna**	
Years	Population	Years	Population
1903	50095	1903	148606
1918	63719	1918	195546
1939	87876	1939	279505
1948	104578	1948	321247
1960	173958	1960	472064
1970	307238	1970	699736
1975	414192	1980	803750
1980	555533	1985	973104
1990	977448	1990	1370232
1995	1312489	1995	1631082
2000	1707218	2000	1965872

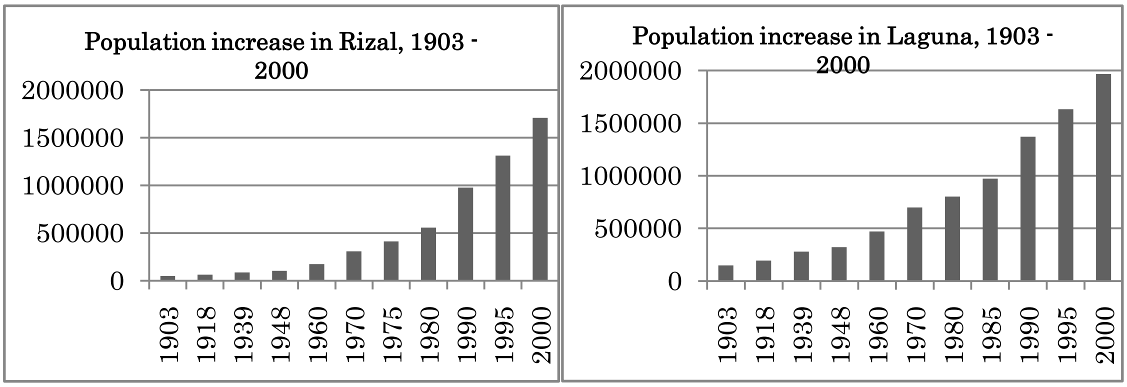

Figure 4.2: Population increase in Rizal and Laguna Provinces (Courtesy: NSO, 2000)

Table 4.2: Areal extent of principal land use types in the Laguna de Bay region according to various literature.

Categories of land	**Sierra et al., 1990**	**Sierra et al., 1990**	**Lansigan, et al., 1982**	**Pacardo, 1993**	**Tachikawa et al., 2004**
	1[24]	**2**	**3**	**4**	**5**
	1966	**1977**	**1982**	**1993**	**2004**
Built up		12135	22233	24830	52463
Open area	22253	41892	80469	-	-
Agriculture	200274	129916	131495	189314	203958
Forest	23236	68326	33147	-	17689
Brushland	51900	-	28722	61703	84896
Marsh	-	1646	4396	3811	437
Water	-	1286	1538	-	1538
Total Basin Areas	**297663**	**255201**	**302000**	**279658**	**360981**

[24] Numbers indicate bars in the figure below.

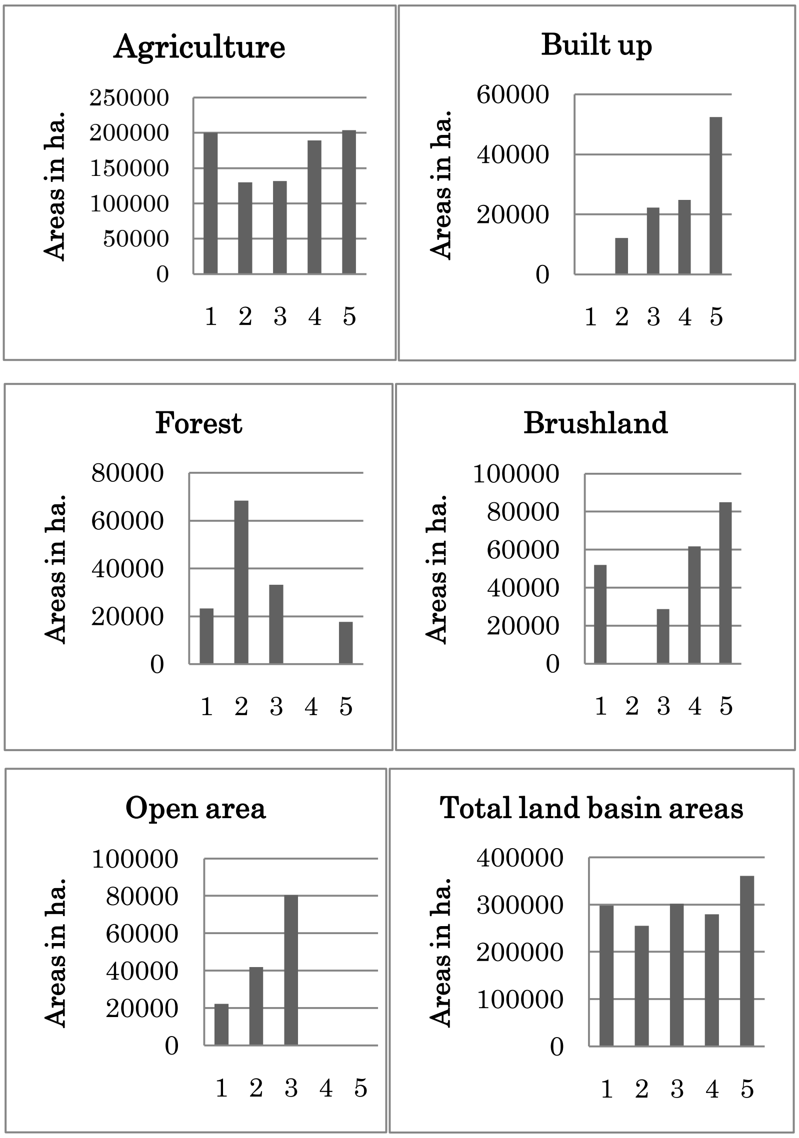

Figure 4.3: Comparisons between agricultural, built up, forest, brushland and open areas in the Laguna de Bay basin as available from existing literature. See table 4.2 for more information. Although the literature used in this study provides conflicting estimates of total land areas, a sharp increase in the amount of built up, grassland and open areas shown commonly in all literature make it indisputable that a net increase in such land use types has occurred in the basin. Such increases have taken place at the expense of forestlands.

The extent of brushlands and grasslands (referred in the data above as brushland only) decreased considerably until 1983; open areas, on the other hand, increased during the same time period. However, the areal extent of forest cover looks surprisingly high in the 1977 data. As far as this data is concerned, the areal extent of forest cover significantly increases from 23,236 ha to 68,326 ha in just 10 years; which is quite impossible. It is obvious, therefore, that the data of 1977 includes brushlands within the areal extents of forestland. If it is assumed that forestlands did not decrease in area from 23,236 ha in 1966, then the brushlands in 1977 must consequently have an areal extent of 48,090 ha. This shows a decreasing trend when compared to its estimated area in 1966. Thus, a trend of increasing open areas with decreasing brushlands can be observed. This reflects the fact that more brushland areas were opened up during this period with grasslands taking over the ecologically vacant spaces. It should be noted that the brushlands are a result of the opening of pre-existing forests.

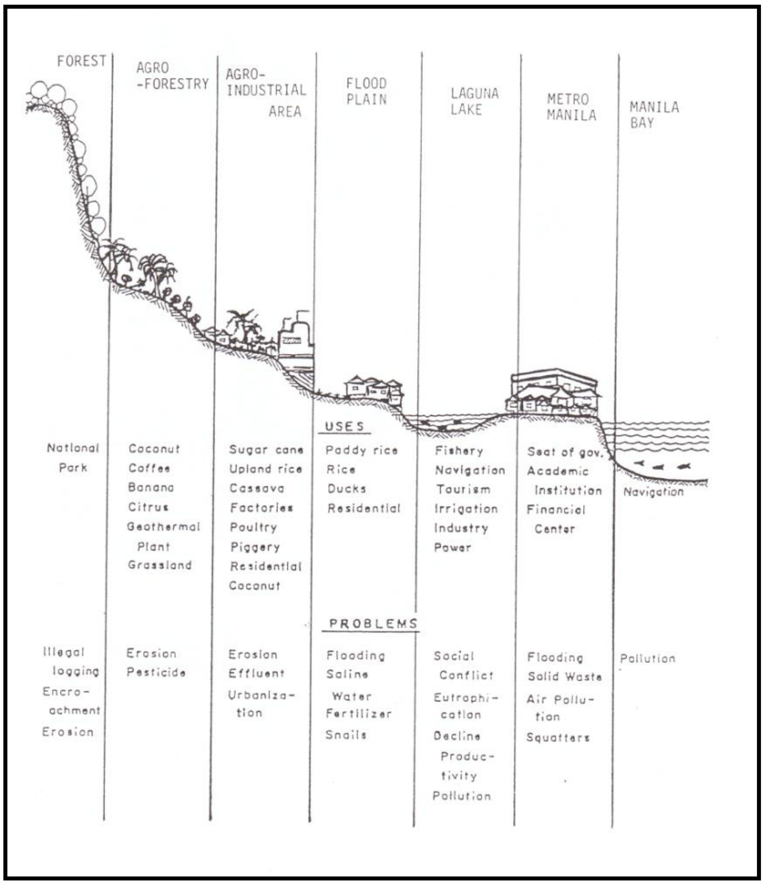

Figure 4.4: General Transect of the Laguna de Bay Basin's watershed (After Pacardo et al., 1988)

However, in the literature from 1993 and 2004, some agricultural lands are included in the category of grasslands (Pacardo, 1993; Tachikawa et al., 2004). In the case of the 2004 data, 77,063 ha of land is referred to as cultivated area mixed with brushlands and grasslands, and 7,833 ha is considered grassland with grasses covering more than 70 percent of the area. Lansigan & Navarette (1989) describe 'brushland' as 'non commercial forests and secondary forests dominated by shrubs and small trees'. This is quite distinct from the standard 'grasslands' that are accompanied by more open spaces and wastelands. The distinction between open area grasslands and brushlands disappears in subsequent literature, as croplands are mixed in with both these types of land uses. In the 1993 data, among a total agricultural land use of 189,314 ha, 92,057 ha of lands were designated as fruit and coconut plantations, which were often mixed with brushlands (Pacardo, 1993). These are the brushlands that are in transition towards agricultural land use, and are the result of regeneration in the present brushland areas after the first forests were felled. A similar trend also applies to grasslands in transition with agricultural land use. These are multi-layered lands that cannot be defined by a single land use, but are rather mixed and in transition from one type of land use to the other.

Based on the above we can say that primary landscapes are natural landscapes with a low level of mixture with human induced landscapes. Primary forests and natural grasslands can be included in this category. Secondary Landscapes are the result of conversions of primary landscapes for human livelihood practices. These may be of two types: one type has a high level of mixture with other types of human induced landscapes. A landscape with forests, grasslands, brushlands and built up areas mixed together can be exemplified as this type. A low level of mixture to other types of landscapes comprises the second type. Brushlands and agricultural areas, or brushlands with built up areas mixed together can be defined in this category. Tertiary landscapes, the third type, are the result of conversion of secondary landscapes towards a more combined form, such as built up areas, representing land uses that are more urbanized.

Table 4.3: Different types of landscapes and their relation to mixed landscapes.

Types of landscapes	**Levels of mixture**	**Levels of mixture**
Primary	Low	-
Secondary	High	Low
Tertiary	Low	-

The status of secondary landscapes in the Philippines is well documented by Wernstedt and Spencer (1967) in "The Philippine Island World".

> Since his advent, however, well before the dawn of the Christian era, man has seen to it that a good share of this primeval forest growth was destroyed and either replaced by his cultivated fields or simply allowed to regenerate in useless jungles[25], secondary forests, or the tall tropical grasses locally called cogon. Some of this destruction was wrought by the early adoption of the system of shifting agriculture with fire-clearing techniques, or *kaingin* agriculture as it is called in the Philippines. Much later the wasteful exploitation of the forests for logs and lumber was to bare extensive forests lands. (Wernstedt & Spencer, 1967; 83.)

[25] By the term 'useless jungles', the author refers to jungles that are not used for any agricultural or commercial purposes.

The ecotone regions in the Laguna de Bay area, area thus a product of time, involving human actions. In terms of forest cover, the Island of the Philippines is unique in the sense that originally about 95 percent of the archipelago was covered by tropical rainforests (W.W.F, 2008). Only in few places did open woodland and seasonal forests prevail. This leaves very little possibility for the existence of ecotone regions such as grasslands, unless the forests are cleared. The tall tropical grasses in the Philippines *Imperata cylindrica* and *Imperata exaltata* (locally known as cogon) are actually remnants of forests of the pre-Christian era. They predominate in areas where forests never returned or returned with a secondary forest type of shrubs and small trees, better known as brushlands in the literature. Assumptions of change in the landscape in the Philippines can be achieved by looking at cross sectional data, with a consideration of ecological history of the landscape under analysis. Thus, a landscape with tropical rainforests mixed with grasslands and brushlands can be assumed to be once closed forests if the region does not represent an ecotone[26].

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[26] An *ecotone* is a type of the natural landscape when a particular type of biome meets with another. The differences in biomes occur due to an array of geographical factors like variance in temperature, precipitation, topography, flow of winds, etc. and their combined effects. However, one particular type of biome, with its unique ecosystem, does not change suddenly to another. The changes in their properties take place gradually, through a zone of transition to another biome and ecosystem. It is in this zone of transition that characteristics of both biomes can be found. Let us take the example of the tropical savannas in Africa. Tropical savannas appear where grasslands meet forests. However, the change in the biomes is gradual as characteristics of both the biomes can be found in the transitional zone. The climax vegetation in the savanna is supported by special climatic and edaphic factors given by scanty yearly precipitation. The grasses lay dormant under the topsoil in the dry season in wait for the seasonal rain for their

Figure 4.5: Mt Makiling reserve forest. One of the primary landscapes of the Laguna de Bay watershed, preserved by the State through dictation of ownership by the University of the Philippines at Los Banos. (Photograph by the researcher, February 10, 2010)

Figure 4.6: Talahib grasslands *(Saccharum spontanium)* mixed with residential areas near Silang. Talahibs grasslands are natural successors of the cogon grasslands, which grew due to clearings of forestlands by slash and burn or kaingin agriculture. (Photograph by the researcher. February 10, 2010).

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seeds to sprawl. The trees often have tap roots deep enough to draw water from the regional groundwater table. The biological diversity living in these areas have specialized adaptations developed through hundreds of thousands of years of evolution which makes them fit in the surrounding landscapes. The examples of different savanna landscapes with the spatial diversity in plant and animal life are there but are beyond the scope of this chapter. It is argued here that they represent *naturally produced transitional land covers*. The term *naturally produced* has an application with the length of time involved to establish these landscapes over space.

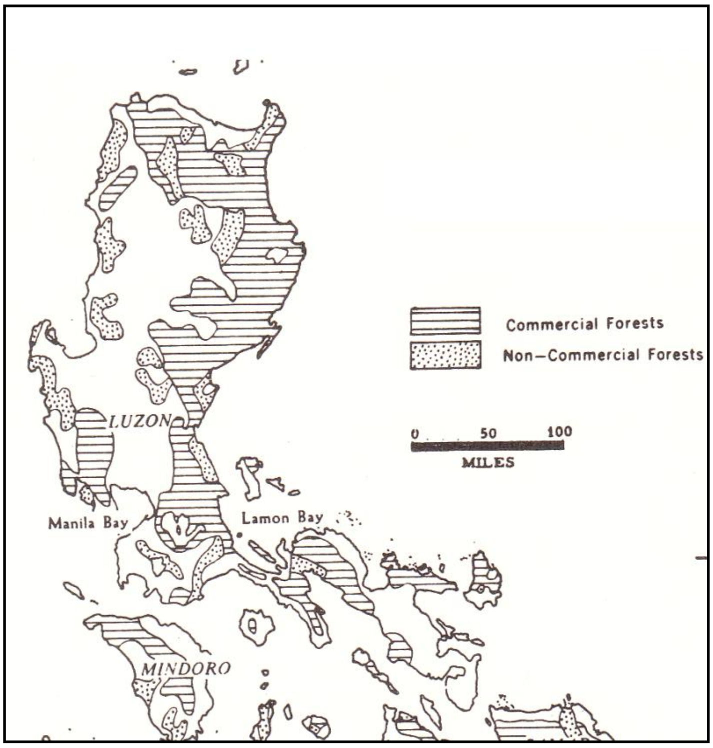

Figure 4.7: State of the forests in Luzon, 1957. Note the existence of commercial forests in the Laguna de Bay area around the lake with non-commercial forests in the Southwest of Laguna de Bay Basin. The non-commercial forests represent secondary growth brushlands resulting from previous forest clearings by slash and burn or *kaingin* agriculture and commercial logging. These forests are of low economic value for the harvest of timber. (Source: Wernstedt & Spencer, 1967)

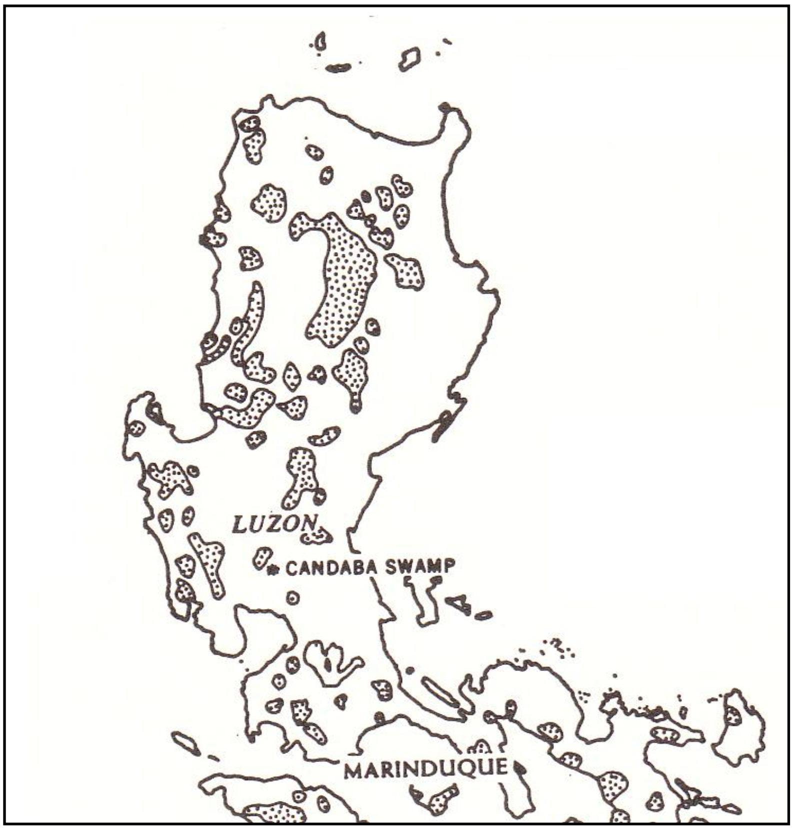

Figure 4.8: Existence of cogon grasslands in the Island of Luzon, 1957, represents Human created ecotones in the island. Cogonales dominated in the Cagayan valley and uplands of the Zambales Mountains. Grasslands in the vicinity of the study area are confined to the highlands of Tagaytay and Silang. (Source: Wernstedt & Spencer, 1967)

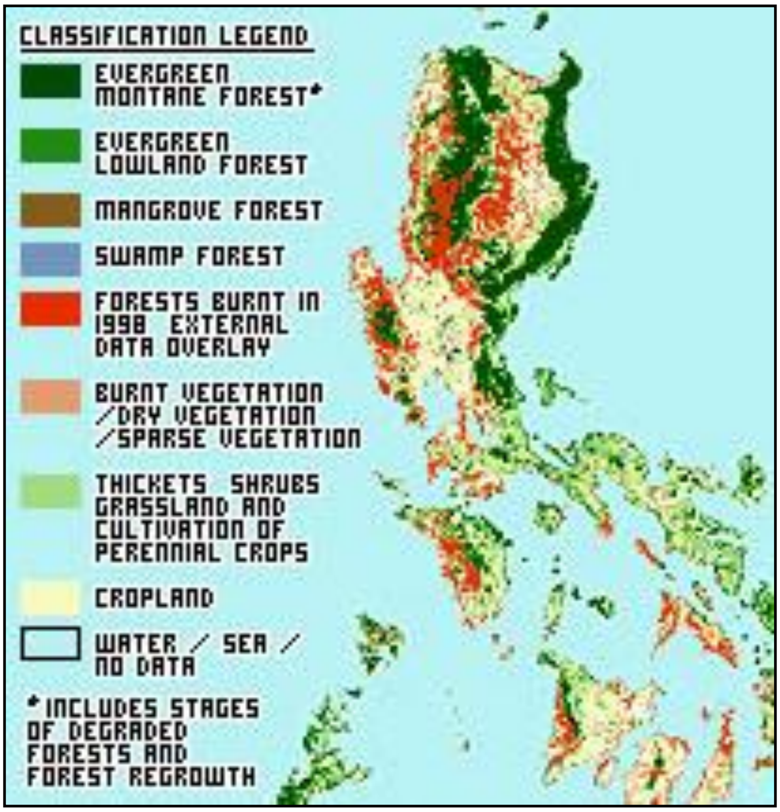

Figure 4.9: Forest cover map of Luzon, 2000. Note the existence of burned and dried forestlands in the watersheds of West Bay of Laguna Lake. The watersheds of the East Bay remain more forested than the watersheds of the West Bay, with patches of thickets, shrubs and grasslands, and cultivation of perennial crops. Note further the strong spatial correlation of existence of cogon grasses during 1957 (see Figure 4.8) and the areas of burnt, dry and sparse vegetation cover during 1998. This reflects that controlled use of fire in the landscape is a continuous process to get rid of regenerative forestlands (Image courtesy CIFOR, 2003).

According to the then Bureau of Forestry, during 1951 much of the landscapes around the Laguna de Bay Basin were forested (see Figure 4.7). These forests formed a continuous stretch throughout the Sierra Madre and its extension, and were present in patches at the southern part of the Zambales Mountains. A preserved sample of such forests can be found at the Mt. Makiling Reserve Forest, Laguna Province. These forestlands, however, were designated as public lands used for commercial forestry; more specifically for timber extraction, charcoal making, and expansion of settlements. This resulted in the subsequent razing of forests. Forests of the lowlands were the first to be razed. The study of extent of grasslands in the Philippines by Buenaventura (1957) was represented in Wernstedt and Spencer's study. The study shows a high correlation with the occurrence of cogonales and areas of low forest cover. The forests were primarily of the secondary type occurring with brushlands, whereas grasslands occurred in patches around the southwestern part of the lake watershed. Land cover data of forests and grasslands during the 1950s can be compared to the Stibig, Beuchle and Janvier (2002) study of the forest cover map of insular Southeast Asia (the transect of Luzon island has been used for the present argument). The transect shows a high spatial correlation of burnt vegetation covers, during 1998, with the occurrence of grasslands. The presence of grassland now indicates burning in the regions of possible re-growth. Furthermore, these burnings are repeated to maintain the grassland regions.

Saccharum spontanium (locally known as talahib) grasses (see Figure 4.6) are natural successors of the cogons. They occur usually where early settlers during the Spanish occupation opened the forests for slash and burn or *kaingin* agriculture. However, it is noted that a single event of clearing of forests is not enough to establish grasslands permanently. Several burnings are needed to reduce the extent of the forests to grasslands, otherwise short bushes, quick growing shrubs, and trees become the first colonizers. These first colonizers, with increasing shade, cause the grasses to give way to the invasion of slow growing species of trees until the forest returns. Although the cogon and the talahib are the dominant species, the repeated clearings and the subsequent time involved in the process has seen the evolution of grasses in the Philippine savannas with a variety of about 60 different species (Wernstedt & Spencer, 1967). This makes the detailed account of the ecological change quite complex, and is beyond the scope of this work. However, for the purpose of current discussion, we can assume that the levels of human activities in the landscapes of change can be interpreted by looking at the vegetation cover in the landscape cross-sectionally, as described below:

1. Forested landscapes mean that there is minimum human influence on a continuous basis. Landscapes which have not been modified by the human system and are high in biological diversity.
2. Brushlands mean that there is a two way interaction between clearings and re-growth. Here, changes are due to human activities to the original land cover, but are also either on the way to re-growth or further clearing for human activities.

These landscapes occur when the primary landscapes have been consumed. Brushlands therefore, have higher biodiversity than grasslands but lower than forests.

3. Grasslands have continuous annual clearing through burning of the original and secondary land covers (mainly in the short dry season) due to which the brushlands cannot be reestablished naturally. The burnings are done for the reestablishment of new shoots of grasses for grazing. They occur more in areas where grasslands occur in patches together with brushlands and forests (Lasignan & Navarette, 1989). These landscapes have more direct value for future use such as agriculture, grazing, and settlements, more controlled by the human systems, and are partially consumed. The areas where grasslands can be observed have high correlation with the areas of burning at present and forest cutting in the past.
4. Agricultural landscapes are a total abolition of natural succession and establishment of new successions as selected by humans. Here, these are consumed landscapes as human influences occur on a continuous basis.
5. Built up areas mean a conversion of nature to a maximum level. Maximum human influences occur on a continuous basis; they are primary sources of infrastructure facilities and amenities to the agricultural landscapes and are receivers of other

landscapes' end products.

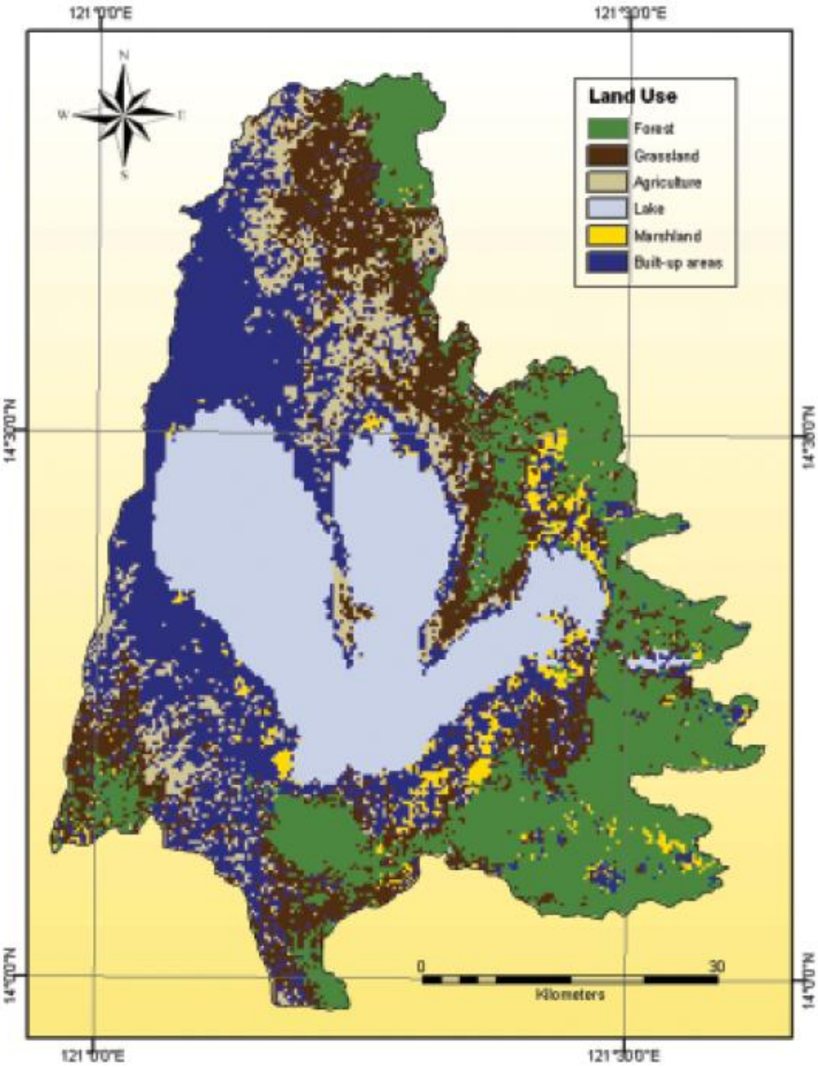

Figure 4.10: Land use in the Laguna de Bay basin as of 2002. (Source: Environmental Forestry Program, University of the Philippines, Los Banos, 2005)

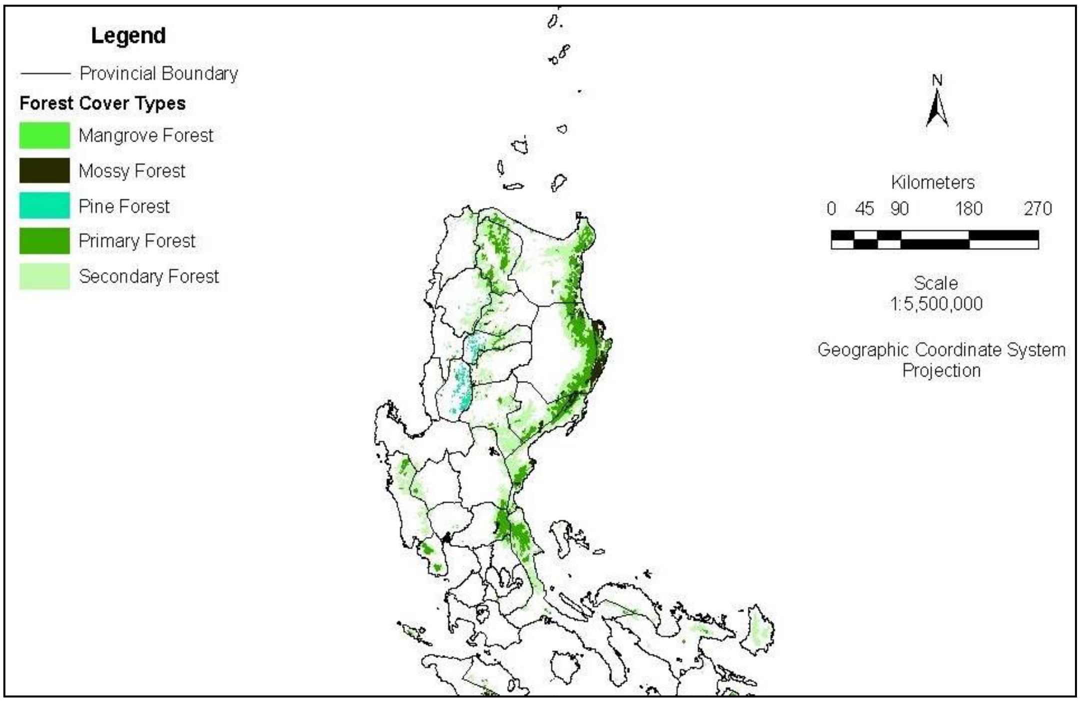

Figure 4.11: State of the Philippine forests as of 1987. Note the lack of forests in the Laguna de Bay area. The western margins of the lake are covered by secondary regenerative forest types. When compared to the 2002 map of forest cover prepared by the ENFOR group of the University of the Philippines, a noted forest cover change can be observed. The secondary forests have reclaimed a large part of the eastern margin of the lake basin despite population increase. (Source: DENR, 1987)

Figure 4.12: Secondary landscapes near Silang, with a high level of mixture: complex of residential areas, banana, and pineapple plantations. (Photograph by the researcher. February 10, 2010)

Figure 4.13: Secondary landscape near Silang, with a mixture of residential and planted areas for visual recreation, appears with brushlands (Photograph by the researcher. February 10, 2010)

The characteristic tree species in brushlands of the west bay watersheds represent species that are mainly chosen by humans. The dominant woody plant species found in the San Cristobal watershed is given below.

1. Mango *(Mangifera Indica)*: Tropical exotic species home to India, Bangladesh, Myanmar, and Malaysia. Used for fruit and wood.
2. Acacia *(Samanea Saman)*: Acacia is an exotic plant and a common species in the grassland and savanna landscapes. Originally from Northern South America, it is a widely cultivated species in the tropics. Used for wood.
3. Ipil-ipil or horse tamarind *(Leucaena leucocephala)*: Ipil is an exotic species and a fast colonizer in the secondary and disturbed forestlands and degraded lands, and

can withstand fire. Used for wood.

4. Gmelina/Yamane, gomar teak or white teak *(Gmelina arborea)*: This tree was originally introduced as a fast growing tree species in secondary plantations from Inland Asia and Southeast Asia to other Southeast Asian countries. Occurs in moist fertile valleys with sandy loam soil, and has a stunted growth in the drier areas due to repeated drought conditions. Used for wood.
5. Kamachile or sweet tamarind
6. Kaatoan Bangkal or common bur-flower *(Anthosephalis cadamba)*: This tree is native, and occurs in deep alluvial soils and seasonally or permanently flooded areas in primary and secondary forests of South and Southeast Asia. Used for wood and fruit.
7. Jackfruit *(Artocarpus heterophyllus)*: Jackfruit is exotic to the Philippines. This tree is native to India, Bangladesh and Malaysia and is very common in tropical and subtropical areas in these counties. Introduced in many countries around the world.
8. Santol (Sandoricum koetjape): Santol is a native species, found in primary and secondary rainforests and lowland dipterocarp forests. Also cultivated for fruit and timber.
9. Star Apple *(Chrysophyllum cainito)*. Native to lowland seasonal forests and is a

widely cultivated species for its fruit.

10. African Tulip *(Spathodea campanulata)*. African Tulips thrive in the savanna countries of Africa and are a fast colonizer. Used for wood in the Philippines.

4.3 Land use change in the San Cristobal micro-watershed

4.3.1 Introduction and objectives:

San Cristobal has a relatively small watershed compared to Marikina and Pagsanjan. Flowing in an easterly direction after its origin in the highlands of Tagaytay and Silang, with an area of 14,100 hectares, San Cristobal contributes about 5% of the total freshwater input in Laguna Lake. The upper and middle courses of the river flow through the Taal tuff and Laguna formation, while in the lower course the river flows through the Holocene alluvium, which covers vast areas between the volcanic formations and Laguna Lake. The river has a drainage density of 5.75 (LLDA, n.d.).

San Cristobal's main stream has four main tributaries. These tributaries are:

1. Dismo, joined by Lanke as a major tributary
2. Mangumit, joined by Banias as a tributary
3. Cauacauang
4. Mayapa joined by Palo Alto and Puasan as tributaries

The confluence of Mangumit and Cauacauang takes the name as San Cristobal. The three main tributaries, the Dismo, Mangumit and Cauacauang, join at the southwest of Barangay Pulo in Cabuyao Municipality. Cauacauang joins the San Cristobal Main flow to the north of Barangay Paciano Rizal in Calamba Municipality. The Mayapa joins with the San Cristobal to the west of Barangay Parian

In this study, inquiries were made of land use change spanning for nearly six decades, which is expected to give a medium term perspective of the land changes in the watershed. The main objectives of this section are as follows:

1. Describe the land uses in 1944 and 2003 in relation to the landscapes of recovery and alteration.
2. Quantitatively analyze the change in land use over this 59-year time period in the San Cristobal River Watershed.
3. Establish relationships between the dominant land uses in the past to those of the present, and with the existing literature about land use changes in the Laguna de Bay Basin area.

4.3.2 Analysis of land use change

During 1944 the San Cristobal watershed, was markedly different than what can be observed today. Vast areas (about 59%) of the watershed were under grasslands and low growth brushes. These grasslands, mainly composed of cogon and talahib, were actually the results of logged off areas left without any further human activities except repeated burnings to prevent forest regeneration. Surveyors of the Corps of Engineers of the US Army report that in 1944 these areas were often scattered with trees or bushes. This shows that land cover was mainly composed of grasslands with scattered woody plants; a picture that supports forest regeneration.[27] Grasslands in the watershed during that time can be divided in two broad categories: the grasslands of the upper reaches of the river, and the grasslands of the lower reaches. Human impacts on the grasslands are reflected by the mixture of woodlands and logged–areas with the latter in the upper reaches of the river, denoting the landscapes of recovery. In the lowlands, however, grasslands are mixed with open lands (about 9%), and built up areas (about 2%). Therefore, the areas of grasslands in the lower reaches of the river denote landscapes toward further interference rather than recovery, and these can be found in the upper reaches of the river. Furthermore, the existence of grasslands and brushlands, in the areas of relatively low population density means that the changes of land use are policy related rather than being a natural by-product of increasing population.

[27] See section 4.2 of this chapter for details.

Woodlands and forested areas in the watershed covered about 21%, second only to the grasslands in terms of area. These landscapes are the results of deforestation due to continuation of logging practices. This implies that these forests were available in small patches, with sparser crown cover than the original stands. Grasslands comprising of mixed and scattered woodlands mean that more than 21% of the San Cristobal Watershed in 1944 remained under these landscapes. An example of how landscape was in the uplands of the San Cristobal watershed during this time can be understood from the forested areas in southern Luzon, where villages still thrive inside or close to the forest fringes[28]. One of these areas can be found near the village of Santa Lucia upland in the Banahaw Mountain Region from Village Dolores in the Province of Quezon, where the tiny tributaries of the Langas River flow[29].

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[28] This means the areas are not strictly protected from the activities outside the forests by command and control.

[29] These forests at the foothills of Mt. Banahaw have a cool, damp feeling when one enters; retained by the shaded canopy in the forest. The shade is enhanced by such species as the giant ferns, which survive from indirect sunlight in areas of permanent shade. The soil in the areas where the giant ferns thrive are more moist than the surrounding areas and are vital contributors of the sustained runoffs to the rivulets. The ferns also hold rainwater as sponges through their bunch roots and numerously serrated leaves. Such species are numerous in the moist and shady rock walls; the results of age old volcanic eruptions, and putting up root inside to open cracks and crevasse, shattering the rocks into soil through time. The thriving of the ferns cannot be possible without permanent shade by the dipterocarps, and the nature of the terrain which has a moderate to high slope factor to allow sunlight only for a limited time each day.

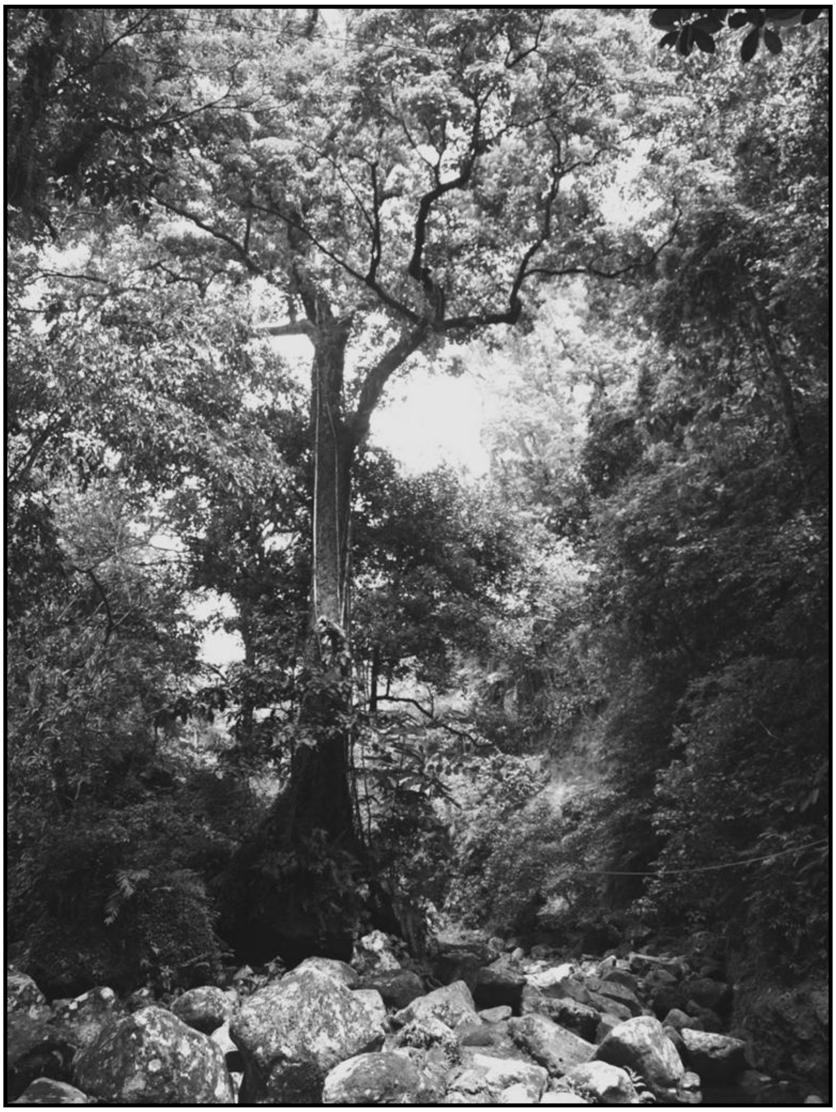


Figure 4.14: A dipterocarp finds its way where there is sufficient sunlight available, providing shades and making new forest structure below by creating environments suitable for species that thrive in indirect sunlight. (Photograph by the researcher. March 19, 2010)

Figure 4.15: Rivulets such as this and their sustained flow with little or no turbidity are possible due to the undergrowth supported by the shades of the dipterocarps, specialized undergrowth, and topography. (Photograph by the researcher. March 19, 2010)

Figure 4.16: The clear waters of the forest landscape are sources for drinking and bathing. The latter is often recreational as children and youth play in the water during the heat of the day. (Photograph by the researcher. March 19, 2010)

In 1944, the forests in the San Cristobal watershed, much like the grasslands, were found in two large patches. One patch was located in the uplands of the 2,200m Mt. Sungay system, the second was around the village of Majada. The latter patch of forest was substantially altered to grasslands, open lands and bamboo plantations near roadways. Areas around the Mt. Sungay uplands formed a more continuous stretch with grassland areas in between. Roadways and railways stretched from Canlubang, then a major sugar estate to inland and upstream. The railways were made to bring sugarcanes for the production of sugar, a principal export commodity, to Canlubang from where they were transported to Manila. The railways were often accompanied by roadways that penetrated up to the Mt. Sungay region with grasslands. The retreat of the forests is highly correlated with these roadways. The plantations of banana and abaca are an effect of similar practices in the neighboring watersheds of the Taal Lake, in the Municipality of Silang.

According to James Halesma[30] (1949), although the initial expenditures for priority projects came from an economic development program, the main aim of Philippine regional development was to earn as much foreign exchange as possible through either welcoming foreign investments in the Philippines for the exploitation of Philippine lands, or exporting products from the Philippines to foreign countries, mainly the U.S., where it was possible to sell domestic products for a much higher price. Halesma further notes that this approach for Philippine regional development was mainly unsuccessful due to investment policies and attractiveness of domestic investments in America, and ultra nationalistic attitude of Philippine politicians. However, the country pressed on with exports of national products and its natural

[30] Halesma was a journalist in the Philippines for 8 years from 1940 (except during the Japanese occupation from 1942 to 1944). During this time, the Philippine government was run by President Elpidio Quirino.

resources, and forests were ready to be sold. Improvement in agriculture, in addition to lumbering and fishing, was planned with investments in better machineries, better strains of plants, and fertilizers to open up lands for the production of six essential crops: rice, corn, sugarcane, coconut, ramie and jute. Increases in rice production were achieved in the Province of Rizal near Manila through portable pump irrigation and better seeding techniques. The government expressed hope that major achievements in food self-sufficiency in the country would be possible by 1952, an aim which is yet to be achieved[31]. Yet, before the achievement of food self-sufficiency, still new types of land use practices were implemented in the San Cristobal watershed. These are industrial and residential areas that replaced secondary landscapes (grasslands and brushlands in the case of residential areas, and agricultural lands in the case of industrial areas). How this type of land use conitnues to replace grasslands, brushlands and agricultural lands in the watershed, is discussed in detail in chapter 6.

How landscapes have changed over the past 59 years can be seen by comparing topographic maps of 1944 to land use maps of 2003. In 2003, vast areas of the San Cristobal Watershed became croplands (47%). The lowlands, being confined to rice lands, extend roughly from the east of the Southern Luzon Expressway (SLEX) to the

[31] See Chapter 6 for a more detailed analysis on how land use decisions replaced critical rice lands in the country. See the chapter on policy perspectives and their relation to land use in the basin, which is based on the case of the Calabarzon region.

lake shore regions, often through densely formed settlements. The croplands in the mid and upper courses of the river are characterized by plantations of coconut and banana, with considerable built up areas (villages) in between. The croplands have replaced regions that were previously grasslands with plantations (sugarcane, banana, abaca and bamboo) to plantations (coconut, banana, pineapple) and rice. Former grassland areas have been replaced by croplands and built up areas (21%), shown in the graphs below.

Table 4.4: Land use categories of San Cristobal Watershed (1944)

Types of Land Cover	**Number of Grids (cm^2)**	**Area in hectares**
1. Woodland/ Forest:	118.0	2950.0
2. Bamboo/ Brushwood / Low Tropical Growth	19.9	497.5
3. Banana or abaca	7.3	182.5
4. Grasslands	329.7	8242.5
5. Ricelands	12.6	315.0
6. Openlands	50.9	1272.5
7. Marshes	2.6	65.0
8. Built-up	8.7	217.5
9. Unclassified	16.8	420.0
10. Total Area	**566.5**	**14161.5**

Error in Percentage= 0.44

{ Error = N/ actual watershed area x 100 }

Where N = Actual watershed area – calculated watershed area[32]

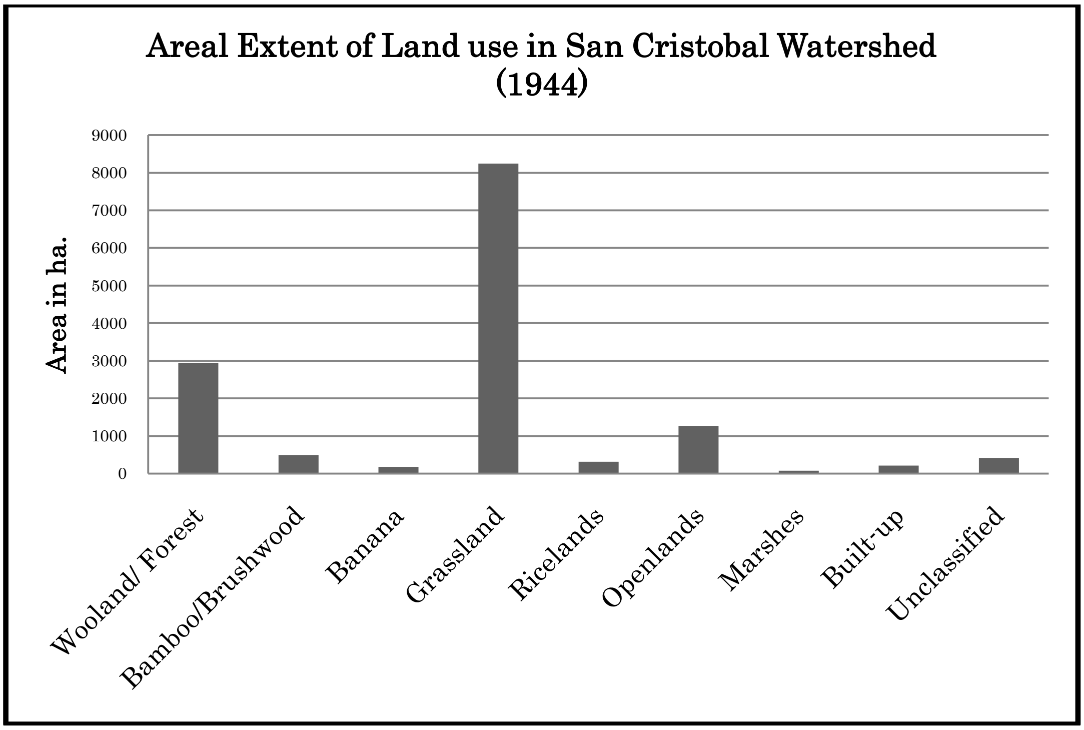


Figure 4.17: Areal Extent of Land use in San Cristobal Watershed (1944)

Table 4.5: Land use categories of San Cristobal Watershed (2003):

Types of Land Cover	Number of Grids (cm^2)	Area in hectares
1. Brushwood / Low Tropical Growth	117.6	2940.0
2. Plantations	36.9	922.5
3. Grasslands	22.8	570.0
4. Croplands	262.6	6565.0
5. Built-up	119.8	2995.0
6. Unclassified	3.2	80.0
7. Total Area	**562.9**	**14072.0**

Error in percentage = 0.20

[32] Actual watershed area = 14,100 ha.

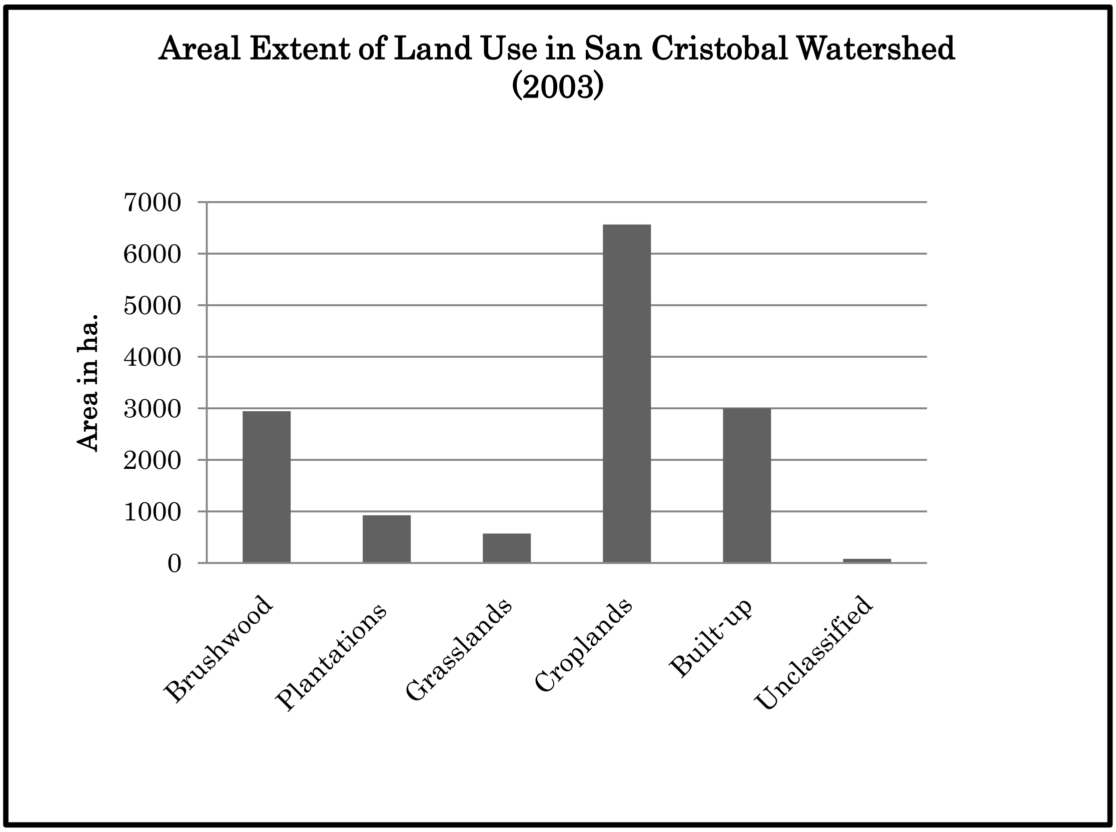
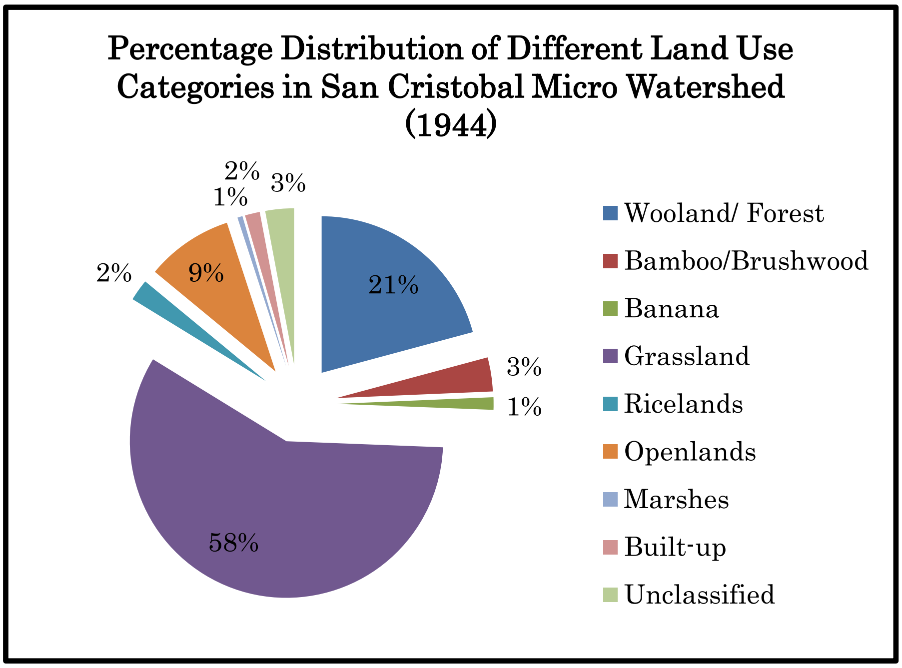


Figure 4.18: Areal Extent of Land Use in San Cristobal Watershed (2003)



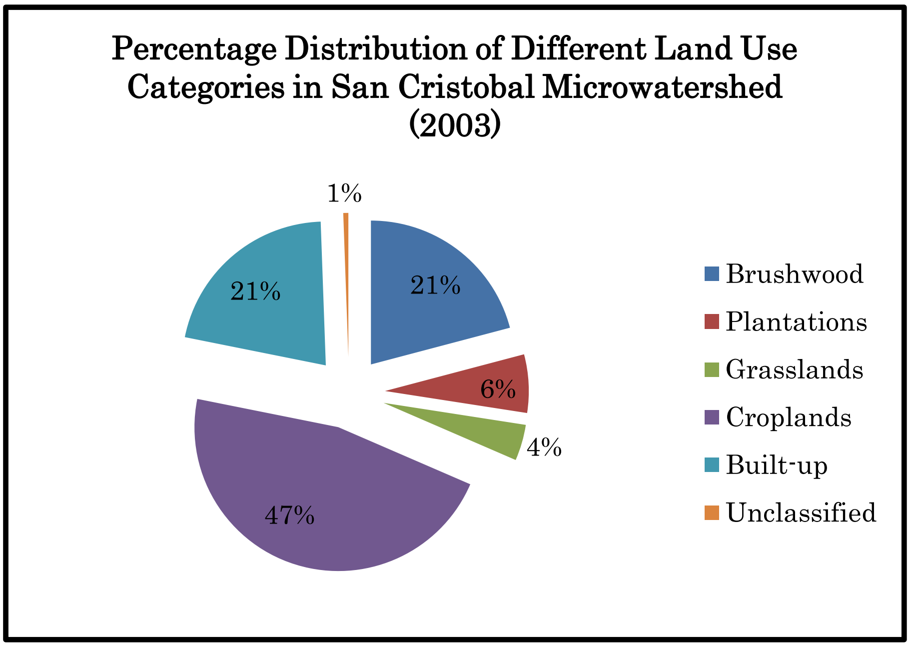


Figure 4.19: Percentage distribution of different land uses in San Cristobal watershed in 1944 and 2003.

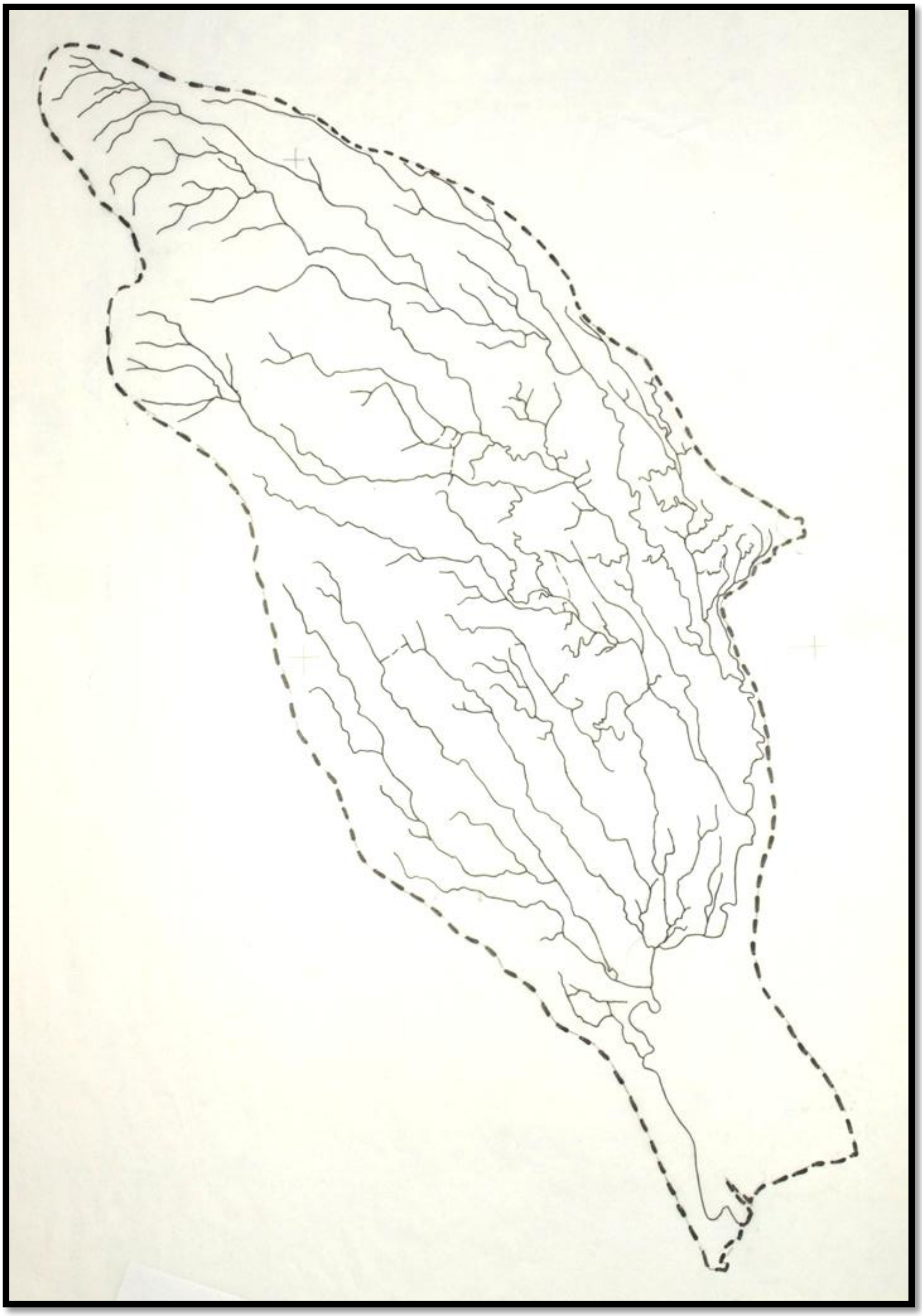


Figure 4.20: The San Cristobal River System

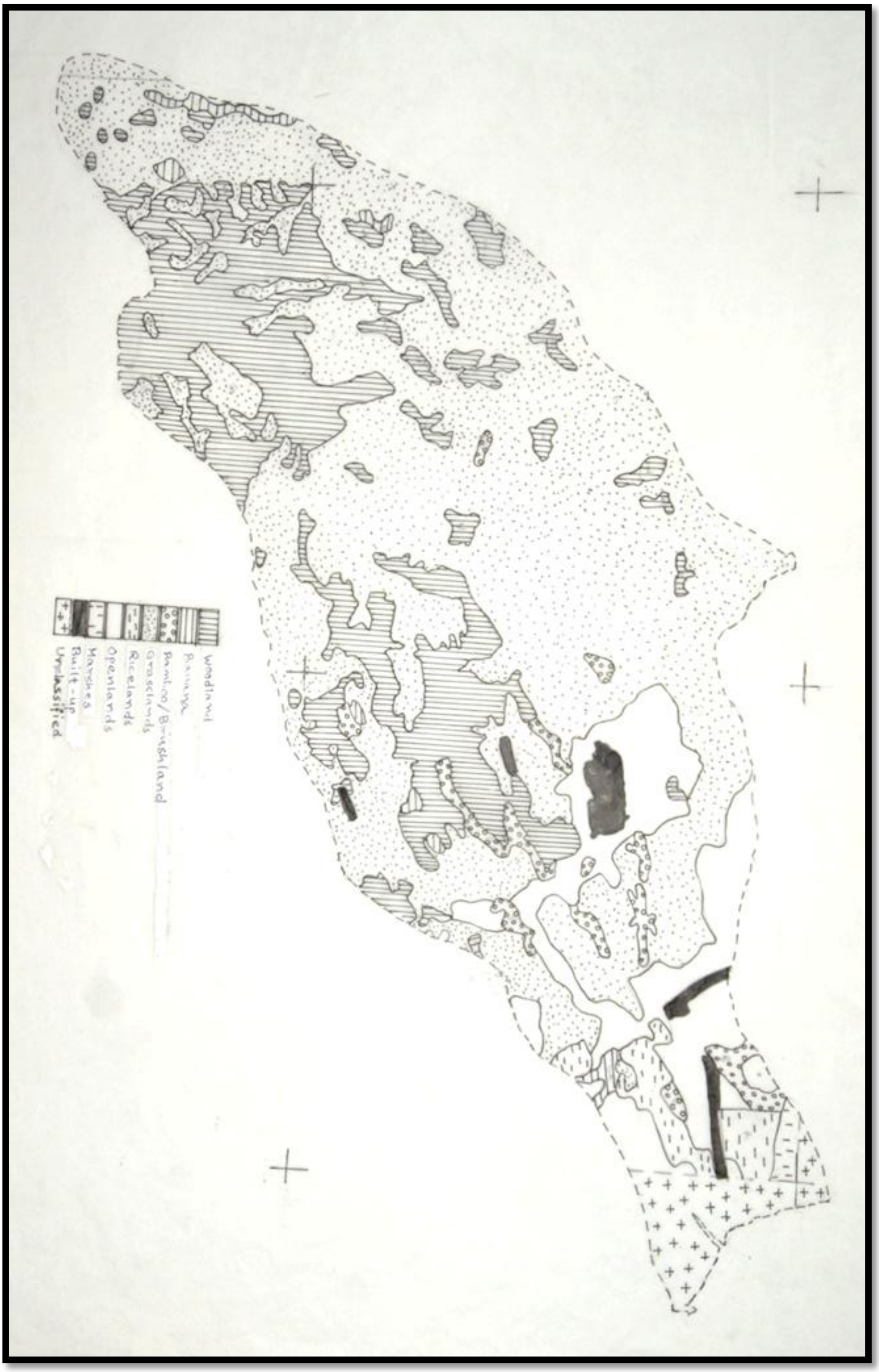


Figure 4.21: Land use in San Cristobal Watershed (1944).

Figure 4.22: Land use in San Cristobal Watershed (2003).

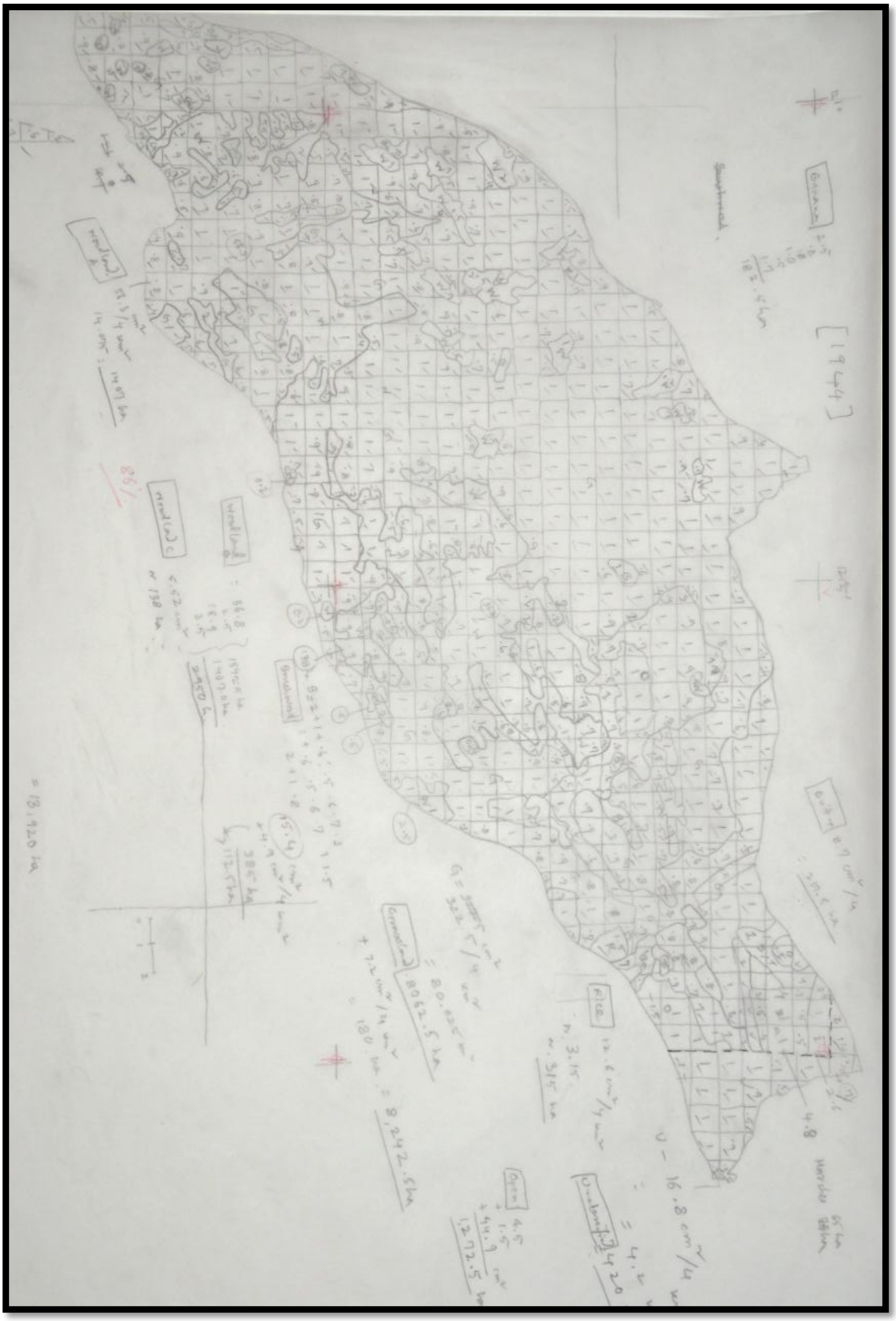


Figure 4.23: Calculation of land use in San Cristobal Watershed (1944).

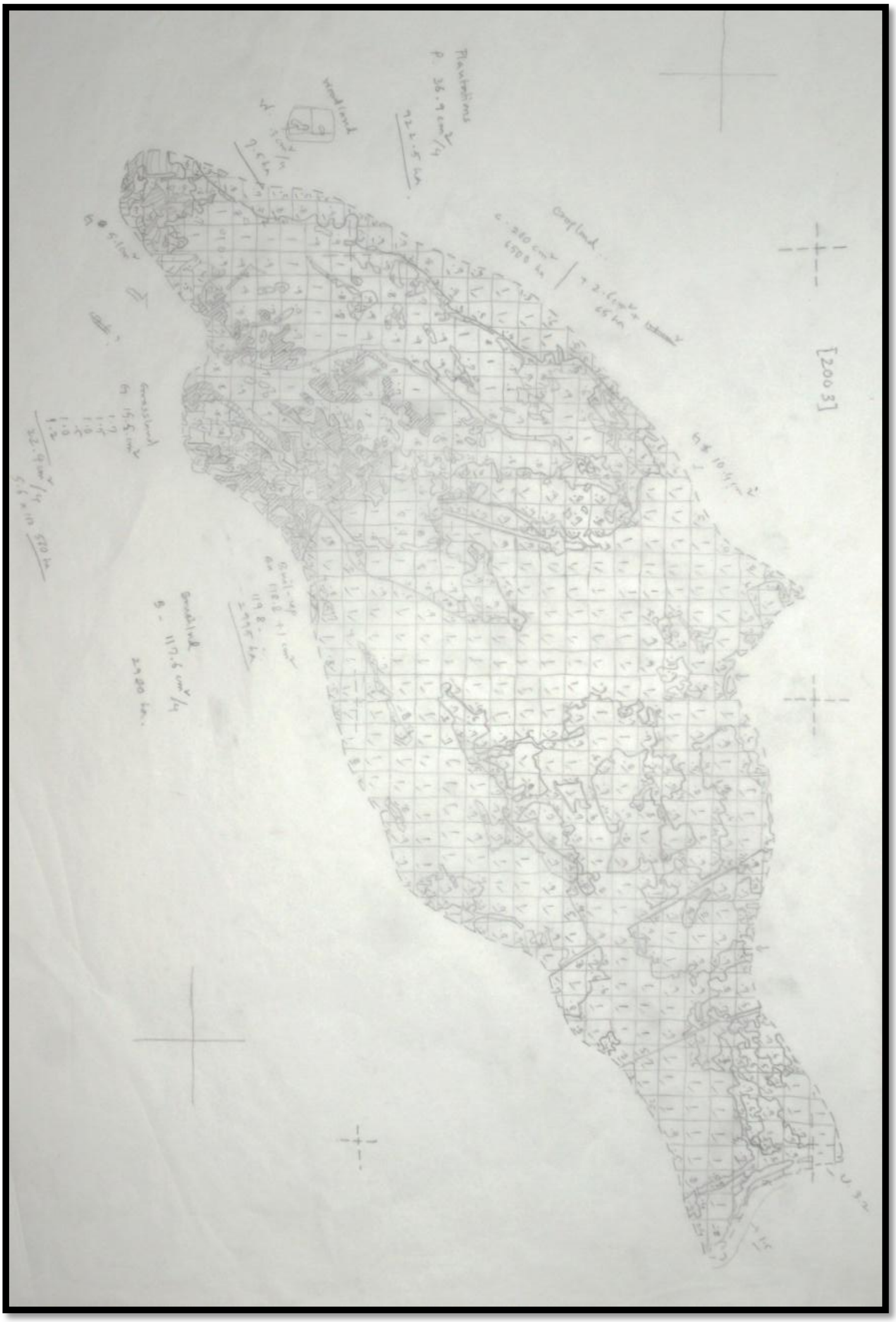


Figure 4.24: Calculation of land use in San Cristobal Watershed (2003).

4.4 Summary:

The foregoing discussion provides an analysis of land use change in the Laguna de Bay Basin with a particular example using one of its tributary watersheds. The characteristics of this change have been analyzed through trends of vegetation succession in the Philippines. While analyses in this chapter follow a primarily quantitative approach, latter chapters (i.e. chapter five and chapter six) analyze the mechanisms and consequences of such changes in a more qualitative manner.

The analysis of land use changes in the San Cristobal Watershed, from 1944 to 2003, reveals the following:

1. The amount of built up areas in the watershed increased from 217.5 hectares in 1944 to 2995 hectares in 2003; a change from 2% to 21% of the watershed area.
2. The amount of forestlands decreased from 2950 hectares to 7.5 hectares, a change from 21% to 0.1% of the watershed area.
3. The woodlands and forests of 1944 changed to brushlands and built-up areas, the latter in small pockets.
4. The grasslands and brushlands in 1944 changed to built-up areas croplands with plantations as the main land use.
5. The marshland areas of 1944 disappeared altogether with cultivation of rice and

sprawling settlement areas in 2003.

6. The small pockets of banana, abaca and bamboo plantations observed in 1944, changed into plantations of coconut, banana and pineapple in 2003.
7. The overall land use change in the watershed, in relation to land use change literature from 1966 to 2004 in the Laguna de Bay basin area, is consistent in the case of change in forestlands, built-up areas and agricultural lands. However, the watershed land use changes shows inconsistency in the case of brushlands, grasslands and open lands, as they all show a decreasing trend (open lands have become nonexistent).

Based on the example of four key land uses ranked 1 to 4 from each time frame under analysis (between 1944 and 2003), the emergence of predominant landscapes can be found as replacements of the previously dominant landscapes. A high correlation can be found between the change in the areal extent of woodlands, grasslands, and open areas and that of brushlands, croplands, and built up areas, indicating the consumption of the three former land use types by the latter three. This means that the grasslands, woodlands, and open areas have been converted to croplands, brushlands and built-up areas. Thus, forests in the watershed are converted to brushlands, which are then converted to croplands. Rice paddies replaced open areas, marshes, and grasslands, which existed in the lower reaches of the river.

It is evident from quantitative assessment of land use change that landscapes of recovery have been drastically reduced in the San Cristobal Watershed. With this, the bio-physical attributes for practicing sound land and water resource management has also diminished. It is interesting to note that the amount of reduction in forestlands (21%) and the increase in the built up areas (19%) are nearly the same. The possible factors of such changes in land use will be discussed in subsequent chapters. The bio-physical attributes provide the base on which different components of integrated water resource management is related. Therefore, it is interesting to explore how land use policies are related to land use changes, a discussion that follows in chapter 6 of the present research.

Natural landscapes have been converted to built-up areas and lands for plantation agriculture in the San Cristobal Micro-Watershed. The primary process of land conversion is through burning. At present the burning of land for agriculture is replaced by burning of land for developing private residential estates[33]. The mixed landscapes represented by brushlands, which are still present in the upper San Cristobal watershed, represent landscapes of recovery. These are areas that can be targeted for possible

[33] This trend is discussed more elaborately in chapter 6.

conservation efforts toward sustainable utilization of landscapes for water resource/lake basin management. This can be done through conservation corridors, not by introducing selective species in order to create forested landscape, but by allowing the landscape to recover towards a well vegetated state inclusive of human activities. This is not possible in areas of urbanization where landscapes have been exploited for residential and industrial uses. However, the fact that secondary forests have reclaimed a large part of the eastern margin of the lake basin despite population increase, suggests that these landscapes have ample potential to be conserved in peri-urbanized spaces[34]. Fast growing, short lived species with low density wood are chosen for many reforestation projects (LLDA, 2011) but natural successors provide a better environment with dense wood and slow turnover of woody tissues, which replaces the degraded landscape with more biomass through natural forest regeneration (Chasdon, 2008). Natural forest regeneration is an extremely important management aspect because it does not need large sums of money or manpower, to reduce them in the target area. It is a difficult job to let ecology play a dominant role in conservation efforts, as it needs political will, knowledge, and commitment in the long term. Ultimately, a successful program or approach depends on the relationship between landscapes and humans who inhabit them

[34] A definition of ‘peri-urbanization has been provided in chapter 5.

(Jordan, 2003). In the San Cristobal watershed, the restoration of degraded land is the primary necessity. However, much of these degraded lands are in the upper reaches of the watershed, which are currently under rapid and massive conversion into built-up areas.

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Chapter 5

Characteristics of Urban Expansions in the Shoreland Regions of Laguna Lake

5.1 Introduction and objectives:

Shore-land areas of a lake basin are eco-tones, as a shore-land is a region where a land based eco-region mixes with an aquatic eco-region. In other words, this is a region where land and water interface each other. The importance of natural shore-lands of a lake is well noted among scholars. Natural shore-lands provide stabilization of the shorelines by the root systems of plants, maintain natural bank geometry, provide food for fish from leaf litters and insect drops, create critical habitats for wildlife species, and reduce non point source pollution in the lake (Wuneh, 1998; Koonce et al, 1999; Evans et al, 2004; Chafota et. al, 2005; Monaghan, n.d; Nindi, 2007; Strayer & Findlay, 2010). Likewise, the shore-land regions of Laguna Lake serve vital biological functions for the production and sustenance of the lake's ecosystem on which not only aquatic and terrestrial life forms depend, but human societies as well. It is important to note how these areas of such ecological importance are being altered by human activities.

This chapter focuses on the following inquiries:

1. How the lakeshore regions in the Laguna de Bay Basin are being altered and the major force(s) behind such alteration.
2. How different landscapes are being affected by ongoing urbanization[35] of such areas, and how such alterations are related to the sustainability of Laguna Lake.
3. Significance of shore-land regions to livelihood options for the local people is explored as well in order to understand the ecological values of such regions.

To understand the mechanism of land conversions through the planning literature, two municipalities, namely, Calamba, and Cabuyao, in the newly urbanized southwestern part of the lake basin were chosen. Characteristics of the land use policy process have been analyzed based on content examination of comprehensive land use plans and key interviews. Shore-lands represent pulsed ecosystems under the works of water and land, representing alternative works of the two on the same landscape. However, in the present chapter, the term is used loosely, representing an area which is near to the lake or where an ecosystem found in aquatic environments thrives. Such areas are situated in extremely low lying regions around the lake.

[35] Refer to chapter 6, for a more detailed account of urbanization processes.

5.2 Some features of urbanization and peri-urbanization

Urbanization as an age old process and has taken place in parallel manners in different counties. Parallel cases often show common processes at work, such as structural change of production, with manufacturing (which can be considered a major process) among the dominant economic activities for livelihood (Andersen & Engelstoft, 2004). David Harvey (1989) touches on the dynamism of the urbanization process noting that,

> …the domain of spatial practices has, unfortunately, changed in recent years, making any firm definition of the urban as a distinctive spatial domain even more problematic. On one hand we witness greater fragmentation of the urban social space into neighborhoods, communities, and a multitude of street corner societies, while on the other, telecommunicating and rapid transport make nonsense of some concept of the city as a tightly walled physical unit, or even coherently organized physical domain (Harvey, 1989; 6).

Others have described the phenomenon of expanding cities into the periphery region as peri-urbanization, which in today’s world, is widely seen in developing and under developed countries (Halkatti et al., 2003). Peri-urban areas are spaces over which urban interacts with rural, representing spaces of food production intermingled with spaces that are more urban in nature. These spaces are more often a result of population explosion in cities of low income countries. Iaquinta and Drescher (2000) differentiated the peri-urban areas according to proximity to the main urban center, and migration patterns. They divide peri-urban areas into five types:

1. Absorbed peri-urban
2. Diffused peri-urban
3. Chain peri-urban
4. In-place peri-urban
5. Village peri-urban

The absorbed peri-urban areas are geographically within cities. They were were once outside the city fringe but have since been absorbed by the growth of the city. Diffused peri-urban areas are places located near the vicinity of the city where migration of mainly the poor and homeless takes place from a number of different areas, including the main urban area. Chain peri-urban areas are formed in areas along the fringes of the main urban center, where migrated village populations are trans-located to a particular locale in the urban periphery. By definition, this makes chain peri-urban opposite to diffused peri-urban in the process of migration patterns. In-place peri-urban areas are areas along the urban fringe, close to the urban center. These places are either in the process of being absorbed into the city region, or have become individual urban centers in themselves. In-place peri-urban areas are more often formed by peri-urban villages, constituting populations who are poor and chose not to migrate, and those who are rich and powerful, who have vested interests in remaining. The village peri-urban areas are places not in geographical proximity of the city regions but are essentially rural areas with an urban consumption and behavior pattern.

Some say that peri-urban areas are indicators of deterioration of environmental conditions, taking place through qualitative and quantitative deterioration of natural resources (Brook & Davilla, 2000). Others have seen them as areas of opportunity. Socially, the areas provide relatively cheap livelihood options for the poor to survive and ultimately be absorbed into the urban sphere (Gundel, 2006). According to Pacione (2003) urbanization should address the vital question of livable spaces, through offering a condition of quality of life. This quality of life is the product of sound social, political, and environmental health; factors that are vital indicators for the overall health and well being of a nation. Pacione also asks for further development of such indicators in search of livable cities.

Pacione's idea of sustainable urbanization is often not present in developing countries, as urbanization in developing countries is related to homogenization of biodiversity through alteration of agricultural and natural vegetation covers. However, loss of biodiversity, in the case of these developing countries, is associated with areas that are adjacent to the urban core, whereas in developed countries the effect takes place throughout a larger area (McGranahan & Satterthwaite, 2003 in Pauchard et al., 2006). Moreover, according to McGranahan & Satterthwaite, the urban and peri-urban sprawls tend to destroy the natural vegetation of the peri-urban areas through fire as they are burnt down, with higher densities of households that replace the sprawl of native vegetation. With higher income of the inhabitants, however, the intensity of human disturbance on native vegetation and biodiversity decreases, and decreased household density results in fewer incidence of direct control of the landscape.

Land use changes in the urban and the peri-urban areas come from linkages between the urban and the rural. Intensifying food production in the peri-urban as well as the rural areas for the urban food demand is a major force in changing the land (Eder, 1991; Kasfir, 1993; Guyer & Lambin 1993; Godoy et al., 1997). However, Seto et al., (2004) note that urban sprawls have a negative influence on the prime croplands of urban fringes. Seto et al. (2004) also note that this type of negative influence on prime cropland regions has been observed in urbanization processes in China and other newly industrialized countries. However, influences of urbanization on the peri-urban areas have positive impacts as well, as indicated by Rudel et al. (2000), and Naylor et al. (2002). Economic gains in rural areas from monetary remittances of migrated family members, as well as foreign aid, can raise living standards in peri-urban regions. This in some cases can result in a decline of direct dependence on local natural resources despite increase in the peri-urban population.

5.3 Population trends in the shore-land regions of Laguna de Bay

The shore-land region of Laguna Lake is a long and narrow belt bounded to the northeast by Metropolitan Manila and to the west by other cities and municipalities. This geographical zone runs for 285 km along the shorelines of the lake and is of immense ecological significance for the physical and biological processes in the lake. However, there have been limited studies on the state of the physical and biological resources of this region. The lake and the rivers serve as common resources of direct ecological significance as providers of fishing, drinking water, water for irrigation and recreational facilities. Water quality monitoring stations in the lake and the tributary rivers were first established in 1970s, by SOGREAH, a French company. Since then, production and maintenance of water quality data has been undertaken by the Laguna Lake Development Authority with data available from 1996 to 2008. Studies on the state of fisheries, biological diversity and cultural attributes are also undertaken by the Laguna Lake Development Authority. A reference to the Philippine Millennium

Ecosystem Assessment in 2005, however, reveals that data is not available for the state of the forests as well as the shore-land areas. Thus, two[36] of the most vital functional spaces for the sustainability of the Laguna de Bay Basin have not yet been thoroughly investigated.

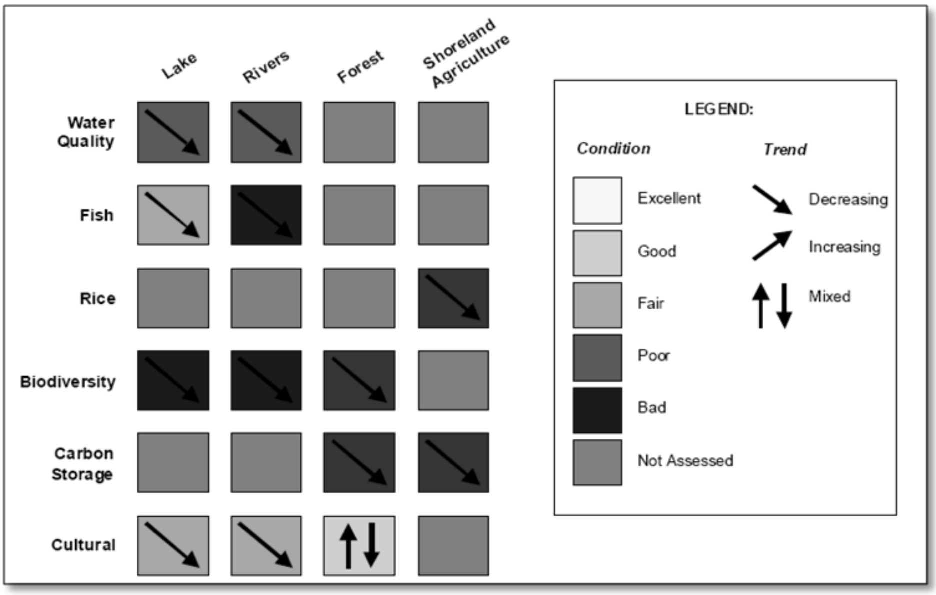
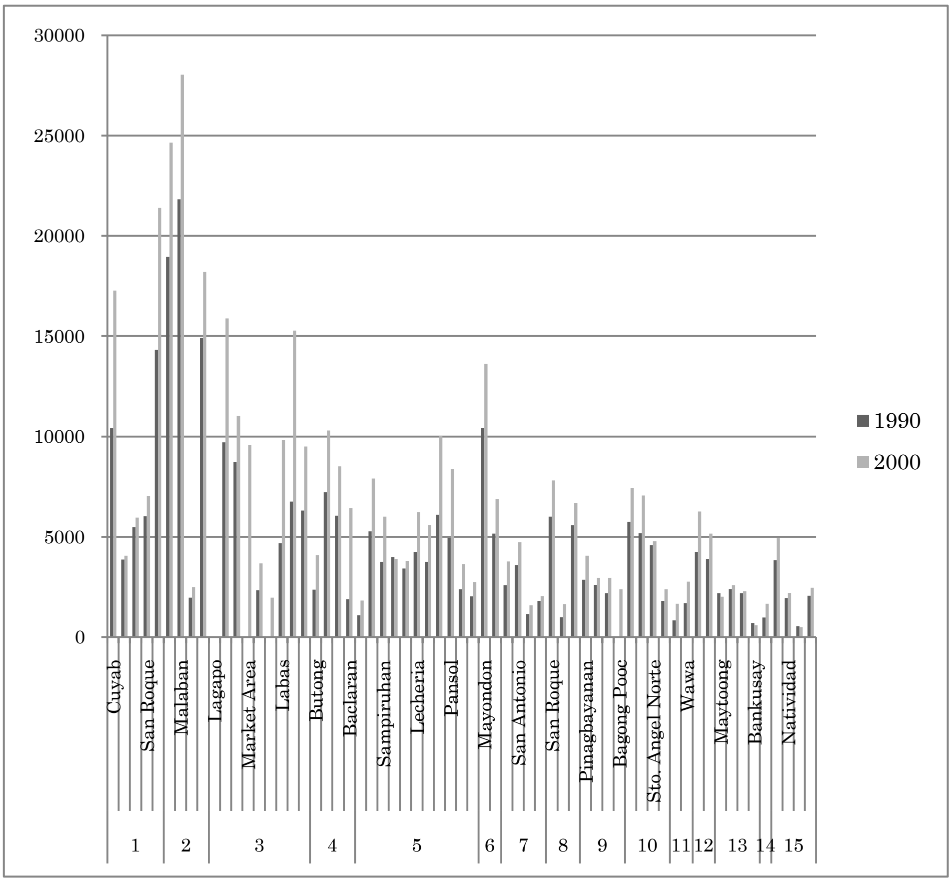


Figure 5.1: State of the ecosystem in the Laguna de Bay Basin after the Philippine Millennium Ecosystem Assessment was conducted by Lasco and Espaldon in 2005. The Laguna de Bay Basin in general shows a declining trend in its ecosystem services. Much of the ecosystem services in the shore-land and forests are not well assessed.

Overfishing and pollution of tributary watersheds, coupled with population increase in the basin, have contributed mainly to the deteriorating ecosystem services of

[36] The other one being the forested areas of the Laguna de Bay Basin; which have declined constantly. Forest cover has since decreased by 15,458 hectares in the Laguna de Bay Basin from 1982 to 2004 (Lansigan, et.al, 1982; Tachikawa, et.al, 2004). Particular watersheds such as the San Cristobal have undergone a greater forest loss. In addition to excessive logging of virgin and regenerative forests in the region, the remaining forests have been constantly under pressure due to exponential growth of population, which grew at a rate of 3.56% from 1995 to 2005; this is 1.4% higher than the national average (NSO, 2007). See chapter 4 for details.

the Laguna de Bay basin. The population of the lakeshore regions has increased quite rapidly, the quantitative estimate of which is yet to be done. Much of the increase in population is confined to the western margin of the lakeshore region. The western shores of the lake up to the municipality of Calamba can be taken as an extension of the Metropolitan Manila Development Region, connected by the Southern Luzon Expressway (SLEX). Manila by road is just about an hour away from Calamba, a principally urban municipality, with other rural municipalities of Los Banos and Tanauan to its east and south respectively. Municipalities become more rural toward the east of the lake with cultivation of rice and plantation crops dominated by coconut, banana, and other fruit trees. Easy access to the southwest margins of the lake via expressway, and well paved roads make the flow of goods and services more efficient.



1.	San Pedro
2.	Binan
3.	Sta. Rosa
4.	Cabuyao
5.	Calamba
6.	Los Banos
7.	Bay
8.	Victoria
9.	Pila
10.	Sta. Cruz
11.	Lumban
12.	Kalayaan
13.	Paete
14.	Pakil
15.	Pangil

Figure 5.2: Population increase in the lakeshore villages, from the municipality of San Pedro to the municipality of Siniloan in the Province of Laguna, from 1990 to 2000 (NSO, 1990; NSO, 2000).

Table 5.1: Population increase in lakeshore municipalities in the Province of Laguna (1948-2000)

City/ Municipality	1948	2000
Laguna	**321,247**	**1,963,872**
Bay	7,395	43,762
Binan	20,794	201,186
Cabuyao	15,206	106,630
Calamba	36,586	281,146
Kalayaan	3,817	19,580
Los Banos	10,954	82,027
Lumban	7,516	25,936
Paete	5,546	23,011
P akil	3,055	18,021
Pangil	4,156	20,698
Pila	13,606	37,427
San Pedro	9,063	231,403
Sta. Cruz	22,534	92,694
Santa Rosa	17,259	185,633
Victoria	No Data	29,765

(*Source*: NSO 2000)

Population pressure on shore-land regions from the more rural municipalities are much less than the urban municipalities on the western margin of the lake. However, some of the rural municipalities like Los Banos, Victoria, Sta. Cruz, and Kalayaan have high population distribution in their lakeshore regions. These municipalities thus have greater possibilities of deteriorating shore-land environment in the future.

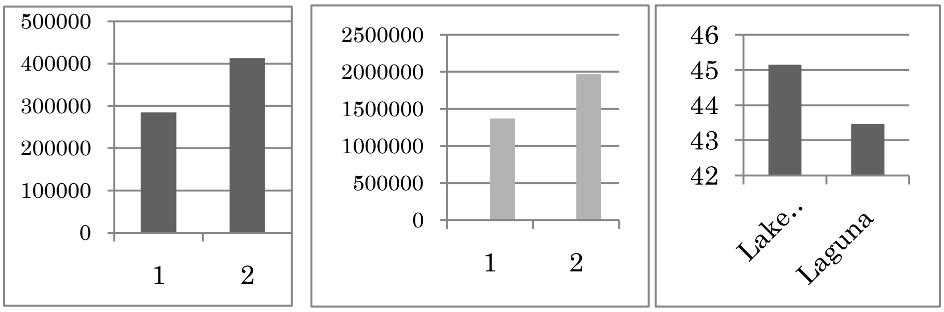


Figure 5.3: Above left: Increase in total population in lakeshore villages. 1. 1990, 2. 2000. Above right: Increase in total population of the Laguna provinces 1. 1990; 2. 2000. (Courtesy; NSO 1990, 2000). Population increase by percentage in lakeshore villages and the Laguna province from 1990 to 2000: In the period from 1990 to 2000, population among the lakeshore regions of Laguna province increased more rapidly than the provincial average, an indication of greater lakeshore occupancy in the rural provinces.

Lakeshore villages close to Manila have typically witnessed a sharper increase in their population in recent times. The municipality of Sta. Rosa is an extreme example where the population of its lakeshore villages increased by 100% during the last one decade, indicating a 10-year doubling period of their population. Other lakeshore villages of urban municipalities have seen as much as a 50% increase in population over the last 10 years. As the total population in Laguna province has increased from 1,370,232 to 1, 965,872, indicating a 43% increase in the last 10 years, one can see that some of the lakeshore villages have had a sharper population increase in comparison. Along the western margin of the lakeshore, agriculture has been confined to pockets of production among the settlements. In spite of greater population increase, much of the information about shore-lands environment of the lake remains un-assessed (Philippine

MEA, 2005). The Philippine Millennium Ecosystem Assessment was conducted on the basis of shore-land agriculture and not the ecological characteristics of the area.

5.4 Status of lake pollution and policy issues among the shorelands:

Laguna de Bay has long been reported as a dying lake because of the decrease in fisheries and water quality parameters over the past 3 decades (Lasco & Espaldon, 2005). It is argued that the growth of informal settlements along the urbanized riversides and lakeshore regions are a major cause of lake water quality deterioration (ADB, 2004; LLDA, 2009). Besides providing vital ecosystem services like fisheries, transport routes, hydropower generation and coolant for industrial power plants, the lake serves as a base level of erosion for the river basins and provides rich soil for the cultivation of rice in the lowlands and shore-land regions (LLDA, 1995; HLURB, 1981; 1991; 2000). Rice-lands once dominated the shore-land regions of the Laguna de Bay Basin. However, they are becoming increasingly urbanized, with settlements extending to the land water interface regions of the lake, altering the lake buffer zone of perennial grasslands that once dominated these areas (Carandang et al., 1988). Shore-land settlements, thus, have replaced two types of land uses: shore-land agriculture and the riparian vegetation covers. Although agricultural lands are a primary cause of water pollution from nutrient runoffs, their affect is still much less than in urbanized spaces. This is shown in two NASA images taken during the 2003 floods in the lake basin region (see Figure 5.4). The images show clear contribution of newly urbanized spaces injecting sediments and other pollutions into the lake waters. This is because water is released much more slowly through rural agricultural fields in contrast to the impervious urban spaces, as sediments take time to settle in the runoff channel beds. Although the waters become clear due to flocculation by saltwater intrusion from Manila Bay, the sediments are deposited in the lake along with pollution and have a potential to make the lake basin shallower.

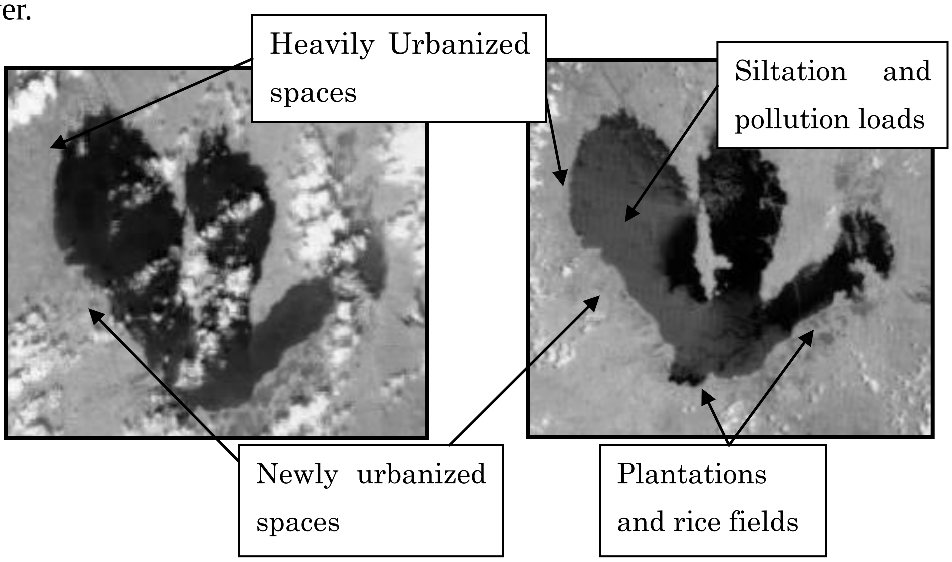


Figure 5.4: Clear water resulted by the intrusion of salt waters through the Pasig River as seen by NASA's Terra MODIS satellite (top left). Flocculation processes in high tide makes the water free of turbidity partially, a process on which fishermen depend for their catches as they can see the schools of fish through the clear waters more easily. Areas of high siltation (top right) predominates the more urbanized side of the lake waters in the absence of saltwater intrusion (Courtesy: NASA, 2003).

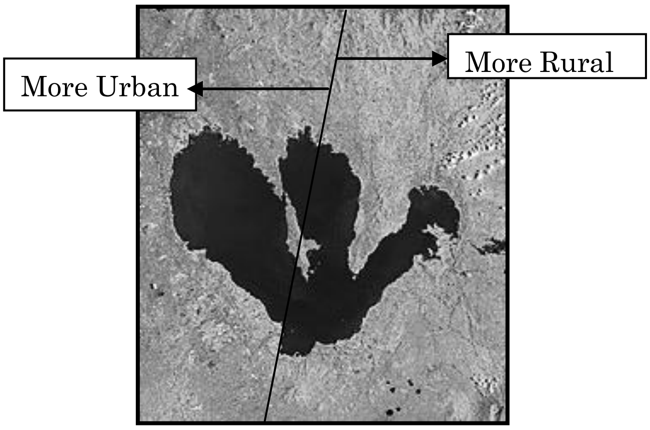


Figure 5.5: A section of the LANDSAT image taken in April 2002, showing the urbanized west and more rural eastern parts of the Laguna de Bay Basin (Courtesy: Landsat, 2002).

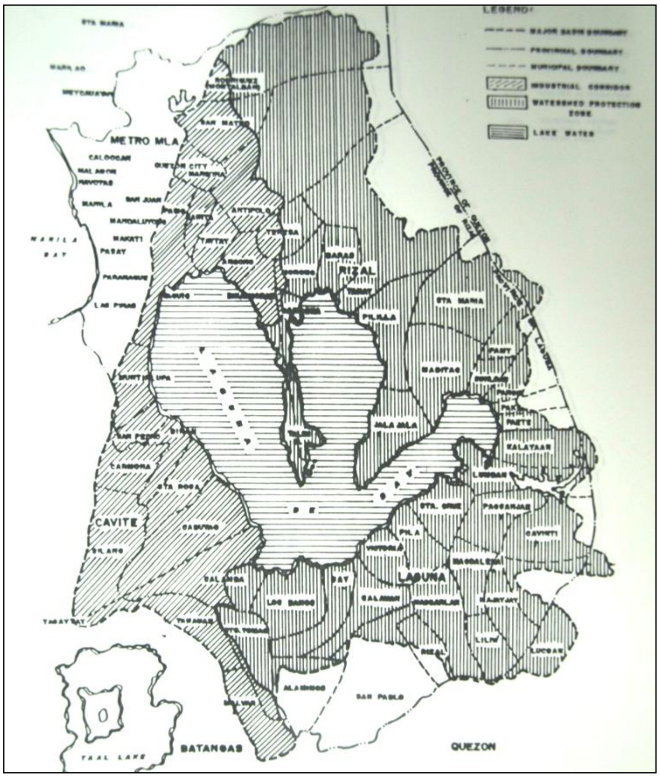


Figure 5.6: Industrial growth corridors (oblique shades) and watershed protection zones (vertical shades) in the Laguna de Bay Basin. The watershed protection zones are characterized by two protected forests: Mt. Makiling and Mt. Banahao. The rivers that drain to the lake have lower BOD values, but pollution in the lake is often dispersed from the areas of industrial growth to watershed protection zones. Note that there is no protected area in the shoreland regions as yet in spite of their ecological significance to the lake's biological production. (Source: Housing and Land Use Regulatory Board. (2006). A Guide to Comprehensive Land Use Plan Preparation. Vol. 1. Diliman, Quezon City)

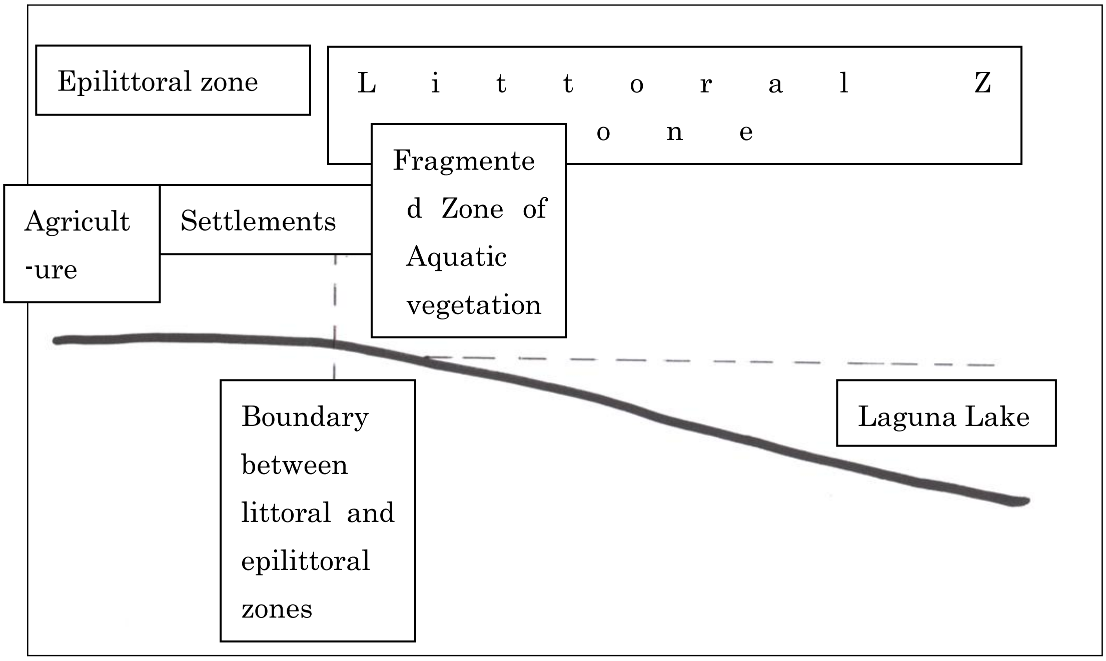


Figure 5.7: Characteristics of the shore-lands in peri-urban areas in the western and southern shore of Laguna Lake at present. The settlements extend often to the littoral zone, which is inside the intertidal zone of the lake basin. The zone of aquatic vegetation is pushed out toward the lake, reducing ecosystem productivity in the lake. (Source: Author)

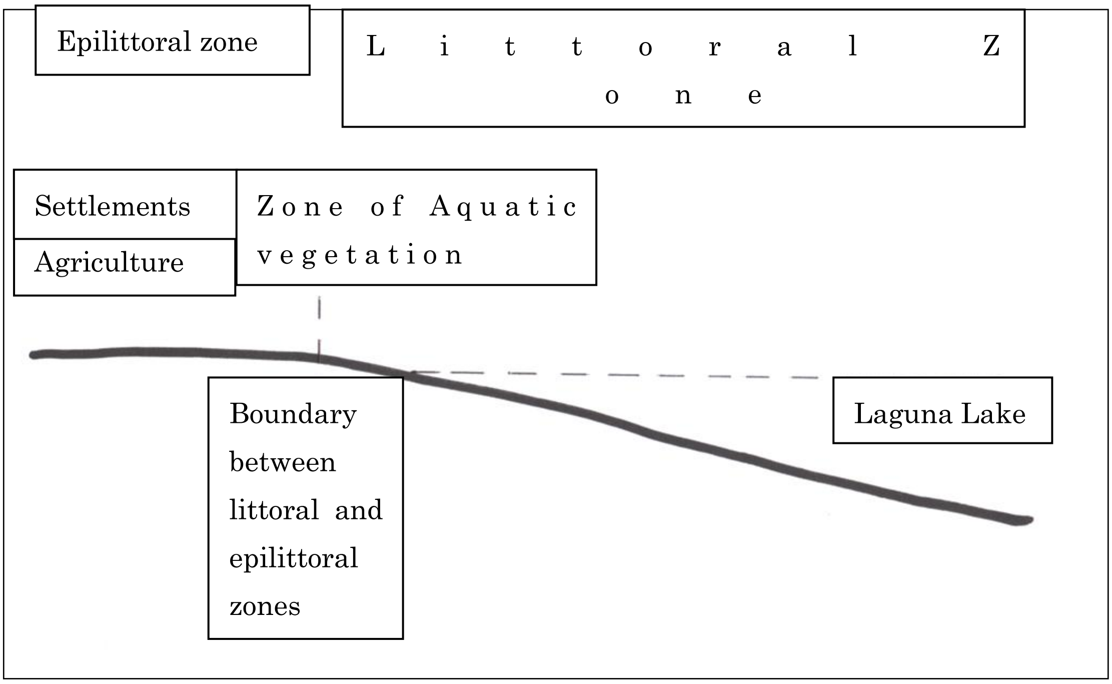


Figure 5.8: Characteristics of shore-lands in the peri-urban areas in 1944. The landscapes were characterized by a much broader zone of aquatic vegetation, with settlements mixed with agriculture, which occupied part of the epilittoral zone. (Source: Author)

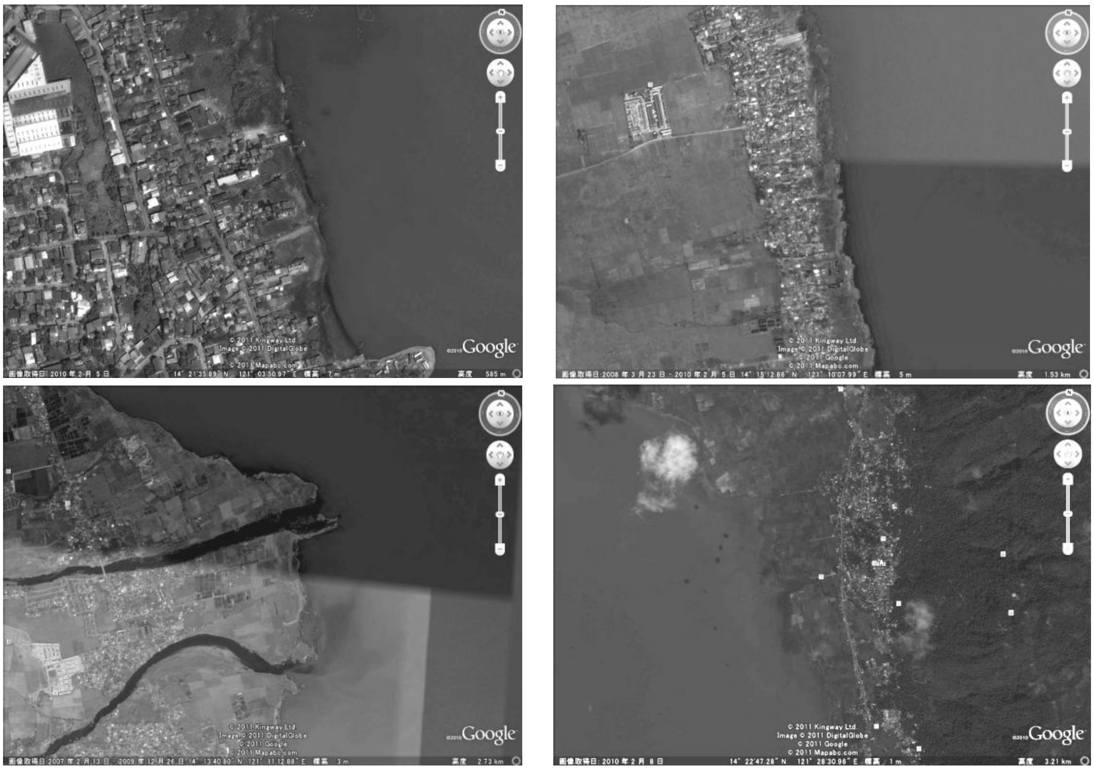


Figure 5.9: Examples of settlement sprawls in the shore-land regions of Laguna Lake. Clockwise from the top left; Western shore-lands near Muntinlupa, about 5 km north of

Calamba, near the confluence of San Cristobal and San Juan Rivers, eastern shore-land north of Paete.

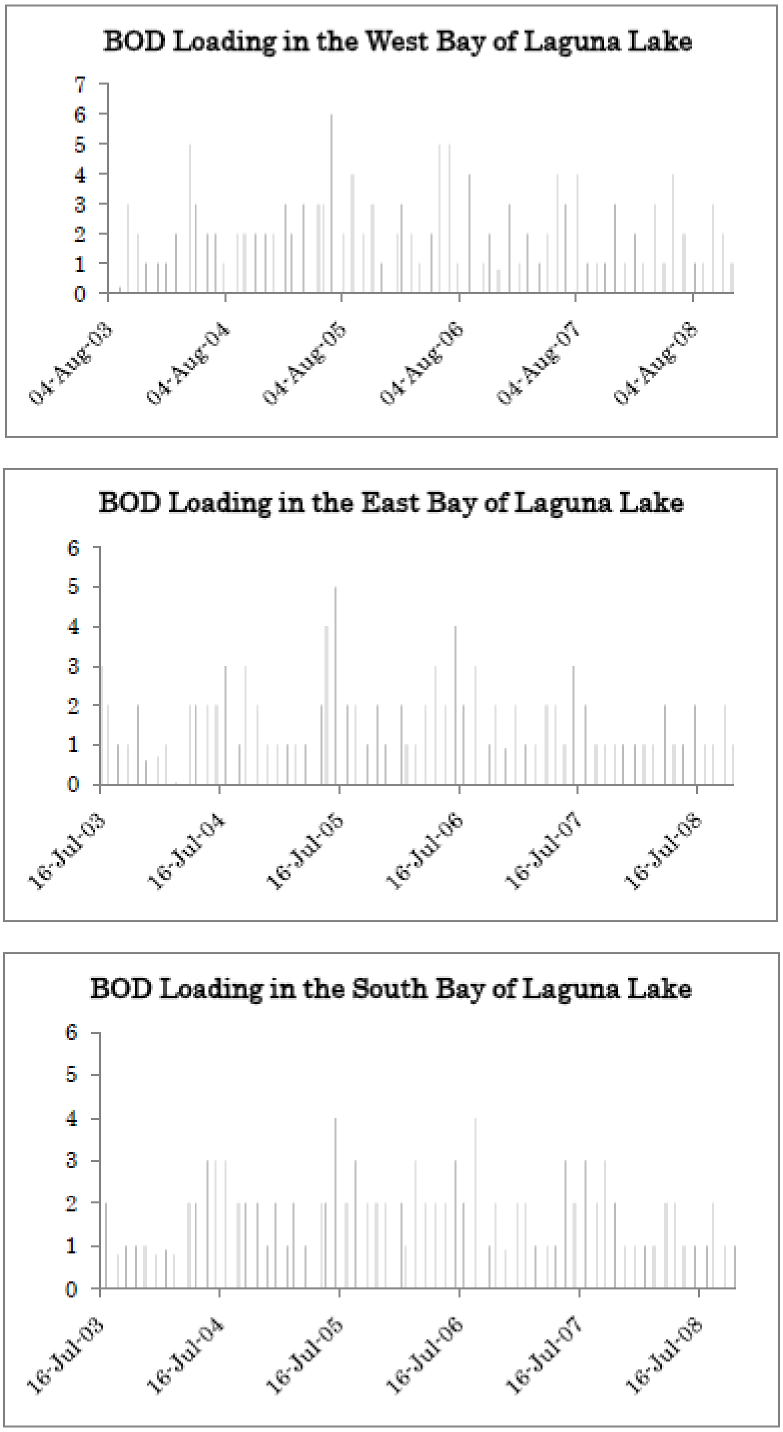


Figure 5.10: BOD values in the West, East, and South Bays of Laguna Lake.

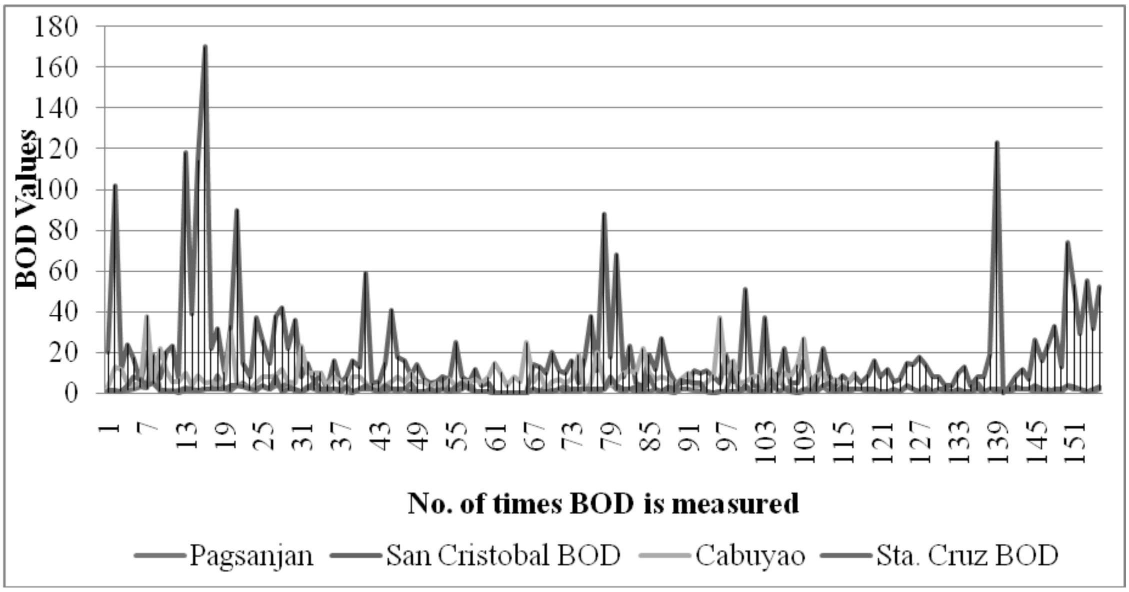


Figure 5.11: BOD values of four selected rivers draining to Laguna de Bay. Cabuyao and San Cristobal rivers are tributaries of the west bay, while Sta. Cruz and Pagsanjan are the rivers of the east bay of the lake. West bay is urbanized while east bay is still rural. Note the contrasting figures of BOD between the rural and urban sides of the lake. (Data, Courtesy: LLDA, 2009)

One of the main causes of these informal settlements is the population, which increased exponentially in Calamba, Cabuyao and Sta. Rosa from 104,916 in 1960s to 573,409 in 2000 (Census of Population and Housing, 1990; 2000). Growth of informal settlements along the lakeshores and shores of urbanized river basins have sprawled in lands previously under rice cultivation and unused lands and bases for fishing grounds. Based on interviews with local residents it was found that much of the landscape of Metropolitan Manila’s lake shore regions were characterized by rice lands in the 1960s. The productivity of the Pasig River during those years is supported by the fact that a member of the interviewee’s family used to swim in the Pasig River and catch fish, which his father says were quite abundant in those times. The fish used to come from Manila Bay to feed on the rich feeding grounds in the shallow waters near the intertidal mudflats. The Pasig River used to support 25 varieties of fish and 13 different types of aquatic plants whereas after the 1990s the river could support only 6 species of pollution tolerant fish and two species of plant (Cruz, 1997). The river is now notorious for heavy pollution and stench. It is to be noted, that as the Laguna de Bay represents a pulsed system, supported by the fore and backflows of the Pasig, the biological diversity found in the Pasig logically should have also migrated to the Lake with the intrusion of saltwater, and a whole ecosystem followed. From 1979 to 1982, a study by S. Gast revealed that about 32,000 shorebirds accompanied annually to the intertidal mudflats near Manila (ARCBC, 2009). Therefore, it can be assumed, that the death of the Pasig (in biological terms), cut this flow of flora and fauna off from the lake to a great extent.

The lakeshore regions were settled by village population as far back as 1948, as evident from maps of the Corps of Engineers of the United States Army. However, most settlers were farming and fishing communities, catching fish, crustaceans, and mollusks from the Laguna Lake and Pasig River. While, the Pasig was inhabited by a sprawl of informal settlers with about 12,000 households (Cruz, 1997) conversion mechanisms of such informal settlements around the lakeshore was greatly facilitated by creating roads along its shore-land regions. This made the lands between the roads and the lake water unusable for economic activities. Furthermore, as informal settlers often occupy shore-lands separated by roadways, the shore-land regions become too narrow for the cultivation of crops. Such areas are settled or occupied by shops, with the vacant areas covered by fragmented zones of perennial grasses, often littered with garbage produced from these regions.

The settlers do not have to pay anything to state or private institutions to construct a dwelling. This practice was greatly enhanced by Presidential Decree 399, which was put forward in February 1974 under the Marcos administration. PD 399 reserves strips of land along highways and public roads for human settlements and other non-agricultural use. Consequentially, unabated growths of settlements become easy and quite natural beside provincial roadways around the lake. However, it would be wrong to refer to PD 399 as the primary cause of shore-land occupation around the peri-urban areas of the lake[37]. This is because settlements around the lakeshore existed long before the implementation of PD 399. The beginning of the lakeshore occupation started as early as immediately following the Second World War. In 1944, the areas

[37] It is to be noted that the alterations of lakeshore regions to settlements in the peri-urban areas, and not the urban areas of Metropolitan Manila which also shares vast areas of lakeshores, are of more concern here. This is because the change in land use is much newer than in the urban core regions of Manila. Also, due to excessive population pressure, it is not possible to alter the occupation of shore-lands in urban Manila and its immediate fringes.

around the Western Bay of the lake had seen construction of roadways and settlements to the inland side of the roads, a combination that extended up to the shore-lands of the village Mamatid. PD 399 enhanced or re-enforced the trend of settlement formation beside roadways, disregarding the functionality of such spaces for the ecosystem and health of the lake.

MALACAÑANG

M a n i l a

PRESIDENTIAL DECREE No. 399 February 28, 1974

LIMITING THE USE OF A STRIP OF ONE THOUSAND METERS OF A LAND ALONG ANY EXISTING, PROPOSED OR ON-GOING PUBLIC HIGHWAY OR ROAD, UNTIL THE GOVERNMENT SHALL HAVE A COMPETENT STUDY AND HAVE FORMULATED A COMPREHENSIVE AND INTEGRATED LAND USE AND DEVELOPMENT PLAN

WHEREAS, it becomes imperative to limit the use of all lands of the public domain within a strip of one thousand (1,000) meters along existing, proposed or on-going public highway or road for the purpose of formulating a comprehensive land use and development plan;

WHEREAS, it is necessary to limit the use of these lands in favor of human settlement sites, land reform, relocation of squatters from congested urban areas, tourism development, agro-industrial estates, environmental protection and improvement, infrastructure and other vital projects to support the socio-economic development program of the New Society;

NOW, THEREFORE, I, FERDINAND E. MARCOS, President of the Philippines, by virtue of the powers vested in me by the Constitution as Commander-in-Chief of the Armed Forces of the Philippines and pursuant to Proclamation No. 1081, dated September 21, 1972, and General Order No. 1, dated September 22, 1972, as amended, do hereby order and decree:

Section 1. Any provision of law, decree, or order to the contrary notwithstanding, all lands of the public domain within a strip of one thousand (1,000) meters along any existing, proposed or on-going public highway or road outside existing towns cities and settlements are withdrawn from settlement or sale until an appropriate government agency shall have made a competent study and formulated a comprehensive and integrated land use and development plan for such lands.

Section 2. These lands of the public domain within the strip of one thousand meters along said public highways or roads shall be first available for human settlement sites, land reform, relocation of squatters from congested urban areas, tourism development, agro-industrial estates, environmental protection and improvement, infrastructure and other vital projects in support of the socio-economic development program of the Government.

Section 3. Likewise, all lands owned by private persons within the strip of one thousand meters along existing, proposed or on-going public highways or roads shall first be available for human settlement sites, land reform, relocation of squatters from congested urban areas, tourism development, agro-industrial estates, environmental protection and improvement, infrastructure and other vital projects in support of the socio-economic development program of the Government. The owners of these lands shall not develop or otherwise introduce improvements thereon without previous approval from the proper government agency, who shall in this case be the Chairman of the Human Settlements and Planning Commission.

Section 4. The Chairman of the Human Settlements and Planning Commission shall promulgate rules and regulations to implement this Decree.

Section 5. This Decree shall take effect immediately.

Done in the City of Manila, this 28th day of February, in the year of Our Lord, nineteen hundred and seventy-four.
The Lawphil Project - Arellano Law Foundation

Figure 5.12: Presidential Decree 399

Based on an interview with an LLDA official, it was discovered that once settlers establish themselves, there is little political will from the ruling party to demolish these settlements, as these settlers constitute a considerable voting population. This is also because the elected officials have a short term in office, which is usually 3 years. The interest in election (or re-election) is much greater than in the concern for long term development based on functional integrity of the environment. The shore-land regions of Laguna de Bay have largely been altered by land use policies that do not take functional aspects of these regions, nor create political will to relocate settlers to other more ‘livable’ areas.

Figure 5.13: The making of roadways accompanied by heavy trucks and bulldozers (left) reflect the involvement of centralized power for converting the vulnerable shore-land regions of the lake. Informal settlements sprawl (top right) along both sides of the roadway. Once established, the settlers take an urbanized lifestyle. As a result, not only chemical pollution but the amount of solid wastes discharged into the lake is considerable. (Photographs by the researcher. February 10, 2010)

Figure 5.14: Top left: Water hyacinth (foreground) and water spinach (background) generate some income for the inhabitants of the urbanized lakeshores; however, they are only distributed in small pockets. The huts are not permanent and only used for harvesting crops.
Top Right: An estero[38] in the outskirts of Manila Clogged by solid wastes. (Photographs by the researcher. February 10, 2010).

Figure 5.15: A sprawling of settlements along shore-lands (shown by the arrow). Note the thin patch of shore-land with perennial grasslands stripped of its cover.

[38] Esteros are canals made by Spanish settlers to discharge urban sewage.

Are the people who occupy the lakeshore regions poor? Upon a closer look, the lives of these settlers reveal a curious dichotomy. From interviews with LLDA officials, we learn that many of the dwellers have televisions and refrigerators, and even washing machines in their dwellings. Many others own motor bikes. Therefore, it cannot be said that the people of these areas are absolutely poor. However, they do not have access to safe drinking water. Many draw water from communal hand pumps close to the lake, with polluted water near the settled areas. The sanitary conditions of these areas also depend directly on the lake, as household sewage is dumped into the lake. The inhabitants occupy a narrow area between busy roadways, with considerably poor air quality[39] on one side, and increasingly polluted waters of the lakeshore region on the other. They live in a visually congested and polluted landscape. Thus, the inhabitants of the lakeshore region can be considered relatively poor in terms of resource entitlement, given the standard of air and water quality.

The literature and guidelines for land use policy-making have disregarded the importance of shore-lands and the interplay of the pulsed system of the lake for maintenance of the lake ecosystem. The land use master plan created in 1995 (LLDA, 1995) is of a macro scale with little consideration of functional spaces for ecological

[39] The amount of suspended particulate matter in Manila's air is 138µg/m^3, high above the standard of 90µg/m^3 set by DENR. The SPM concentration can become as high as 282 µg/m^3 in areas such as near EDSA.

integrity. There is a lack of comprehensive land use planning based on the watersheds and a bioregional approach ideal for integrated management of land and water. The Comprehensive Land Use Plans of Calamba, Cabuyao and Sta. Rosa (HLURB, 1981; 1991, 2000) point to the fact that the word 'comprehensive' is used for attributes of scale rather than function. They are just detailed descriptions of some selected spaces in the lake basin chosen on the basis of developmental priorities, mainly settlements and agriculture. Instrumental value of land is overwhelming in land use planning, but socio-economic parameters are only partially touched in these reports. Bio-physical and ecosystem based resource appraisals are extremely limited in these zoning plans. The absence of a comprehensive master plan in the lake basin shows a lack of coordination in the land use policy implementations regarding land developments, and the spaces of ecological function of the watershed. It was noted that the comprehensive land use maps available from HLURB were actually land suitability maps based on municipal boundaries. No consideration of watershed boundaries or any other bio-physical attributes can be seen in these reports or maps, let alone their functions in creating the landscape. This shows that primary consideration is given to the instrumental value of the watershed for human consumption.

Furthermore, no single government sector is responsible for land use decision-making and cannot be held accountable for such activities. Responsibility is diffused among the institutions of land use decision-making. In accordance with this, three types of land use decision processes can be identified that rapidly change the landscapes of the shore-land regions. First, the negligence of space as a function of ecological integrity in the land use planning process; Second, the vested interests of the local politicians in the region; and Third, the need of informal settlers (who comprise the poorer lot of society) to occupy zones of minimum economic value, which is an outcome of population explosion in the region and increase in the price of land, especially after the Calabarzon project has been implemented (see chapter 6). These three concepts can be considered collective human actions that are not internalized in the policy-making process. As a result, the ecological vitality of the shore-land regions of the lake basin is not integrated in governance.

Land use policies such as the PD 399 fail to institutionalize ecological values of the shore-lands. Instead they institutionalize unsustainable human behavior present for decades in the landscape, thereby establishing unsustainable land use practices in the lake basin. To what extent then is an activity considered “unsustainable”? An activity is deemed unsustainable with respect to its environment. In other words, the state of the local environment determines whether a particular action is sustainable or not.

Considering the vulnerability of low lying shore-land landscapes of the lake to human interventions, occupying and changing the landscape of these areas is much more detrimental to the lake ecosystem compared to such practices relatively upland, making these activities unsustainable.

Ideally, institutions dealing with land use decisions should have profound knowledge of the impact of collective human actions in the concerned area, considering the functional ability of a given space to determine its ecological integrity. However, it is clearly evident that even the 'experts' involved in deciding on the usage of a particular bio-region, fail to address this principle. In this case, the main limitation is that the macro scale master plan for the Laguna de Bay watershed does not give adequate importance to both the bio-physical and socio-economical aspects of this region. The master plan is outdated as well, as it is dated 15 years back. The socio-economic and environmental conditions of the lake basin have changed profoundly since then.

The combined effects of flawed environmental policy processes, vested interests of local politicians and the conversion of fertile lands to settlements due to population pressure, seriously compromise the future productivity and ecological integrity of the Lake Watershed and sustainability of its water resource management.

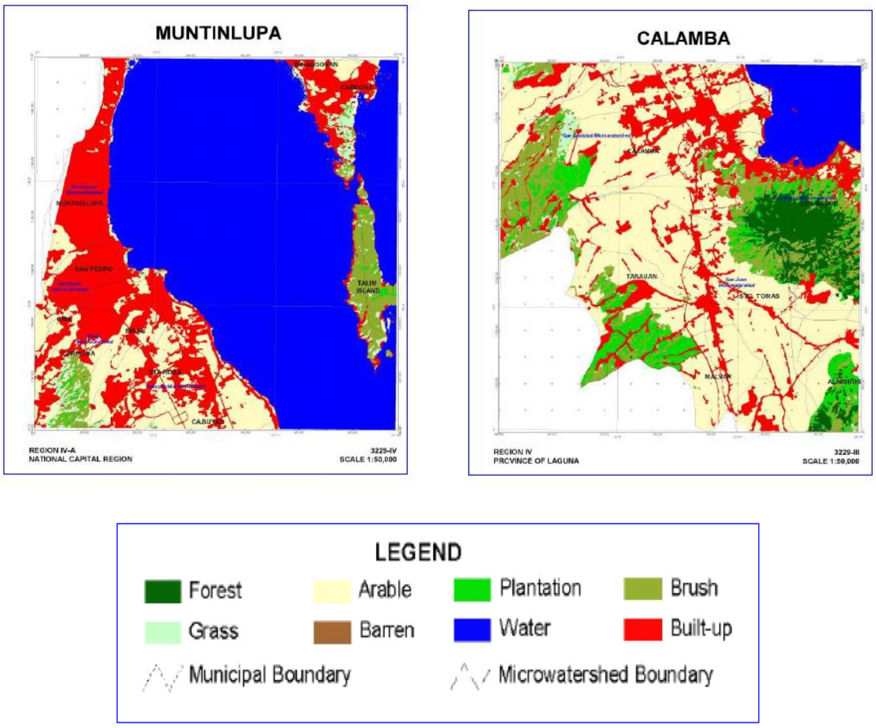


Figure 5.16: Newly urbanizing areas 'eating away' the rice lands of the southwestern part of the lake, as seen in the section of the land use map prepared from a SPOT image in 2005. Note the existence of built up areas along the lakeshore regions. (Courtesy: LLDA, 2003)

5.5 Ecological values of shore-land regions:

Understanding the effects of land use change in the shore-land region of a given lake is of considerable significance due to the fact that the original shore-lands (occupied by perennial grasses) enhanced control of erosion runoffs, spawning and habitation of fish, mollusks, and nutrient influx from biogeochemical cycles (Green & Kauffman, 1989; Wudneh, 1998). In the present chapter this argument has been put through photographs taken from a handheld camera during fieldwork, to give a micro scale analysis of the landscape.

Two kinds of agricultural livelihood practices can be found in the vicinity of the lakeshore regions; one, irrigated rice or palay cultivation, and two, grasslands with a mixed type of agriculture (mainly vegetables), fishing and hunting. The grasslands are maintained through continuous burning in small plots, carried out to make regeneration of grasses possible and land penetrable for fishing, hunting and agricultural activities. Burning is necessary as these lands are generally covered by talahib grasses, which can grow more than two meters when fully matured. As noted in the previous chapter, these grasslands denote transitional landscape from brushlands toward irrigated agriculture or built up areas, and tend to follow a transition toward palay cultivation urbanized spaces surrounding the lakeshore regions. One of the main characteristics of these lands is that they are in the transition between a two-way interaction between clearing and re-growth, maintained by human activities.

These shore-lands have now been replaced by either lakeshore settlements as found in the western shorelines of the lake, or agricultural cash crops as found in the eastern shores of the lake. The shore-lands with mixed livelihood options have retreated inland and away from the lake. The livelihood options that are possible in the low lying brush-lands have thus, diminished further.

These types of landscapes, unless consumed and degraded by the process of urbanization, are rich in biological diversity and have multiple livelihood values for the locals. The biological diversity is less than in the forests, but is more prevalent than in the irrigated agricultural lands with mono-crop cultivation; much of which in the shore-lands is dominated by wet rice cultivation. Although the lands are dominated by grasses (cogon and talahib), mixed types of agriculture are also practiced in these areas. The varieties of crops cultivated include fruits, vegetables, legumes, and leafy vegetables such as water spinach (see table 5.2).

Fish, mainly the catfish species and eels, are usually found in the waters of these areas, as the waters have low oxygen concentrations due to their stagnant nature and murkiness. These fish are the only type that can survive under such conditions. Some have to travel for short distances to find new waterholes in the dry season.

A short account of the different ecological services available in the undisturbed shore-land regions is given below. The data has been gathered through open interviews.

> When asked about how fish are caught the interviewee, a 50 year-old who previously worked in Saudi Arabia and now has opted for a livelihood of fishing and vegetable farming, said that fish are caught by stunning them with electrocution. However, only fish that have grown to a significant size are

eventually retained and juveniles below reproductive age are released[40]. The fish caught can be sold at the local market for a price of approximately 100 pesos per 500 grams. Prior to going to Saudi Arabia for work at a construction company, he remembers catching pythons having a girth of an adult human leg, measuring 10 to 12 feet in length. These snakes are not found here anymore but are found in dense scrub vegetated areas near the lake or near the mountains.

The Philippine Reticulated Python (sawa) is at the top of the food chain in the region. The existence of a top predator in a region shows the diversity of life forms related to the food web of the region. The eventual disappearance of the python then, is an indicator of the overall decline of the ecosystem's health. The mixed livelihoods that are practiced in the areas of lakeshore region, where perennial grasslands are present, indicate that shore-land areas with perennial grasses not only can serve as a buffer zone for slowing down nutrient and sediment runoff to the lake, but also can provide livelihood options to the locals. These represent landscapes that have both intrinsic and instrumental values. Perhaps the most important attribute is that these activities conserve the ecological processes and internalize ecological values of a landscape in their activities.

[40] This is possible as the electrocution stuns the fish only momentarily.

Table 5.2: Resource bases for mixed livelihood practices in the lakeshore regions where perennial grasslands are present. The multi-functional utilization of the shore-land regions suggests that these landscapes have considerable ecosystem values for sustainable livelihood options.

Mixed Agriculture	Fishing	Hunting
Banana, Papaya, Corn, Tomato, Cucumber, Eggplant, Beans, Leafy vegetables (water spinach, etc.)	Palos (Bengal eel) Hito (Broadhead catfish) Dalag (Snakehead murrel, or mudfish) Buhol Tilapia Hipon (Shrimp)	Sawa (Philippine Reticulated Python) Birds Snails

Table 5.3: The most common nesting bird species found in the lakeshore regions are described below.

1. Blue breasted quail
2. Red turtle dove
3. Philippine bulbul
4. Yellow vented bulbul
5. Branded rail
6. Barred rail
7. Barred buttonquail
8. Philippine glossy swiftlet
9. Pacific swallow
10. Barn swallow
11. Richard’s pipit
12. Brown shrike
13. Schach shrike
14. Philippine flower pecker
15. Eurasian tree sparrow
16. White breasted wood swallow
17. Large billed crow

The cultivation of cash crops through irrigated agriculture keeps the shore-land of these areas comparatively cleaner than the urbanized shores, which mainly produce solid wastes and municipal and industrial sewage. However, agriculture in the shore-land areas is often done in locations not well suited for such practices, with the exception of a few crops that can be cultivated in that particular environmental condition of the region. This is because a large part of the riparian zone becomes waterlogged in the wet season and during the high tides. The cultivation of a single crop means rapid loss of nutrients from the soil as the soil is kept barren and open to the processes of mass wasting. Moreover, these crops are cultivated as cash crops and the land is pushed to the limit by cultivating intensively. Cash crops alter ecosystems by eliminating species thriving traditionally in the aquatic landscapes and securing it solely for human use. Once this change takes place, the land transforms into a private property or occupied space, or is bought and sold, thus expanding consumer activities disproportionately over ecosystemic integrity.

According to Lee (1992),

> The sociological concept of institutionalization can make a significant contribution in understanding how the processing of ecological information is affected by human organizations. Institutionalization involves the development of persistent patterns of human behavior expressed as formalized rules, rituals, or customs or as informal rituals and patterns of social interaction or interaction

with the nonhuman environment. (Lee, 1992; 77)

Such institutionalization of ecological information and processes erode social interactions with non human nature due to an over emphasis on economic and politico-demographic issues. Moreover, pollution carried to relatively pristine shore-lands through various pathways give an added far-reaching dimension to this problem. The intensity of pollution in the lake is enhanced by the wind generated waves, pathways by which the pollutants are diffused. Much of the pollution of the more urbanized areas of the lakeshore is diffused by wind generated waves in the lake to further inside, and also to shores that are comparatively less polluted. The polluted waters therefore, accumulate in 'pockets' of heavily polluted zones. The shore-land areas on the windward side are especially vulnerable to this process, making the shore-lands biologically dead in the worst cases. Complex relationships involve an array of different sources, pathways and receptors for social-environmental outcomes. This explains the non-linearity, diversity and dynamism of resource management options in the shore-land regions of the Laguna de Bay Basin. Here, pathways of pollution lead to positive feedback, as the zones of minimum pollution receive pollution from other areas, impairing biological activities there. Second, degraded shore-lands become the source of pollution to other areas through the movement of lake waters by wind generated waves.

Figure 5.17: Wet rice or palay Cultivation in the shore-lands of Laguna Province about 2 km to the south of the lake. (Photograph by the researcher. March 26, 2010)

Figure 5.18: The areas of burning take place more inland from the shore, where the ground is flat but a little higher than the reach of the seasonal inundations. The burning is carried out in pockets of small areas such as this; as a result, the landscapes of recovery can never dominate the landscape. The series of coconut plantations in the background indicate provincial roadways. A documentation that such types of landscape alteration are often carried through roadways. (Photograph by the researcher. March 26, 2010)

Figure 5.19: Re-growth of grasses *(talahib)* in the burned (darker) areas. (Photograph by the researcher. March 26, 2010)

Figure 5.20: Fishing boats are seen more where the shore-lands are not degraded. Picture taken from San Juan Port, looking toward the provinces of Laguna and Bay. (Photograph by the researcher. March 26, 2010)

Figure 5.21: Burning at the shore-land area. Burning is for managing the grasslands, hunting and for making charcoal. This picture has been taken from San Juan Port, looking toward the provinces of Laguna and Bay, presenting a more rural side of the lakeshore. (Photograph by the researcher. March 26, 2010)

Figure 5.22: The peri-urban shore-lands have less fishing activities indicating a degraded lakeshore. (Photograph by the researcher. March 26, 2010)

Figure 5.23: Fish feed gathered from urbanized lakeshores at the San Juan River mouth. The increasingly polluted nature of the water has a high level of eutrophication, and they do not support healthy open fisheries. (Photograph by the researcher. March 26, 2010)

Figure 5.24: Degradation of the lake due to increasingly urbanized shore-lands. The dark color of the water near the shore is from municipal sewage draining to the lake along with silt. The breeze toward the land during the day keeps pollutants close to the lakeshore, but they are dispersed into the lake due to a reversal of wind in the night. During the typhoon season the wind blows toward the western shores for 4 months (June to September), but in the remaining 8 months (October to May) a slow but steady wind blows toward the southeast, ensuring dispersal of pollutants to the eastern margins of the lake. (Photograph by the researcher. March 26, 2010)

Figure 5.25: Considerable amounts of solid wastes are generated in the degraded shore-land regions, which also represent those degraded parts of the tributary river basin. The degradation of the tributary rivers and the degradation of the shore-land regions have a high correlation. (Photograph by the researcher. March 26, 2010)

Figure 5.26: Degraded shore-lands in the vicinity of San Cristobal River mouth (Mt. Makiling can be seen in the background). The pressure from land degradation to one of the two reserve forest areas is considerable. Much of the forest in the lower elevation of Mt. Makiling, despite being declared a Special Ecological Zone (SEZ), are degraded and developed by real estate companies. States of further degradation loom largely over this area. The University of the Philippines (the institution accountable for maintenance of the biodiversity of the Mt. Makiling ecosystem) had to close all activities inside its jurisdiction. (Photograph by the researcher. March 26, 2010)

Figure 5.27: There are people who fish, gather mollusks, and seek recreation in these polluted waters. This is partly because they do not have much choice but to live with their immediate environment, and partly due to the fact that the lake still holds an ecosystem which, although degraded, can support a considerable population. (Photograph by the researcher. March 26, 2010)

Figure 5.28: This is an area of our everyday lives: recreation and extending friendship. Children from the junior high school and high school of the village Looc. (Photograph by the researcher. March 26, 2010)

Figure 5.29: Children gathering mollusks from the lakeshore of the village Looc in Calamba municipality at the San Cristobal river mouth. The River is one of the most polluted in the area. The eroded soil and pollution can be observed by a change in color of the water near the shore-land, where water is darker in color. (Photograph by the researcher. March 26, 2010)

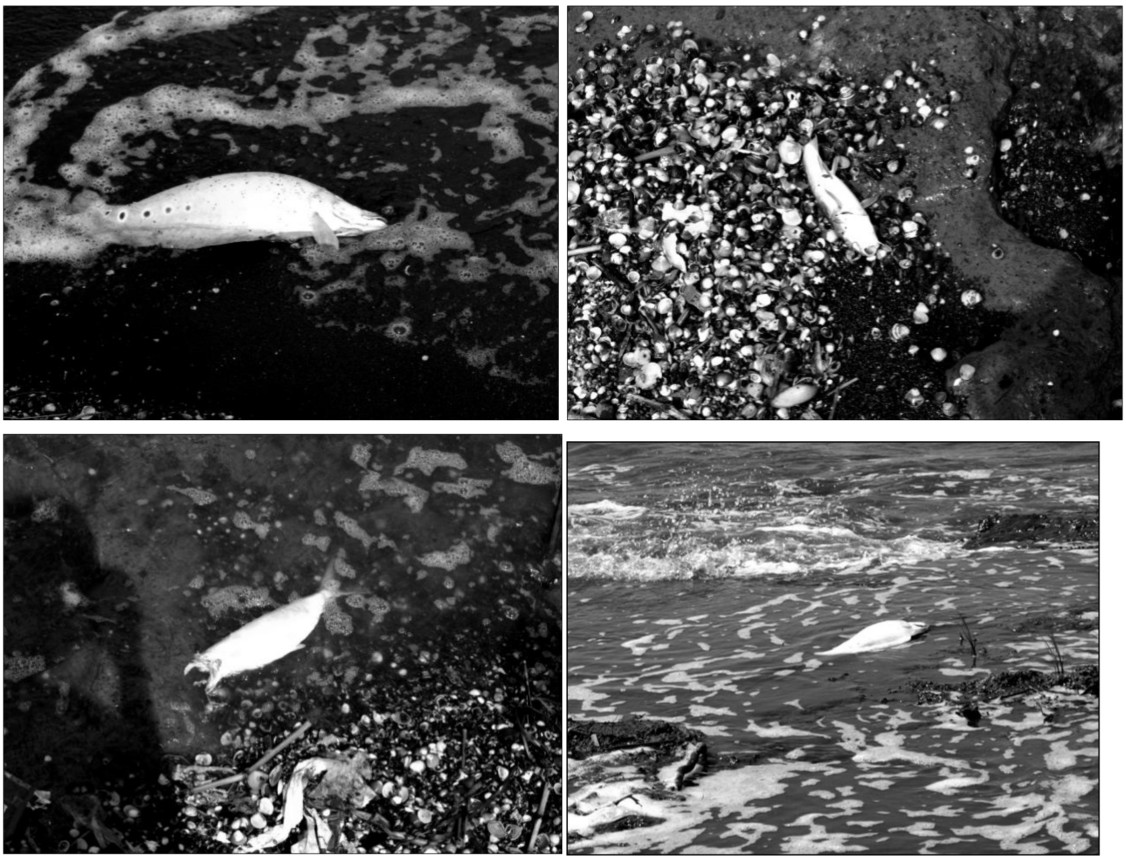


Figure 5.30: Death of fish due to eutrophication in the lake. Such fish deaths are remarkably high in the western margins of the lake. (Photograph by the researcher. March 26, 2010)

Figure 5.31: Shoreland region in the urbanized western lakeshore. The indiscriminate sprawl of squatters replaces the riparian zone that was not only rich in biological diversity, but also acted as a buffer zone for nutrient and sediment runoff from the denuded and young rivers. (Photograph by the researcher. March 26, 2010)

Figure 5.32: The rural side of the lakeshore region is dominated by agriculture such as this in the Pagsanjan delta. The fertility and availability of freshwater from Pagsanjan River, the largest of Laguna de Bay’s tributaries, makes agriculture a lucrative livelihood option. (Photograph by the researcher. March 26, 2010)

Figure 5.33: Squash *(Kalabasa)* and corn are planted in the seasonally inundated areas inside the shore-land regions. Cultivation of rice takes place much higher up in the zones of inundation. (Photograph by the researcher. March 26, 2010)

Figure 5.34: Slope of the land in the shore-lands of the Pagsanjan delta. These lands are inundated seasonally. The reason why squash is chosen more often to plant in these areas is because they can give quick money to the farmer and landlord, and can be harvested quickly before water levels rise. Choosing to cultivate few crops means removal of nutrients from the soil and the land becomes vulnerable to soil erosion. There is an increase in bare ground and the process of mass wasting will have a great effect on the land. Cultivation of crops extensively in areas unfit for agriculture means agriculture is pushed to the limits. With increased urban areas,

agricultural lands have become fewer and fewer. (Photograph by the researcher. March 26, 2010)

Figure 5.35: The original cover of seasonally inundated swamps can be seen in the background, with squash cultivation in the foreground. Agriculture that supports both perennial grasslands and livelihoods of the locals is preferable, but is only possible if a mixed type of agriculture is practiced. (Photograph by the researcher. March 26, 2010)

Figure 5.36: Simply, the natural beauty of the undisturbed shore-land regions of the lake is much greater than of urbanized shore-lands. This puts an aesthetic value to the landscape. (Photograph by the researcher. March 26, 2010)

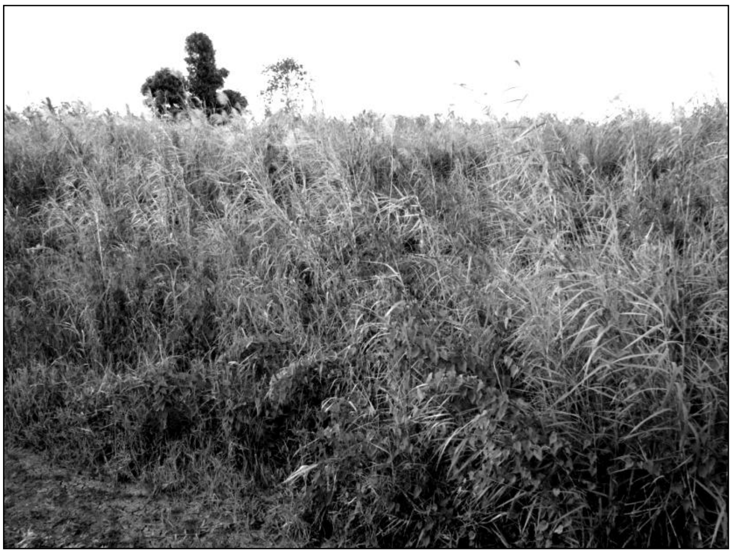


Figure 5.37: Perennial grasslands produce enough shade for the soil, keeping dehydration to a minimum and facilitating a moist environment near the lakeshore inhabited by fish and mollusks common to the lake and rivers of the region. (Photograph by the researcher. March 26, 2010)

Figure 5.38: Dispersal of sludge into areas disturbed indirectly by urbanization. This picture is taken at the Pagsanjan Delta as it meets the lake, looking toward the southeast. Municipal sewage and sludge are carried by wind generated waves from urban centers such as Kalayaan, Paete, Siniloan and Mabitac. (Photograph by the researcher. March 26, 2010)

5.6 Summary:

Spaces are functional. Each space on the earth's surface has particular functions depending upon its geographical location. Spaces are functionally interrelated to each other, and thus are synergic (Mazur & Urbanek, 1983). Space is also a socially constructed attribute; it is used, seen, consumed or preserved in different ways for human survival, recreation or conservation for future generations. The conversion of shore-lands of the Laguna Lake is a function of political and demographic forces. Statistics show that population in the lake basin, especially along lakeshore villages; has increased at a faster rate than the provincial average. Populated lakeshore villages have replaced the prime agricultural lands ideal for cultivation of rice, with built-up areas. The growth of occupancy along the lakeshore is accentuated by policies such as the Presidential Decree 399, which support construction of built settlements along the highways and provincial roadways. However, such land use decrees cannot be singularly held accountable for the sprawl of settlements along the lakeshore region, because roadside settlements have been common phenomena around the western margins of the lake as early as during the 1950s. Thus they indicate more spontaneous actions of making of trail systems through the low contoured areas around the lake, which were later enhanced by the economic growth of the region. These areas in turn have become the receivers of urban population, carrying the urbanization of Manila further afield into rural belts. The ‘mega-urban’ areas became dispersed regionally throughout a space which is much broader than the city region itself, thereby leading to peri-urbanization. The process is enhanced when roadways are made through spaces functionally related to the lake’s ecosystem. In this way, zones of lake protection become zones of lake pollution. These short sighted and benefit driven policies enhance population along the shore-lands or riparian zones of Laguna Lake, which alter spaces of vital ecological functions for the ecosystem and health of the lake. Spontaneous population increase cannot be completely controlled by land use policies, but the distribution of such population can be controlled to some extent through land use. Policies that enhance the externalities of increase in population are examples of internalization of unsustainable human behavior into the policymaking process. Both the construction and betterment of roadways, which facilitate the sprawl of informal settlements in the lakeshore region, can be regarded as a result of vulnerability embedded in land use planning and society. This influences land use policymaking in the region. Furthermore, the land use decision-making in the region takes place in a diffused manner with ecological uncertainties. Land use planning literature show that resource-governing institutions fail to internalize collective human actions, and land use options remain instrumental. A principal component of integrated water resource management is reduction of human actions that are unsustainable to the ecosystem. In this case a reversal of unsustainable collective human actions is necessary as this will increase the resilience of the ecosystem of the shore-lands of the lake. This in turn will help create a robust framework of social ecological systems (SES) in decision making.

Spaces in the shore-land regions have considerable livelihood options, such as hunting and fishing, with mixed agricultural practices. These not only address the question of regional food security and livelihood options but also give an aesthetic value to the landscape. These are the bio-physical attributes of the watershed that are needed to base a sound land and water use policy option. The conservation of shore-land regions keeps the original perennial grasslands intact, which is often regenerated through controlled fire, keeping the zones richer in biodiversity not possible through mono-crop cultivation. Conservation of ecological processes by these farming-cum-fishing activities is an example of internalization of ecological values. As Firey noted as far back as in 1960s, these values must be internalized and must be recognized by society as beneficial to both the individual and society. These characteristics can also be addressed as vital indicators for livable urban environments as noted by Pacione. Providing multiple livelihood opportunities in the peri-urban areas is a major challenge for confronting poverty in these areas and to diversify income sources and promote food security (Satterthwaite, 2000 in Gundel, 2006). In this sense the shore-land regions are critical geographical spaces for the provision of ecosystem services with emphasis on bio-physical attributes and linkage to economic and social characteristics.

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Chapter 6

Policy Perspectives and their Relation to Land Use in the Laguna de Bay Basin with Special Reference to San Cristobal Watershed

6.1 Introduction and objectives:

This chapter seeks to explore how land-use policies and environment are related with respect to the state of the river, and how the two are related to each other in the peri-urban areas of the Laguna de Bay basin. A review of land use policies that influenced land use changes in the research area is the primary issue addressed in this chapter.

Accordingly, the chapter seeks to answer the following questions:

1. How do land use policies take effect in a micro watershed of the Laguna de Bay Basin?
2. What particular development pathways do these land use policies follow?
3. What is the approach of such policies toward institutionalizing the human-nature interactions as far as a micro-watershed environment is concerned?

In the first section of the chapter, the structure and process of regional development policy in the Philippines is discussed. Special attention is given to the question of how agricultural land uses are altered due to industrialization. The second section analyses how land use is altered in the watershed of the San Cristobal River due to development in the region. Data is represented through descriptive analysis of present land uses in the river basin. Results are drawn from fieldwork with unstructured and semi-structured interviews and observations.

6.2 Calabarzon project in the foreground of national economic policies of the Philippines

Looking back on history, the Philippine government was highly decentralized during the Spanish Colonial era.(1565-1898) The decentralized systems later changed to a centralized nation state, which began from the period of American occupation (1898-1946), with the country stressing more on regionalization especially during the 1960s and 1970s. Programs for increasing agricultural production, fiscal incentives for industries located outside Manila, and the post-independence strategy of import restrictions, are three examples of major moves toward regionalization in the country. However, it was not necessarily sufficient to raise the livelihood of people by increasing agricultural output. Poverty in rural Philippines increased due to unequal distribution of land between landlords and tenants. Decentralization of industries also meant that waves of urbanization were invited in the country outside Manila. The export orientation of the industries meant more leakage of resources from Philippine lands to other regions of the world. Nevertheless, despite having a long background of decentralized power and policies, the power at the center remained the strongest and most influential in the Marcos regime, with limited power designated to local government units (Hill et al., 2007).

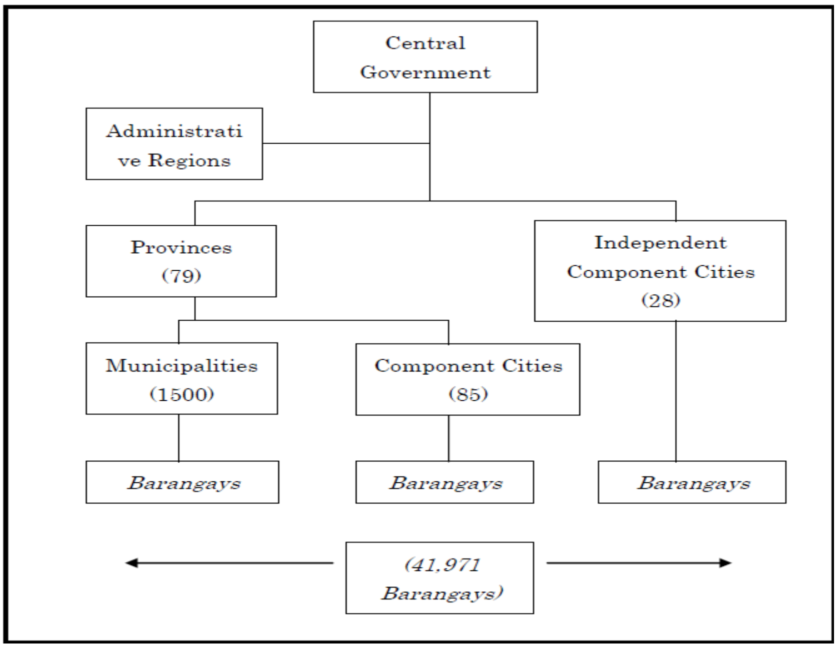

Figure 6.1: Present government structure of the Philippines. The governor is in charge of the provinces, mayors for the municipalities and component cities, and barangay[41] captains for the barangays or villages. All officials have a 3-year term period in office and a maximum limit of 3 terms. Hill et al. (2007) notes that as of 2005, the number of cities almost doubled compared to that of 1991, which indicates an increase in both regional and national population. (Redrawn after Hill et al., 2007).

[41] Barangay is named after local rafts called balangay. The first settlers used them to navigate the ocean and they were very likely the method of transport when settlers first arrived.

Land conversion in the Philippines has been a matter of great concern, as over decades the country has been under various colonial rules and, to a greater extent, under a variety of internal political regimes. These regimes used the country's resources to gain foreign exchange, encouraging an accumulation of resources for the elite rather than keep the country self-sufficient.

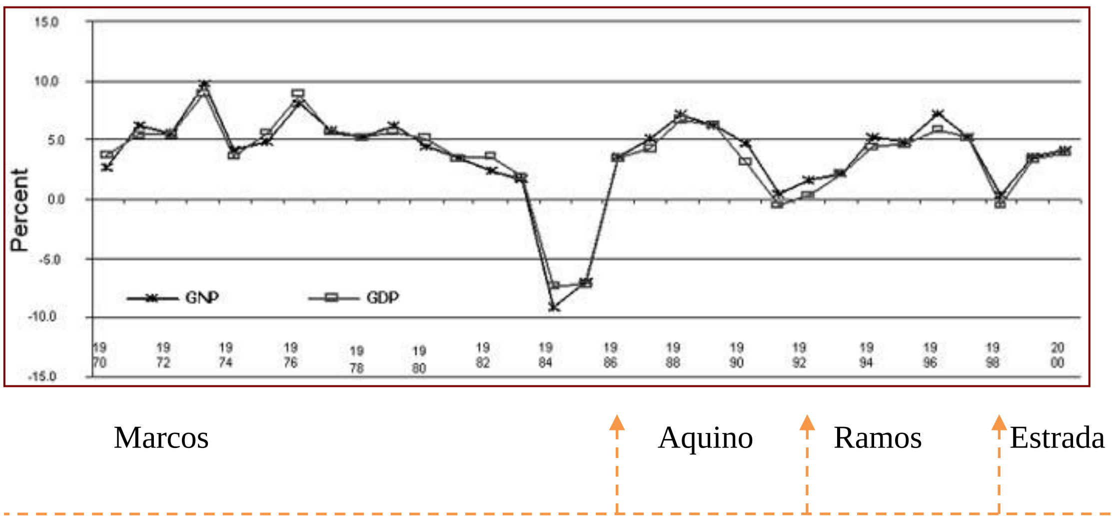

Figure 6.2: Various Presidential Regimes in the Philippines and the growth of national GDP. (Source: Templo, 2003, In Pedro & Benavides, n.d.)

By looking at the GDP growth rate of the Philippines since 1976 with corresponding presidential administrations, it can be seen that during the last decade of the Marcos dictatorship, the economy fell sharply (see Figure 6.2), and the country was reeling under poverty and inequality. The Philippines was under severe political unrest since Benigno Aquino was assassinated in 1983. It is said that in the 1986 election, Marcos claimed victory through electoral fraud (Manikas, 2004). Corazon Aquino, the opponent, and her followers started a rally against Marcos. Eventually after 21 years of dictatorship Marcos had to bow out. During this time the Philippine economy plunged to its record low in GDP terms. The beginning of the Ramos administration saw the retreat of the Americans from the Clark Air Base and Subic Bay, indicating the end of the American occupation in the Philippines. Ramos, with his policies on privatization of industries and improving infrastructure facilities, helped the Philippine economy grow considerably. However, at the end of the 1990s the economy fell once again, possibly due to the Asian Financial Crisis[42].

A hallmark project conducted during the economic recovery years was the Calabarzon Project. The idea of the project was to develop selected areas of the five provinces - Cavite, Laguna, Batangas, Rizal, and Quezon (hence the name Calabarzon) - with industrial growth, to support the increasingly populated and industrialized capital region of Manila through provision of space and economic, social and environmental resources. It was the Calabarzon Project that actually put an emphasis on the 'urbanization' that spread throughout given regions.

42 In 1998, the Philippine fiscal deficit reached P49.981 billion from a surplus of P1.564 billion. The Peso depreciated from 29.47 per U.S. dollar to 40.89 per U.S. dollar. From 1997 to 1998 the GNP fell from 5.3 percent to to 0.1 percent.

Table 6.1: Some characteristic social and land use features of the two provinces, Laguna and Rizal, compiled by the Japan International Cooperation Agency (JICA) during the preparation of the master plan for Project Calabarzon. (Source: Top, Master Plan on Project Calabarzon, JICA. Bottom, Philippine Forestry Statistics, 2003).

1985	**Laguna**	**Rizal**
Population	1,374,000	973,000
Population growth	3.5	5.8
Population below poverty line	50.9	59.6
Total Land Area	175,974	130,894
Agricultural	107,117	18,764
Forest/woodland	26,079	17,771
Bamboo	-	4,773
Grassland/shrubland	29,968	69,855
Wetland	2,147	442
Built up Areas	10,593	15,237
Unclassified lands	-	2,572

2000	**Laguna**	**Rizal**
Population	1,965,872	1,707,218
Population growth	-	-
Population below poverty line[2]	10.6-	6.4-
Total Land Area	175,974	130,894
Agricultural	111,080	13,770
Forest/woodland	19,010	21,830
Bamboo	-	40
Grassland/shrubland	29,770	80,090
Wetland	2,147	442
Built up Areas	11,140	11,190
Unclassified lands	-	2,572

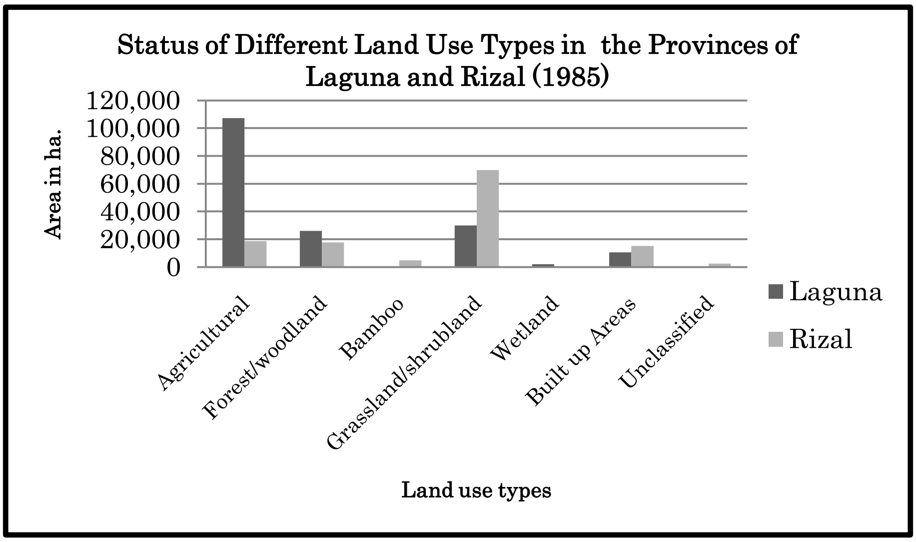

Figure 6.3: Land use status described by the Japan International Cooperation Agency (JICA), during 1985 as a master plan for Project Calabarzon.

While compiling the master plan for the Project Calabarzon, much of the landscape in Laguna was agricultural (60.9%), while more than half (53.4 %) the area of Rizal had vast areas defined as grasslands. Also note the status of built up areas during this time was negligible, considering the status of built up areas in the two provinces at present. No doubt that Project Calabarzon was a major force behind the rapid increase of built up areas in the two provinces. Regarding the land use change on a macro scale in the provinces of Rizal and Laguna, we can refer to surveys made prior to the Calabarzon project for its implementation. The wise provincial assessment of land use change gives an opportunity to zoom out in space and time (constructing land use statistics of similar criteria as done before the implementation of the Calabarzon

Project), which is important for generalizing and understanding land use changes on a micro scale. Laguna was a province with agriculture as its priority land use type when the Calabarzon project came under consideration. This agriculture-based Laguna also had about half its population below the poverty line. However, the level of poverty was not as high as in the Province of Rizal, in which almost 60% of the population lived below the poverty line. In Rizal, about 14% of the land was composed of forest or woodland, while 17% of the land was grassland and brush-lands. The share of forests and woodlands in the province of Laguna during this time was about 15%, while the share of the transitional landscapes was about 53%. The share of built up areas in the two provinces of Laguna and Rizal was negligible, 6% and 12% respectively. The forestlands in 1985, as noted above, were of a secondary type, with the forests of natural succession representing landscapes of recovery. The grasslands and brush-lands on the other hand, represent landscapes in transition either toward recovery or further alteration. The general land use after 15 years of the Calabarzon survey can be referred from the Philippine Forestry Statistics data published in 2003. In Laguna, the areal extent of forest cover has decreased by 7069 hectares, whereas forests in Rizal have increased by 4059 hectares.

Efforts to make the Philippines a newly industrialized country or (NIC) started before the Aquino administration, with the surveys for Project Calabarzon starting as early as 1985. The idea and its implementation were largely carried out by incentives of the Department of Trade and Industry (DTI). The main tasks of the Department of Environment and Natural Resources (DENR) were monitoring and protection of the environment. Devolution of policies came later in October 1991, in the form of Local Government Codes or LGC and the power of LGUs to implement policies according to LGCs. The mandate of the Department of Trade and Industry is an incentive based approach, made for promoting regional economic development through incentives for firms willing to invest in the region. The investments are specially made, and are increased for investments in the less developed areas, whereas areas that are already urbanized are discouraged to be developed further to avoid industrial overcrowding. Thus, DTI's main mandate is to open new tracts of land for economic development.

DENR, on the other hand, has the mandate for regulation and protection of the Laguna de Bay environments. DENR's mandate involves pollution monitoring of industries. To help industries develop in a sustainable manner, DENR has introduced the Industrial Environment Management Program or IEMP, with the help of the United States Agency for International Development (USAID) for industrial firms nationwide. The main aim of IEMP is to ensure economic growth of the industrial sector, with reduced pollution, improved human health, and providing technological solutions and expertise to environmental problems through industrialization. The restoration of degraded forests is one major protection activity of the DENR. The forest regeneration project is implemented in small plots of lands (about 10 to 12 ha in size) in Rizal, Laguna and Cavite, mainly planted with species of Narra, Gmelina and Mahogany. However, compared to the massive degradation of forestland in the Laguna de Bay area, these planted areas are negligible. Other mandates of DENR for the Calabarzon area include watershed and upland protection, and sustainable mining operations.

The Laguna Lake Development Authority (LLDA), created in 1966, is the lead institution under the Department of Environment and Natural Resources with a mandate to quasi-governmental authority under DENR (previously under the National Economic Development Council). Its main mandate is to ensure sustainable development of its jurisdictional area (mainly the Laguna de Bay watershed) through regulatory and law enforcement functions. LLDA's main tasks are to increase the water quality of Laguna de Bay from class C to class A[43], manage the uncontrolled land conversion practices,

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[43] **DENR water quality classification** (for more see http://www.llda.gov.ph/Mondriaan/Mondriaan_reports/2010/2010_05.htm)
Class A waters – suitable to meet national drinking water standards, but require complete treatment
Class B – suitable for contact recreation such as bathing and swimming
Class C – suitable for fisheries, non-contact recreation and industrial use
Class D – suitable for agriculture and animal husbandry

raise the livelihood of the people, and make institutions more robust for natural resource management on the lake basin.

The land use decisions of the watersheds of the Laguna de Bay Basin are divided into two distinct geographical zones: the industrial zone, and the watershed protection zone. The industrial zone starts from Binangonan and ends at Calamba. The watershed protection zones, on the other hand, represent the eastern watersheds of the Laguna Lake, starting from Rodriguez and Montalban, through the Sierra Madre to Banahaw and the Mt. Makiling region in Los Banos. The following are names of river basins that fall inside the industrial and watershed protection zones:

Table 6.2: Industrial and watershed protection zones in the micro-watersheds of Laguna de Bay Basin.

Land characteristics	**Watersheds**
Industrial Zone	Lower Marikina, Mangahan, Angono, Taguig, Muntinlupa, San Pedro, Binan, Cabuyao , San Cristobal
Watershed protection zone	Upper and middle Marikina, Morong, Baras, Tanay, Pililla, Jala-Jala, Sta. Maria, Siniloan, Pangil, Caliraya, Pagsanjan, Sta Cruz, Pila, Calauan, Los Banos, Eastern part of San Juan

It is argued that the local government units have been unable to implement an effective governance scheme for sustainable management of their natural resources as they lack administrative, technical, financial and political capabilities for sound environmental management options (Radford & Butardo-Toribio, 1996). The LGUs have options for either a bottom up or top down land use planning approach. For example, the barangay development plans follow the bottom up approach. The barangay development plan is prepared under the Local Government Code of 1991, and is submitted to the Sangguiniang Barangay for approval. In this way, the barangay development plans are integrated into the city development plans. In case the Barangay Development Plan is not present in a region's provincial land use plan, a Provincial Physical Framework Plan (PPFP) may serve as a planning purpose. Even the PPFP is not available, then any other higher level plan such as a medium-term development plan, regional physical framework plan, metropolitan development plan, etc. may also serve the purpose of a comprehensive land use plan. The implementation of such land use plans spans across a long time period that may stretch for a decade with a review process every 3 years (HLURB, 2006).

It is important to note that there are 10 decision making organizations entitled to review comprehensive land use plans for component cities and municipalities (CCMs), and 12 decision making organizations for the highly urbanized cities (HUCs), and independent component cities (ICCs). The tasks of these organizations in reviewing the CLUP for implementation are given below:

Table 6.3: Main Tasks of the organizations accountable for the economic and environmental well being of the Calabarzon region.

PPDC	Checks if the local plans are in harmony with the provincial plan, the development priorities of the province, or that of the neighboring municipalities.
PA	Checks whether lands are quantified and delineated, which are irrigated, or have a potential to be irrigated. Determines whether the urban areas are outside the protected areas for agricultural and agro industrial development, or fisheries development zones. Checks whether fishponds are identified and delineated.
NGOs	Notes whether the plans increase the access of the under privileged and other basic sectors to social and economic opportunities. Notes how the land use plans and projects will affect the basic sectors. Evaluates how CLUP is going to affect social concerns like human rights and gender roles.
HLURB	Whether land use decisions of the LGUs are parallel with the visions and goals of the LGU Whether the land use plans are harmonious with the land use plans of other municipalities. With the absence of provincial land use plans, evaluates the city or municipal land use plans with the province. Evaluates whether the basic services are identified and delineated in the land use plans. Whether the locations of different Land Use Plans are suitable and identified. Whether the proposed infrastructural and socio-cultural facilities are sufficient for the development goals Whether the housing lots follow the Urban Development and Housing Acts of 1992. Whether the land use plans follow zoning ordinances with clear boundaries. Whether the CLUP is in accordance with approved agency related programs.
DENR	Whether the settlement site is free from legal or environmental

	constraints. Whether there are conflicts between areas of protection and areas of development. Whether there are sites for solid waste management, and if they are consistent with CLUP. Whether the plan meets environmental quality through local initiatives.
DAR	Whether there are any lands under CARP still to be delineated and quantified for re-classification. Whether there are tenants still not under the CARP program.
DTI	Checks the land under Regional Agro Industrial Centers (RAICs), District Agro Industrial Centers (DAICs), Countryside Agro Industrial Centers (CAICs), Provincial Industrial Centers (PICs), People's Industrial Estates (PIEs), etc. identified consistently by LGUs and DTI. Whether the Special Economic Zones are Identified and quantified. Whether the facilities are adequate for the industries in the area.
DPWH	Whether the road networks are well developed for the proposed land uses. Whether the DPWH plans are incorporated in the CLUP Whether appropriate disaster prevention programs are identified. Whether traffic management programs are consistent with other municipalities.
DOT	Whether potential tourism sites are identified. Whether such local tourism initiatives are consistent with regional tourism master plans. If the facilities are adequate to support proposed tourism activities.
DILG	Whether the proposed projects are the actual needs of the LGUs priorities. Whether the implementing mechanisms are adequate. Notes the financial means of proposed projects. Whether the organization is capable of implementation. Whether the projects are consistent with Local Government Codes.

As observed from the table above, there are considerable policy overrides in the case of CLUP implementation. The PPDC checks whether the LGUs plans are consistent with development priorities of the province. As development priorities are set under national land use decision-making, the LGU plans fall under a higher institution and ultimately, the national land use decision-making. This is a top down approach despite the devolution of policies by the Local Government Code of 1991. The Provincial Agriculturist looks for any inconsistencies whether any urban areas are inside the agricultural and agro-industrial development, but so far a record number of land has been converted from agricultural to settlements or industrial areas. Therefore, the role of the PA has had little effect as far as land use change in the region is concerned. New housings should follow the 1992 act of Urban Development and Housing by HLRUB, which covers sound and pro-poor residential development in the 'urbanizable lands'. Yet, houses and other real estates are being built close, even inside forest protection zones such as the Mt. Makiling reserve. Upland housing in the San Cristobal watershed is also developed in zones of upland protection forests (protected forests are now degraded and in a grassland condition). Despite DENRs effort to keep developments away from the protection zones and identify environmental constraints, lands that are vital for the sustainability of the lake ecosystem continue to be occupied.

6.3 Industry based land use versus critical rice lands: A critical appraisal of policies

The ‘Medium Term Philippine Development Plan’ (1998) states that the main aim of the Calabarzon Project was for transforming the region to a highly productive agricultural sector composed of viable farm enterprises, strong production and marketing links with industry. The Calabarzon project also aimed to create a strong and competitive manufacturing sector that uses local raw materials and provides employment for the majority of the population (MTPDP, 1993). However, this would not possible without converting some of the country’s most vital food production areas to land use with non-food production purposes, such as industrial and housing developments. According to Kelly, 2003, from 1987 to 2001 considerable areas of land were converted from rice land to other uses in Southern Tagalog and central Luzon, when comparing conversions in Philippines. However, the conversion of agricultural to non-agricultural use was considerably high in Southern Tagalog. By converting a total of 15, 455 ha of land to non-agricultural use, the Calabarzon Project caused a deficit of annual rice production of approximately 74493 tons.

The Laguna de Bay region, is a major rice bowl of the Philippines. Although Laguna had less total rice output in comparison to the central Luzon plain, the

Province's rice yield per hectare of land was much higher (Hayami, 1978). The yield per hectare of net area in the Province of Laguna was 4.82 tons/ha, compared to a yield of 2.72 tons/ha for Central Luzon plain (which includes Bataan, Bualacan, Nueva Ecija, Pampanga, Terlac and Zambales). Hayami further notes that the high yields in the Province of Laguna were possible due to the location of two major think tanks of research and extension on agriculture. One being the International Rice Research Institute (IRRI) and the second, the College of Agriculture in the University of Philippines at Los Banos, Laguna. The implementation of technological innovation was reflected in high yielding varieties of rice despite the existence of similar environmental conditions in the Central Luzon Plain and Laguna de Bay area. Due to the fact that Laguna was at the forefront of Philippine rice production, Project Calabarzon was also an effort toward supporting agriculture with industries.

Table 6.4: Areas of land use change from agricultural to other uses in Philippines.

Region	Approved	Disapproved	Total
CAR	171	11	182
I. Ilocos	780	44	824
II. Cagayan Valley	404	15	419
III. Central Luzon	7,707	742	8,449
IV. Southern Tagalog	14,501	954	15,455
V. Bicol	1,625	405	2,030
VI. Western Visayas	2,337	495	2,832
VII Central Visayas	519	233	752
VIII. Eastern Visayas	355	97	452
IX. Western Mindanao	326	0	326
X. Northern Mindanao	1,566	257	1,823
XI. Southern Mindanao	4,396	1,529	5,925
XII. Central Mindanao	526	21	547
XIII. Caraga (NE Mindanao)	99	16	115
Philippines	35,314	4,818	40,132

Source: Department of Agrarian Reform. Quezon City. 2002, cited in Kelly, 2003.

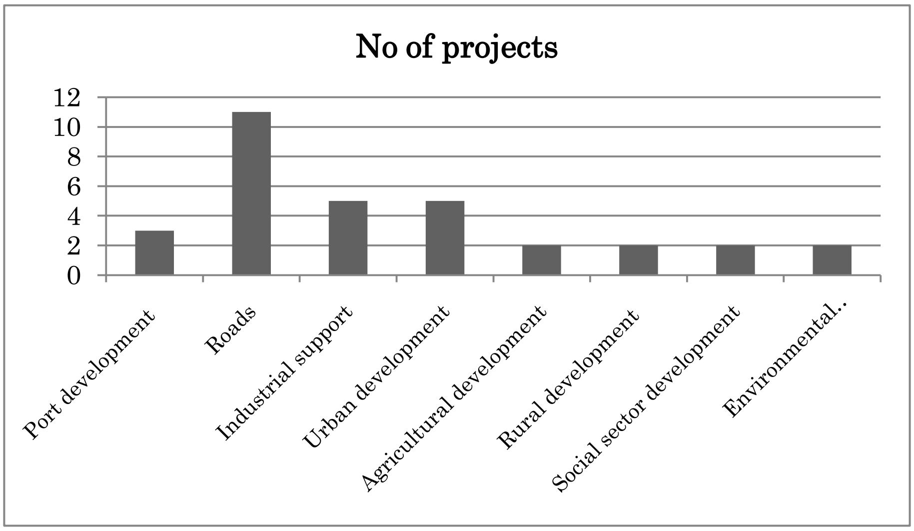
The change to an agro-industry based livelihood for the Philippine people took place in the background of an ever increasing demand of rice. Manalo, (n.d.) pointed out that imports of rice in the Philippines has increased from 257, 000 metric tons in 1995 to 2,500,000 metric tons in 2008. The average Filipino, according to Manalo, spends about 60% of his income on food, with expenditure for rice occupying about 25% of the food expenditure. Furthermore, when compared to Indonesia, Thailand, and Vietnam, from 1961 to 2007, the Philippines had a net growth in rice production area by 33.7%, while the former three countries increased their rice lands by 77.4%, 69.3% and 54% respectively (UNFAO, 2008, In Manalo, n.d.). As the spillover effect of Manila's urbanization is reflected in the Calabarzon Project, the land use has shifted from food production to more secondary and tertiary activity oriented uses. It can be said accordingly, that project Calabarzon pushed aside regional food self-sufficiency to a certain extent, and traded off more productive land use with a more consumptive type.

The Calabarzon Project stems out of two contradictory policies for regional development. The first is the Comprehensive Agrarian Reform Program, and the second involves land use alternatives to agriculture that gives higher returns in economic terms. The latter gained priority in the implementation and institutionalization of regional land use policy processes. This resulted in alteration of land use as noted in table 6.4. According to Radford and Butardo-Torribio (1996), 2000 ha out of a total 2500 ha of agricultural land has been lost in the Municipality of Sta. Rosa, where the Municipality of San Pedro lost all of its 3000 ha of agricultural land. The Municipality of Cabuyao lost 1266 ha of its 3045 ha of agricultural land to industrial land uses. The implementation of non-agricultural land uses through the Calabarzon Project resulted in an increase in the price of the land around the Laguna de Bay Basin. According to Hornilla (1995, in Radford & Butardo-Toribio, 1996) land prices increased by as much as 25 times in the provinces of Laguna and Rizal within the time period of 1985 to 2000. Increase in land price took place parallel to the decrease in available agricultural land,

and is related to a more industrial and urbanized land use in the lake basin. Furthermore, as higher prices of land are related to particular geographical conditions for better living spaces and spaces for ‘economic zones’ for industrial establishments, other geographical areas not suitable for such developments have much lower cost, or are virtually free for occupation. These places become potential dwellings for the urban (or rather, peri-urban) poor.

Table 6.5: Developmental Projects under Calabarzon Area Development (a graphical representation of the table follows below)

1. Port Development (No. of Projects: 3)	Greater Capital Region Port Study, Batangas Port Upgrading, Sangley Point Conversion
2. Roads (No. of Projects: 11)	Cavite Coastal Road, Carmona Ternate Section Road, Nasugbu Road Section, Nasugbu – Tali Road Section, Tali-Natipuhan Road Section, Extension of South Luzon Expressway, Sto. Thomas – Sambat, Sambat – San Pedro, San Pedro – Pusil, Pusil – Lipa city, Lipa city – Batangas City, Marikina – Infata
3. Industrial Support Projects (No. of Projects: 5)	Cavite Export Processing Zone (EPZA), Calaca II coal powered thermal power plant, Telecommunication improvement for urban centers, Pagbilao coal powered thermal power plant, Makban E and E Modular geothermal power plant
4. Urban Development (No. of Projects: 5)	Rizal Industrial estate, Batangas corridor development, Taal lake multipurpose water resource development, Improvement of Philippine National Railway south commuter line, Revitalization of main south main line
5. Agricultural Development (No. of Projects: 2)	Research and extension programs on intercropping and mixed farming, Upland irrigation and rural development projects in southern Luzon
6. Rural Development (No. of Projects: 2)	Jala-Jala rural development project, Rural road maintenance
7. Development of social sector (No. of Projects: 2)	Rehabilitation of Batangas Regional Hospital, Tagaytay City General Hospital
8. Environmental management (No. of Projects: 2)	Marikina watershed development management, Laguna de Bay Basin Environmental monitoring



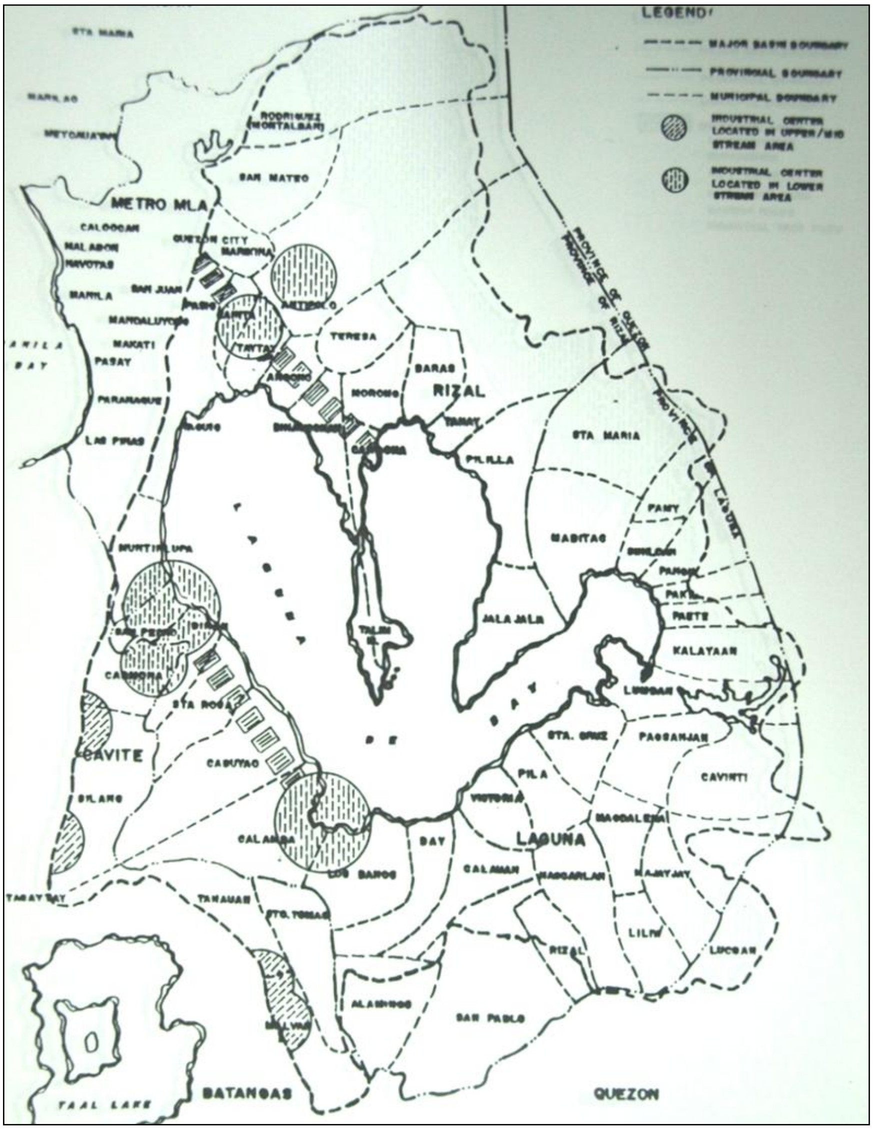


Figure 6.4: Location of industrial centers in the Laguna de Bay basin. Vertical shades represent industrial centers in the lower stream areas, whereas, oblique shades represent industrial centers in the upper stream areas. (Source: Housing and Land Use Regulatory Board, CLUP Guide Book: A Guide to Comprehensive Land Use Plan Preparation Vol.1. Quezon City. 2006.

The above table represents the main projects for Calabarzon area development. The greatest priority is given to road construction and industrial and urban development whereas management of agricultural, social and environmental resources are given least priority. One of the main aims of the Calabarzon project, as noted above, was to provide industrial growth corridors. This was evident from the importance given to roadway network development; a total of 11 such road network development projects were under Calabarzon scheme. In fact, projects related to transportation and communication was a staggering 19 (including building and betterment of roadways, improving railways, and telecommunication) out of 32 projects (see table 6.5 above). The loss of considerable tracts of rice lands due to the development scheme was supposedly compensated by producing better irrigation facilities in the upland areas and extending options for intercropping and mixed cropping techniques for more intense use of the existing agricultural land. However, rice lands in the upland areas are not as productive as in the lowland areas, even if irrigation is provided. Much of the rivers of the Laguna de Bay region are geologically in their youth stage with erosion as their priority; the soil is in-situ in general, with a mean depth of about 20 cm to 1 m. Therefore, agriculture in the uplands, with regard to substitution for the lowland industries, has the vulnerability of soil erosion, depending on the practice of tillage, work of channelized water, and types of crops cultivated.

The reason for such a change in policy toward regional industrialization with agro-industrial (or rather industrial-agricultural, as the priority has been towards industries) land use options, has to be understood in light of population growth and food production in the country. Statistics on rice production from the 1960s to the present show that rice production in the country was much lower than other neighboring Southeast Asian Countries such as Indonesia, Thailand, and Vietnam. The production of rice increased at a similar rate from 1961 to 2007 when compared with Indonesia, Thailand and Vietnam, where the four countries experienced a 4 to 5 fold increase in their total annual rice output since 1961. However, the areas under cultivation have not increased considerably in the case of Philippines when in comparison to Indonesia, Thailand and Vietnam. The areas under rice cultivation in 1961 in the Philippines were 3,179,000 ha and increased to 4,250,000 ha in 2007, whereas this figure increased from 6,857,000 ha to 12,166,000 ha in the case of Indonesia, 6,120,000 ha to 10,360,000 ha in Thailand and 4,744,000 ha to 7,305,000 ha in Vietnam during the same time period. Thailand, Vietnam, and Indonesia, therefore, increased their annual rice production by bringing a larger area under cultivation, which the Philippines could not do. The areas under rice cultivation could not be increased in the Philippines due to its archipelagic character with inherently smaller areas of land available for rice production, as well as due to lack of optimum irrigation potential in the country[44].

Table 6.6: Above: Comparison of change in total harvested areas of rice production between four select countries in Southeast Asia

Below: Annual total rice production between select countries in Southeast Asia (*Source*: UNFAO, 2008)

Year	Indonesia	Thailand	Vietnam	Philippines
1961	6857	6120	4744	3179
2007	12166	10360	7305	4250
Percent Change	77.4	69.3	54.0	33.0

Year	Indonesia	Thailand	Vietnam	Philippines
1961	12084	10150	8997	3910
2007	57049	27879	35567	16000
Times increase	4.7	2.7	4.0	4.0

With increasing population pressure, and increasing demand for imported rice (the demand for rice can be taken as an indicator for the country's food demand and excess of its carrying capacity by population pressure), the Philippines had to opt for alternative ways to feed the population and to manage the initiatives of globalization for increasing livelihood options for its people. After the end of the Marcos regime, and years of colonial influence on resource utilization, and after some of the most unsustainable resource exploitation among Southeast Asian countries, industrialization

44 For more see IRRI, http://beta.irri.org/test/j15/index.php?option=com_content&view=article&id=393&Itemid=100104

seemed to be the only option to raise the economy and livelihoods of the country. However, by this time the country had lost over 90% of its original forest cover with already degraded ecosystems in the land as well as in its inland and coastal waters. From 1965 to 1990 forest areas decreased by 5.5 million ha (Pulhin et al., 2006).

6.4 Regional food security in the Laguna de Bay region: An example of rice

The yearly average per capita rice consumption in Manila is 214 pounds or about 100 kilograms (Sarasota Herald Tribune, August 13, 1998). If we assume that the people of the LDB region consume about the same amount of rice every year as an average person in Manila, then the average rice consumption for the region can be calculated by multiplying the average yearly rice consumption by the total population in the basin, which is about 8.64 million (Santos-Borja & Nepomuceno, 2006). Therefore, the average yearly rice consumption in the Basin can be estimated at 863.9 million kilograms or about 0.87 million tones. If we divide the average annual rice consumption by the average yearly yield of rice per hectare of land, then we can calculate the area in hectares needed to feed the LDB region with only rice. Although the average yield for irrigated, non-irrigated and upland rice differs, we can still assume that the average yield per hectare per year is 3.84 tons (Manalo, n.d). Using this calculation we see that the land needed to produce only rice for the LDB region is approximately 224,974 hectares. With a watershed area of 291,000 hectares, the total available agricultural land in the basin is 198,640 ha. (Santos-Borja & Nepomuceno, 2006). It seems therefore that the region has surpassed its carrying capacity, as reflected through self-sufficiency of rice. In other words, the carrying capacity of the lands in the Laguna de Bay basin for regional food security is insufficient. This most likely occurred due to increase in population and conversion of agricultural lands to non-agricultural use.

The economist's simple answer to the argument of carrying capacity is technological advancement, which makes resource use more efficient and substitutes manufactured capital for natural capital and interregional trade, offsetting regional bottlenecks for growth (Rees & Wackernagel, 1994). However, a region that exceeds its carrying capacity extends its footprint to other areas' carrying capacity, affecting newer areas in this process. Efficient technologies can increase the cost of land through input of various technological facilities and amenities, leaving little scope for conserving particular spaces of ecological significance. Surpassing the regional carrying capacity for rice production means that vital ecosystems within the region, or landscapes that are not directly related to the production of rice and other crop production, also become endangered. These landscapes include brush-lands, grasslands and marshes along the land water interface regions of the lake and its tributaries, which are vital for maintaining the quality of livelihood and health of the ecosystem of the region. How these landscapes are undergoing changes in the San Cristobal micro watershed has been analyzed in chapter 4. The problems of solid waste, water pollution and degradation of forestlands are among the top priority issues for environmental deterioration in the Laguna de bay basin. The conversion of lands is a matter of great concern as well, and in fact disposal of solid wastes, denudation of forests, and pollution of waters are interwoven with the issue of land conversion in the basin. The most recent changes in the landscape in the vicinity of the watershed are analyzed through interviews and content analysis as described below.

6.5 Some recent changes in the land use of San Cristobal Watershed and its vicinity

The municipality of Calamba is in a peculiar geographical position. It is the 5th municipality after the National Capital Region. It has a wide shoreline with three rivers draining through it: the Cabuyao in the north, the San Cristobal, and the San Juan. Of these the San Cristobal basin shares most of the municipal area. Among the western shore municipalities, Calamba is the southernmost municipality from Manila, and has experienced a wave of urbanization. In Calamba, the San Cristobal River Basin has 75 industrial establishments referred to as ‘the San Cristobal Generators’. These are divided into five categories as shown in table 6.7 below.

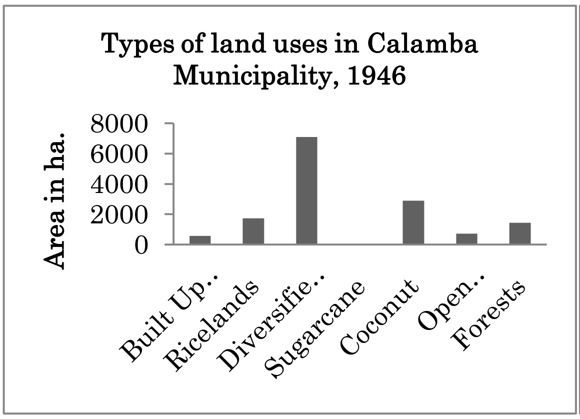
Table 6.7: San Cristobal Generators

Locations of San Cristobal generators	**No. of Industries**
Carmel Ray I Locators	46
Canlubang Industrial Estate	8
Hi-Lon Compound	5
Silangan Industrial Estate	13
CPIP	3
Total	**75**

The Housing and Land Use Regulatory board keeps track of quantified land use changes per municipality under the Comprehensive Development Plan. The latest version of the plan used in the fieldwork for this study, was available for the period 1980 to 2000. This unpublished report has an account of the land use changes in Calamba Municipality over a span of 36 years from 1946. The data is represented below.

Table 6.8: Change in land use over a span of 36 years in the municipality of Calamba in the Province of Laguna. Notable increase of built up areas has replaced grasslands and forests. (*Source*: Unpublished data, Housing and Land Use Regulatory Board, Comprehensive Development Plan, 1980-2000).

Types of Land Uses	**Area in hectares, 1946**	**Percentage**	**Area In hectares, 1980**	**Percentage**
Built Up Area	579	4	5234	36.15
Rice lands	1736	12	2003	13.83
Diversified Crops	7095	49	-	-
Sugarcane	1	-	5555	38.36
Coconut	2896	20	1294	8.94
Open Grassland	724	5	81	0.56
Forests	1448	10	313	2.16
Total	**14480**	**100**	**14480**	**100**



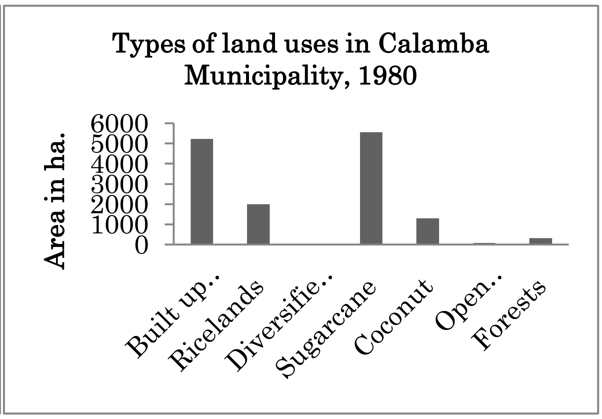


Figure 6.5: Change in land use over a span of 36 years in the municipality of Calamba.

Land use in the municipality as proposed in the 1990s, should be referred to in order to better understand and analyze the above data.

Table 6.9: Land use as proposed in 1990. (*Source*: Unpublished data, Housing and Land Use Regulatory Board, Comprehensive Development Plan, 1980-2000)

Functional use	**Area in hectares**
Built up	**5207.42**
Residential	3417.19
Commercial	450.58
Institutional	160.93
Industrial	912.83
Open space	265.89
Non-built up	**9272.58**
Rice land	1794.24
Sugarcane	5426.31
Fishpond	175.26
Forest	1876.77
Total	**14480**

In 1980 more than one third of the total area of the Calamba municipality was occupied by urban spaces. It should be noted here that the total population of the municipality at this time was 121,175 (NSO, 1980). It was estimated that about 0.8 hectares of land was needed per 1000 people (HLURB, 1980), requiring about 96 hectares of land for residential purposes. In 1948, the municipality had a population of 36,586, requiring about 30 hectares of space for residential purposes (following present space requirements for residential purposes). However, actual land survey data prepared by the HLURB for the quantification of urbanized spaces in the municipality shows that in fact that 910 hectares were used for the residential purposes, 108 hectares for institutional purposes, and 179 hectares for industrial purposes, totaling 1,197 hectares in the category of built up spaces. This shows a significant gap between the estimated and actual space requirements for urban land use in the municipality, as the latter is more than 10 times the estimated area. The area used for built up spaces during 1948 can be estimated from the relationship between population and data on residential areas. In 1980 the population of Calamba was 121,175[45], which was 3.3 times the 1948 population of 36,586. Therefore, the amount of residential areas should also have grown by at least 3.3 times, if not more. Following this estimation, the residential areas required in 1948 should equal approximately 276 hectares.

A land use survey, conducted in every barangay in 1980, put the total area under residential areas as 910 hectares, with 179 hectares under industrial land use and 108 hectares under institutional land use. Thus the main land use categories that augmented built up areas[46] according to the 1980 survey, was 1197 hectares, not anywhere near the 5207 hectares calculated in the CDP (see Table 6.9). This shows an estimated space of 0.80 hectares of land for a population of 1000, an estimate much too conservative to be realized on ground. The increasing consumption of space related to

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[45] The HLURB estimates the total population of Calamba in 1980 as 119,766. The NSO measures it as 121,175; population statistics from NSO are used in this study.

[46] Main Land Use categories that indicate built up areas are residential, commercial, institutional, industrial areas and built up open spaces (see table 6.9 for details).

change in resource consumption patterns should also be taken into account. From 1946-48, the total built up area was 19 times that of the estimated required space for the population. In the year 1980 this statistic stood at a staggering 55 times its estimation (as the total area under built up spaces was 5207 ha during 1980). This greater size of urbanized spaces cannot be correlated to the possible effects of the Calabarzon project as the master plan started in 1989.

A rough picture can be drawn about how changes in land use took place in the municipality of Calamba, from the analysis of land use maps prepared by the Municipal Planning and Development Office in 1980 and 2010 respectively. The implementation of the Calabarzon project started from 1989 when the master plan was created for grounding the concept of regional industrialization around the Laguna de Bay Basin. The 1980s was the seeding period of such an approach and the 1980 land use map shows considerable areas under heavy and light industries. This is an indication that grounding of the Calabarzon project took place even before the master plan was created. A particularly interesting case is the distribution of forestlands. In the 1980s there were two forested areas in the municipality. One was the Mt. Makilling reserve and the second, the uplands of Tagaytay. In the later stages, shown in the 2010 map, the forest lands in the Tagaytay highlands had its status changed from 'Forest Conservation Zone' to ‘Upland Conservation Area’. This is because simply, there are no more notable forest tracts in the municipality or in the uplands of the San Cristobal River. The fact is that a defined upland conservation area in a watershed has a negligible and fragmented vegetation cover, indicating that conservation in these areas is more in pen and paper than being actually present on the ground. The failure to conserve land took place under conversions towards an agro-industrial development pathway that is more industrial than agrocultural.

During fieldwork for this study, different opinions were gathered when the researcher asked about the forests that were once there in the upland of San Cristobal River. Some locals mentioned a forest owned by the DENR to the southwest of the barangay Kabangaan. On questioning the approximate area of the forest, some approximated 10 hectares, with large grasslands surrounding the area, with continued illegal logging and charcoal making occurring within. Some said the forests are even bigger - around 50 hectares or so. At the other end of the scale, there were even those who could not identify any notable forest tract in the area concerned.

First, the existence of grasslands means that proper forests did exist in the region and gradually gave way to the ongoing peri-urbanization of Tartaria, Lumil and

Kabangaan. Of these, Tartaria increased its population from 2210 to 48,564 in 2010 (CLUP report of Silang). The space and resource requirements for such an area just about 3 to 4 km away from the forest mean that the forested zones were under pressure from growth needs for the settled. Second, what remained around the 1980s and afterwards looks like an area similar to the degraded outskirts of Mt. Makiling reserve - brush-lands and stunted trees with housing lots in between. This brush-land in upper San Cristobal watershed is being reduced by increasing space requirements of nearby villages. Third, a forest with an area of just 10 hectares is not a forest, and neither is a 50 hectare land area. And if activities like charcoal-making and logging are present in the landscape, even if in their most negligible forms, this will make the area free of forest in a matter of few years. Low density residential areas accompanying the forested areas in the uplands slowly reduced and eventually ate away the remaining forests.

It is possible to get an idea of the general land use change in the Calamba Municipality from land use maps of 1980 and 2010 (see Figure 6.6 and 6.7). The two land use maps suggest the amount of agricultural land that has been converted to 'growth management areas' composed of residences and light industries. In 1946, 1738 hectares were under rice cultivation, which grew to 2003 hectares in 1980 then decreased again to 1794 hectares in 1990 (CDP, 2000). Croplands consisting of coconut and banana in the upper San Cristobal watershed are still being cleared under CARP procedures for non-agricultural land development activities. Such conversion practices are against the farmers will, sometimes ending in violent conflicts. In May 2010, after completion of fieldwork in the San Cristobal Watershed, conflict arose between the farmers of the Sitio Buntog in Barangay Canlubang, the Philippine National Police (PNP) and Special Weapons and Tactics Team (SWAT). Several were injured in the incident. The best way to describe this land conversion conflict is to quote the news which described it as follows:

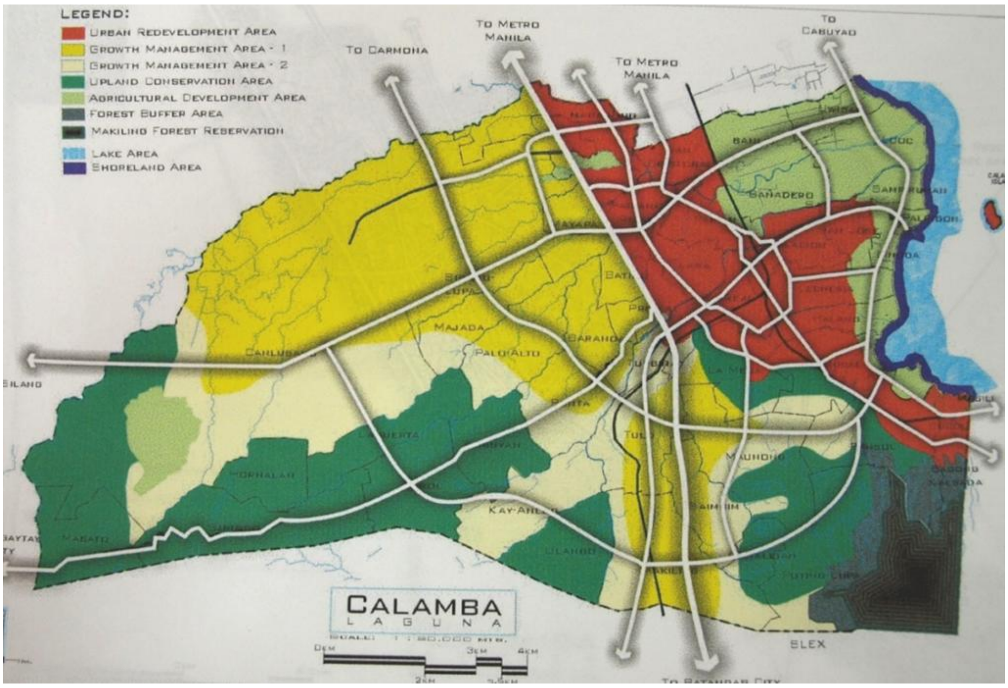
> …He (Dan Calvo of the Laguna Estate Development Corporation) was very hostile and was cursing the farmers. He refused to negotiate with us. The farmers presented legal documents but Calvo tore-up the papers. The farmers refused to leave and that's when the police and security guards started using force…..(T)he local farmers have put-up the protest-campout last April to stop any attempts by the Yulos to enforce the conversion of the more than 7,000 hectare hacienda land into a high-end subdivision. He said the farmers have a pending appeal in court against the land conversion. According to Eric Laurel, leader of the local peasant organization Samahan ng mga Mamamayan ng Buntog, their land, despite being productive, has been approved for land conversion under the Comprehensive Agrarian Reform Program (CARP). (ISKRA, 2010).

The disputed area has about 7,000 hectares of prime coconut plantations, which will be taken for the construction of real estate by the Laguna State Development Corporation. These forceful conversions of land are possible due to gaps in land use policy structure.

In addition to the forceful conversion of prime agricultural lands, land conversions associated with the development of upland residential subdivisions are often related with indiscriminate burnings of open grassland and brush-lands. This type of land use pattern of burning and subsequent development of urban land, destroys natural vegetation succession rapidly in the peri-urban areas as noted by McGranahan & Satterthwaite.[47] It is the destruction of the landscapes of recovery. Burnings to clear land for human use is a spontaneous process active in the Philippines for as long as humans inhabited its islands. However, under present circumstances they become more destructive when carried out with the associated policies for urbanized use. The consequences as well as characteristics of such land conversions can be understood from the pictures provided below.

[47] See chapter 5 section 1.

Figure 6.6: Land use map of Calamba in 1980. (Source: Unpublished data from Municipal Planning and Development Office, Calamba).



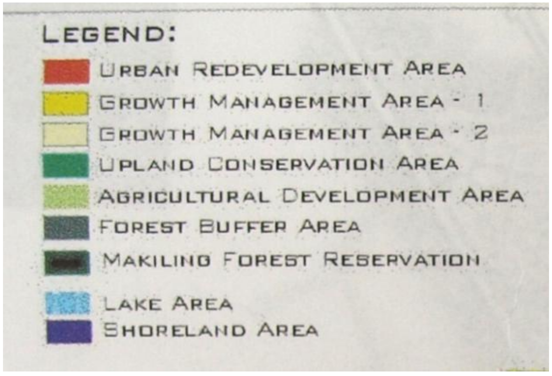


Figure 6.7: Land use in Calamba in 2010. (Source: Municipal Planning and Development office, Calamba).

Figure 6.8: Large tracts of land lay idle for development. These lands invite erection of residential areas. (Photograph by the researcher March 12, 2010)

Figure 6.9: Lands available for erection of private apartments. An example of the single family apartments that will dominate the landscape in these areas can be seen on the advertisement board of the electric post. The advertisement says the name of the property will be 'Richland Hills'. The land does not look rich, but is reserved for the rich. The area is made to look clean through human efforts to keep the area clean of garbage. (Photograph by the researcher March 12, 2010)

Figure 6.10: The lands are cleared by using fire, which sweeps through the grasslands in the dry season. A portion of the Nuvali land that is yet to be developed. (Photograph by the researcher March 12, 2010)

Figure 6.11: A section of landscape burned for the development of Nuvali Land. When a landscape is subjected to burning for creating ‘development zones’, it is burnt irrespective of its general natural cover. Here, woody vegetation is burnt along with grasslands. (Photograph by the researcher March 12, 2010)

Figure 6.12: A parcel of land just after burning for developmental purposes. (Photograph by the researcher March 12, 2010)

Figure 6.13: Landscapes outside the ‘to be posh’ areas such as the above, are not separated by railings are strewn with garbage. In the rainy season, these are carried by sheet erosion to the water channels and ultimately to the lake. (Photograph by the researcher March 12, 2010)

Figure 6.14: Areas of burning (darker patches) and alteration of the buffer zones in the Nuvali land along both sides of Diezmo River, a tributary of the San Cristobal. (Courtesy Google Earth, 2011)

Figure 6.15: Pineapple orchards with coconut plantations. (Photograph by the researcher March 12, 2010)

Figure 6.16: More intensive agricultural land use. Pineapple, coconut and banana are cultivated together. (Photograph by the researcher March 12, 2010)

Figure 6.17: Plantation of pineapples with coconut and banana in the in the highlands. (Photograph by the researcher March 12, 2010)

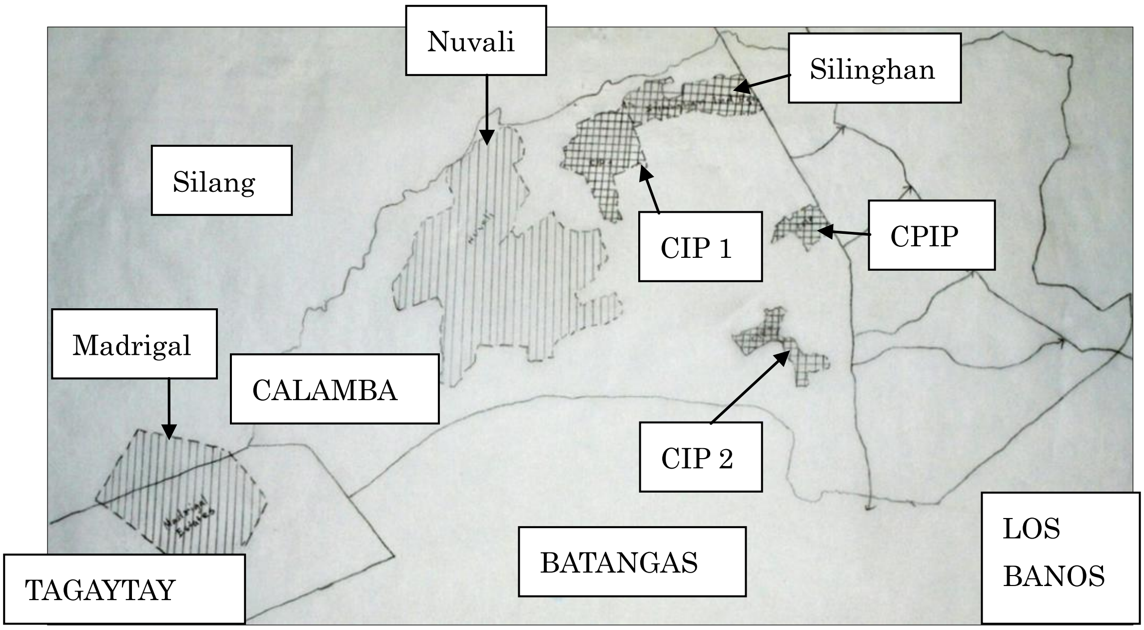


Figure 6.18: The diagram of Calamba Municipality with three of its major industrial estates: Carmel Ray Industrial Park (CIP) 1 and 2, Silanghan, and Calamba Premiere Industrial Park (CPIP). Two notable community residential areas are the Nuvali, owned by Ayala Land, Inc., and Madrigal Estates. Note the land area the two residential private estates hold compared to the industrial land. At Nuvali, large tracts have already been cleared for residential developments, whereas Madrigal land areas are still covered with brush.

Figure 6.19: A schematic diagram of the proposed residential lots in the Nuvali land in the San Cristobal Watershed. (Source: Wikimapia). The close proximity of the residential areas increases the density of built up areas along with simple beautification of nature for visual pleasure. The Ayalas have profound experience in converting land in Manila (Makati City) with their space conscious plan, which converted the grasslands of Makati City in the 1940s into the urban sprawl it is today. Nuvali shows a transfer of urban land development ideas from Manila toward the peri-urban areas of San Cristobal Watershed. The Nuvali land is further subdivided into various residential communities such as Venare (74 ha.), Montecito (60 ha.), and Trevela (60 ha.). The area also hosts Xavier School and Avida estate (26 ha.).

Apart from the land conversions, questions can be raised about the sustainability of agricultural practices in the watershed as well. This applies to extensive pineapple cultivations in the upper reaches of the watershed. There are some instances where it has been discovered through pilot projects and mixed farming practices, that cultivation of pineapple in the uplands can reduce soil erosion. The Australian Center for International Agricultural Research (ACIAR) in Bohol suggests that cultivation of pineapple can reduce soil erosion (Taylor, 2009). The project cultivates a mix of multiple crops like cowpeas, eggplants, squash, sweet pepper and pineapple for reducing soil erosion. However, others have noted that cultivation of pineapple can actually induce soil erosion. Maita et al. (2002) has compared the infiltration rates between forestlands and pineapple and cassava fields. Where the forestlands have an infiltration rate of 44-160 mm/hr, pineapple and cassava fields have an infiltration rate of 5-39 mm/hr. This low infiltration rate, coupled with heavy rainfall, can generate soil erosion of 69 to 163 t/ha/yr. Onaga & Miyagi's (1980) study suggests that the potential of soil erosion varies with the age of the pineapple plants, who take about 50 months before their roots can have sufficient soil compaction strength. Before this age, however, pineapples have much lower soil holding capacity than grass varieties[48]. Based on the estimation of soil loss after the study of Maita et al., it can be assumed that a significant part of top soil from the pineapple orchards of Calamba and Silang are lost, which may range from 60 to 160 t/ha/yr. As rivers in these parts of the country are very young in geologic time scale and are in their youth stage, their main work is to cut through the newly uplifted terrains of Pliocene and Pleistocene volcanisms[49] in the upper reaches of the San Cristobal and Cabuyao watersheds. Second, the soils in the highland regions in

[48] in Onaga and Miyagi's study, Rhodes and napier grasses were addressed
[49] see chapter 2 for details

the San Cristobal and Cabuyao Rivers are in situ in character, and are generally 20 cm to 3 meters in depth. Therefore, factors of sheet and gully erosion can take place at a higher rate than in the lowland soils. The condition of the San Cristobal River and erosional characteristics of channel degradation can be understood from the condition of the river in its uplands.

> When questions were asked to the locals (city planner at Municipal Planning Office in Calamba, barangay captain at Tartaria, and a local farmer in the Tartaria village) about the condition of the San Cristobal River, most said that the river cannot be seen and reached easily on foot as it is hidden beneath very steep and erosive slopes. It is dangerous to go near the river channel due to frequent slumping of soil, and the channel at places is silted. The lands close to the river channel are grassy and one needs a bolo[50] to go near the river channel.

The river is generally non-approachable due to the morphological characteristics of its watershed in the upland regions. Responses about deposition in the upland reaches of the river show that the process of deposition takes place in the zones of erosion. This refers to an increasing load of the river, which it is unable to carry in its present hydraulic regime.[51] A river in its natural condition, does not deposit its

[50] A *bolo* is a Philippine long knife used to cut through jungles and brushes.
[51] The deposition are carried during extreme rainfall toward the downstream reaches and

sediment load in the upper reaches, thus a deposition upstream reflects erosion of catchment surfaces (Morisawa 1985; Thomas, 1987; Whitelow & Gregory, 1989; Brookes, 1994). The deposition in the upper reaches means that the river is shifted away from its natural state of equilibrium by human induced land changes. The river will tend to absorb the effects of such land changes in geologic time (Mackin, 1948[52]) (for more see Chapter 1). In the present case, this absorption of environmental change is reflected through the erosion of the upper reaches. Increasing erosion will wear off the in-bed deposition in later stages. This will lead to deposition in down-streams and into its base level of erosion represented by the Laguna Lake, as the river tries to reach its new state of equilibrium.

ultimately to the lake.

[52] See reference of Chapter 1.

Figure 6.20: In-channel deposition (arrows) inside a well vegetated river reaches the upstream of the Dismo River, a tributary of the San Cristobal, and reflects the possibility of erosion of catchment surfaces. (Courtesy Google Earth 2011)

In another instance, when asked specifically about the changes in the San Cristobal River to a local resident, now working for the Municipal Planning and Development Office in Calamba Municipality, she said she has had close connection with the river since childhood. However, in those days, the river was a lot different from now. The river area was a more pleasant one, ideal for an afternoon tour the interviewee's family used to take. There were fishermen in the river's downstream, close to the lake. Additionally, the water level of the river was much higher than today and a brisk current could be seen flowing through the channel throughout the year.

Although the flow, depth, and volume of a river may vary according to a child and an adult (a child may see the same river as bigger and more powerful than when as an adult), the fact that fisheries thrived at the downstream of San Cristobal, and that it was an ideal place for recreation, is quite contrasting to the appearance of the river at present. Near the lake, the color of the water is black and in the lean periods the flow cannot be detected with bare eyes unless a buoyant material like a table tennis ball is thrown in the river. In the wet season the flow of water is much more voluminous and fast. This indicates that base flow has been altered significantly in the last 30 years.

Figure 6.21: Alteration of the buffer zones along the lower reach of the San Cristobal peri-urban sprawls. The vegetated in channel deposition (arrows) reflect the loss of stream competency and

capacity coupled by the shallowing of the channel (Courtesy: Goole Earth, 2011)

Table 6.10: Chief Pollutants and their highest levels in the San Cristobal River, as measured by LLDA (1996 – 2008).

BOD	170	land degradation, fertilizer runoffs
DO	0.05	land degradation, fertilizer runoffs
TSS	260	eroded soil
T. Coli	1600000000	animal farms, households
NO3	1.3	fertilizer runoff
PO4	4.9	fertilizer runoff

6.5.1 Effluents and biophysical health of San Cristobal and Laguna: vital statistics of a river and the lake

The Laguna de Bay Development Authority is said to have carried out successful implementation of the Environmental User Fee System or EUFS, which can be an example of implementing the notion of the Polluter Pays Principle (PPP). In general from 1997 to 2008 the average biochemical oxygen demand decreased from 24. 45 to 1.98 per operating firm, while the number of registered firms increased from 221 in 1997 to 2401 in 2008. The EUFS caused 219 firms to close since 1997 and out of 2401 registered firms, 2182 are on operation today. The total BOD loadings per year, measured in the firm effluents, have decreased from 5403.29 in 1997 to 4319.60 in 2008.

Table 6.11: The status of industries in the Laguna de Bay Basin in relation to the EUFS (inside the jurisdictional area of LLDA), and the associated BOD loadings in the effluents.

Year	No. of registered firms	No. of closed firms	No. of operating firms	Total BOD loading (MT)/yr.	Average BOD loading/operating firm
1997	221	0	221	5403.29	24.45
1998	254	2	252	4431.71	17.59
1999	427	5	422	1790.03	4.24
2000	623	19	604	2309.08	3.82
2001	731	41	690	1686.53	2.44
2002	907	72	835	790.85	0.95
2003	1065	118	947	827.55	0.87
2004	1387	130	1257	1585.62	1.26
2005	1709	138	1571	1828.68	1.16
2006	1943	149	1794	2541.38	1.42
2007	2183	200	1983	5202.01	2.62
2008	2401	219	2182	4319.60	1.98

A considerable portion of effluents are said to be discharged during days of heavy rainfall in the wet season. As the San Cristobal does not carry a large volume of water in its channels, its waters turn blackish for some hours and then change to a muddy color. The darker color is believed to come from the high level of pollution through the streams for a certain period of time. It is believed that some industries flush excessive pollution to nearby water channels to keep themselves from the burden of paying. If this fact is compared against the decreases in BOD loadings in the EUFS, questions arise about the success of EUFS in real terms.

The Philippines has a wet season that spans for half the year, accompanied by typhoons. During this time, especially in the days of typhoon downpours, the current that flows through the river systems is phenomenal. The lake level rises to such extent that its area increases by as much as 20,000-30,000 hectares during strong and successive typhoons. The case of releasing industrial effluents in the wet season can be a considerable ecological hazard for water environments of the Laguna de Bay Basin, especially for the lake itself. This is because much of the western tributaries of the lake, San Cristobal, Cabuyao, Binan, and San Pedro, have small watersheds and little vegetation cover. Therefore the runoff is fast and efficient in carrying water to the lake quickly. As noted earlier in this work, the lake water retention period of 8 months is a function of hydrological regime of the Manila Bay and the 24 tributaries (see Chapter 2 for details). Effluents discharged by tributaries load the lake with additional nutrients for this time period. Additionally, as the rainy season lasts for half the year (which is shorter than the lake water retention period), the pollution loadings in the lake overlap the annual replacement cycle of the lake, reflecting net increase in BOD loadings with time.

Furthermore, the number of industries in the lake’s watershed has increased considerably. In the 1970s there were just about 400 industrial plants with a population of 1 million located in the lake basin. In 1990 there were about 1000 industries in the basin with a population of 5 million (Santiago, 1993), which increased to more than 2000 (as of 2008) with a 6.5 million population. Therefore, effluents discharged into the runoff systems in the lake's watershed have increased in absolute terms.

What are some of the principal sources of water pollution in the downstream reaches of the San Cristobal in addition to the industries? The answer is not much different than the case of lakeshore regions. The San Cristobal's urbanized river shores are increasingly being occupied by squatters who generate the bulk of the non-point source pollution, consisting of solid wastes and untreated household sewages thrown directly into the river. These households, in general do not have jobs and many are migrants from faraway and nearby islands of Mindoro, Marinduque, Palawan and Romblon. They consist some of the poorest households in the region. An official of the Calamba City office told of increasing crimes, of which most of cases of theft and snatching are done by the immigrants who occupy the shore-land areas of the river[53].

[53] It should be noted that the people who move out from the other islands to live in the lower reaches of the San Cristobal do not leave their land for the social crimes in which they may later find themselves involvd. The island of Palawan, among these four islands, is covered with the last stretch of tropical forests left in the Philippines, and it is often called the 'last frontier' of the country. The fact that even a well intact ecosystem such as Palawan produces refugees means

As of 2003 to 2005, the Municipality of Calamba produced 98,000 jobs. Of these 98,000 jobs 54,000 were related to the service sector, 37,000 were related to industries, and just 7,000 related to agriculture. The increase in jobs took place through non-agricultural land use, as agricultural practices are diminishing with time in the municipality. There is no doubt that land-use systems that have moved away from agriculture have produced more jobs. In 2005 the population of Calamba was 367,620 (Actual and Projected Population by Barangay: City of Calamba. Year 2000-2015). Of this population 189, 000 were workable adults of over 15 years of age. It should be noted that 15 years is not working age, but rather the available population data categorized the age range of 15-64 years old together. This gives a rough idea of unemployment in 2005. Using the example of the Municipality of Cabuyao[54], which had a population of 161,283 in 2006; of this 9.8% (15,806) comprised of those 15 to 19 years old. Using this example as standard in the case of Calamba, we can assume that about 10% of the total population is comprised of those in the 15 to 19 years age group, and come closer to the estimated population of those who are employed or employable. In Calamba's case we can thus assume that about 36,762 people were in the 15 to 19

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that these islands are also running out of resources and the footprints of land use in these lands are reflected in migration toward urban and peri-urban areas.

[54] Population and employment statistics have been taken from Cabuyao because of availability of systematic data for these two parameters.

years age group. As of 2005, about 152, 238 people were of thise age group in Calamba. Among this population, about 54,238 remained unemployed, with an unemployment rate of 35.6%, which is higher than the 2003 rate of 20.7% (CLUP, Calamba, n.d). Although from 2003 to 2005 Calamba produced many jobs, unemployment rose in the region in absolute terms. Many of the unemployed occupy the ecologically vulnerable zones of the river shores that are also said to be involved in social vices. From the standpoint of migration characteristics, it can be said that the peri-urban areas grow with the carrying in-capacity of the surrounding areas. If urbanization grows in such a way, then urban growth cannot be called a sustainable one.

The residential areas in upland and in lowland have different contribution as far as pollution of the river and other runoff systems is concerned. The Barangay Captain in the village of Tartaria, Lumil in the upland of San Cristobal, and the tricycle owners and local shopkeepers in the village of Looc were asked about pollution in the small water channels, both natural and man-made, in their villages. The inquiry was made about the smaller water channels because they are related to the San Cristobal. The man made channels including irrigation canals, storm water outlets and residential sewages, also contribute to the San Cristobal watershed and are related to the main trunk stream to the lake.[55]

The villagers reported that the smaller channels are often clogged with solid waste mainly consisting plastic wrappers, which are most numerous in the rainy season and extreme rainfall events. This chokes the natural outlet of water and causes floods locally. The irrigation canals, on the other hand, are reported to have in-channel deposition with construction materials and eroded soils that reduce the efficient flow of water to agricultural fields. Irrigation canals are also used for throwing garbage from the residential areas.

More than the condition of these smaller channels, it is important to note the correlation of rainfall events and the increase in solid wastes in the smaller channels. As noted earlier, the climate of the Philippines is greatly influenced by the typhoon season that lasts for half the year. The typhoons give rise to deluges with great erosive power. In the rainy season many areas that were dry before, come under sheet erosion. The clogging of the smaller water channels in the rainy season refers to the fact that many areas in their watersheds are strewn with garbage, flowing from sheet erosion during extreme rainfall, The in-channel deposition in irrigation canals indicate that erosion of

[55] When toured through the upland villages, a number of natural drainage channels have been observed that are partly concretized near the residential areas and roads to prevent erosion. These consist of numerous tributary runoffs that the young San Cristobal River has, and are easily distinguishable from the relatively deep and differentially eroded channels they have. They are quite contrasting from the urbanized sewages or irrigation canals.

catchment surfaces is directly related to construction activities associated with stages of urbanization.

One of the principal tasks of the integrated water resource management process is balancing development for resource sustainability. The state of surface water resources in the San Cristobal watershed has deteriorated considerably in the last few decades. This deterioration is greatly influenced by regional development policies that put emphasis on economic growth rather than considering the watershed as a bio-physical base on which development is planned. This in theoretical terms is known as internalizing collective human actions in the policy processes that are unsustainable, which reduces resilience in the planning process. The policies can be divided into two types: policies that guide regional development (viz. the Calabarzon project) and policies that support alteration of rural landscapes to urban and peri-urban ones (viz. Presidential Decree 399). These policies act together with spontaneous human activities (ancient practices of burning vegetation for land or making of trail systems around the Laguna Lake's shore-lands, etc.) to alter the ecological base of the landscapes leading toward a more urbanized use. If we assume the watershed of San Cristobal as a social-ecological system (SES), then its deterioration is brought about by the interplay of these particular policies and particular spontaneous human actions. The associated land use changes bring a deterioration of overall bio-physical quality of the watersheds, thus failing to provide the base on which to support the practice of IWRM. As a result, the micro-watersheds that have undergone these actions have been changed to major polluters of the lake.

Changes in watershed land use have deteriorated the landscapes of natural regeneration, and were followed by peri-urbanization. This change can be divided into three types. First is the indiscriminate alteration of the upland brush-lands, a process that is still present. The consequence of this change is reflected in the increased erosion of catchment surfaces with in-channel deposition in the upper reaches. The second type of change is the deterioration of the San Cristobal's waters given by chemical characteristics. This means pollution of the river by mid course industrial and residential land uses, which have reduced the biological activities of the stream to a minimum. The third type of change is the alteration of the aquatic vegetation zone at the shore-lands of the lake, which have reduced the bio-physical relation between the lake and the river. As a result of these changes, balancing regional development with resource sustainability - the core of IWRM thinking and practice - was never possible in the watershed. With deteriorated bio-physical attributes, the San Cristobal has changed to an environmental system that works against the ecosystem health of Laguna Lake. This has not made the social decision system of basin governance to play the role of an adaptive mechanism for sustained resource use so far.

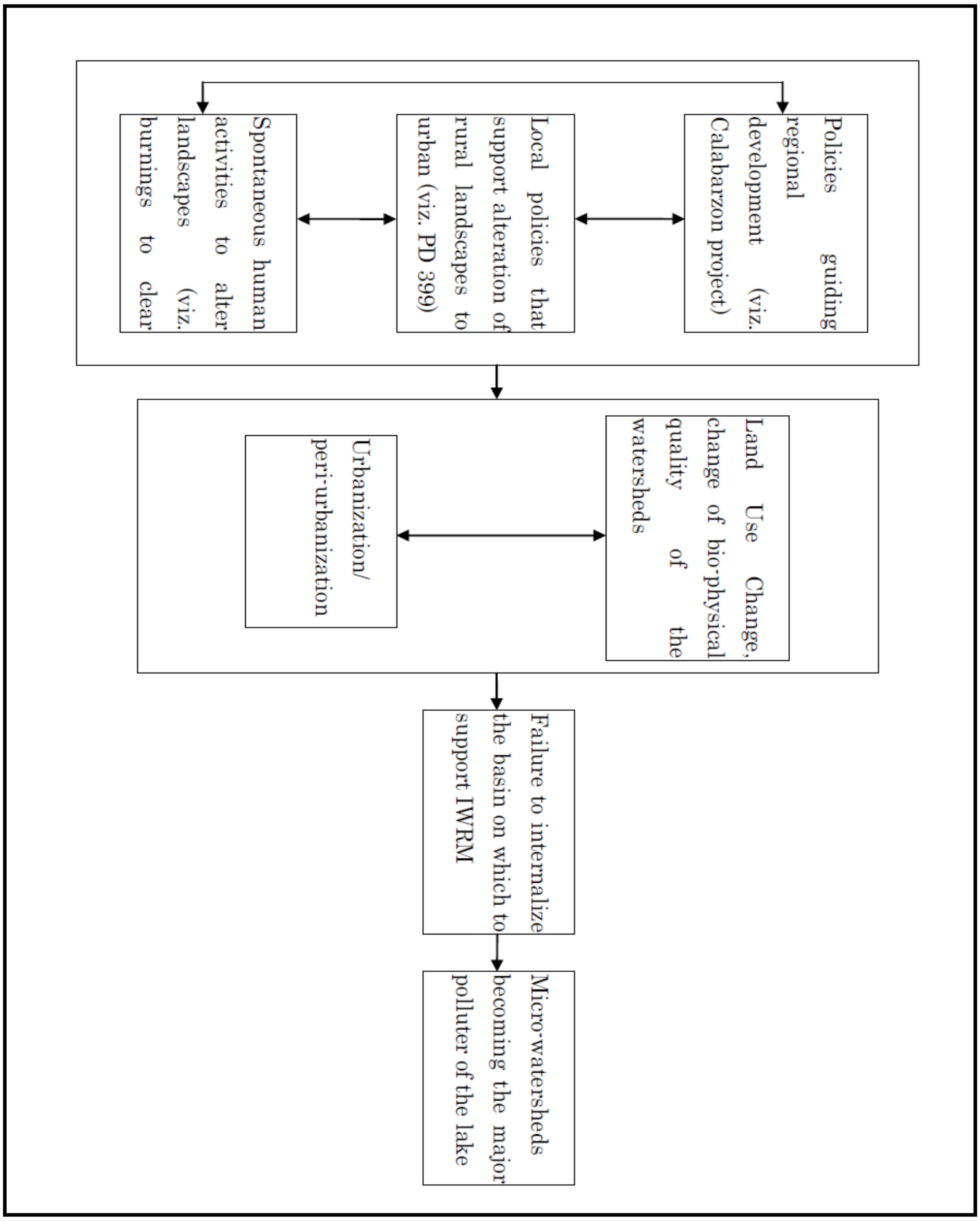


Figure 6.22: Key mechanisms of land use change in the San Cristobal Watershed.

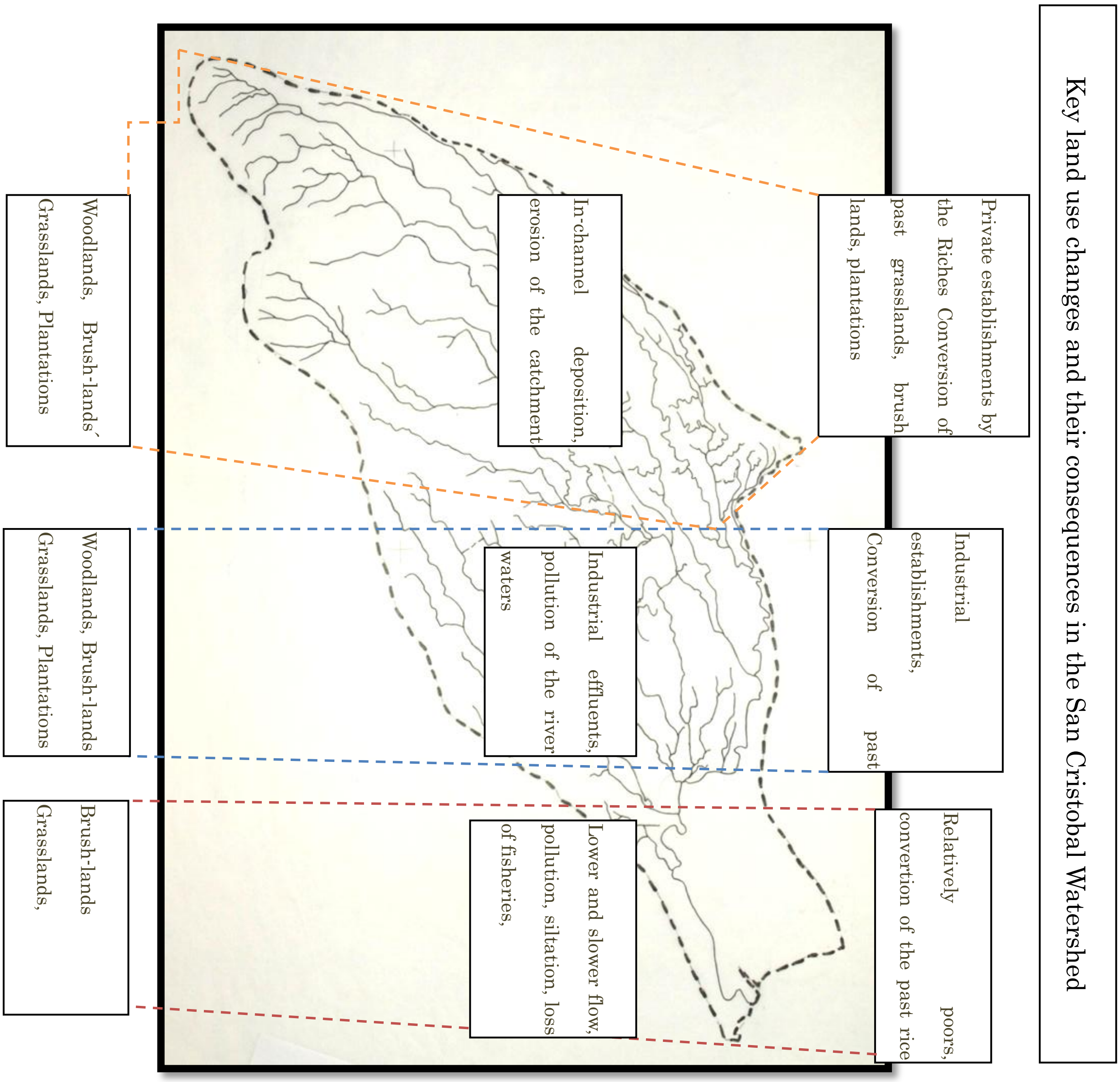
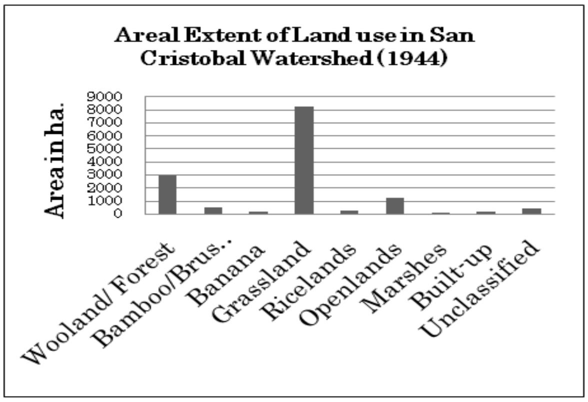


Figure 6.23: Key Human activities in the San Cristobal Watershed with the altered land uses.

1940

Independence of the Philippines



1950

Push for agricultural efficiency, security for tenant farmers

1960

Abolition of shared tenancy, land reform for rice and corn growers, creation of LLDA (1966)

1970

1980

Aquino's comprehensive rural development and agrarian reform, CARP, CARL, Calabarzon Project

1990

Acceleration and acquisition of agriculture, pasture and forest lands for agriculture only, presidential task force for water resource development

2000

Consolidation of small farms for to medium and large scale for attracting long term capital

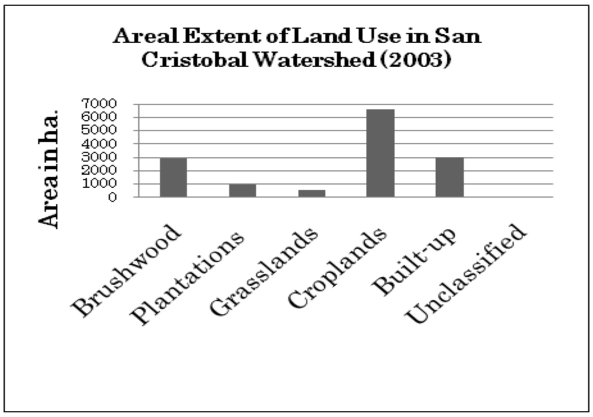


Figure 6.24: Key policy changes in the Laguna de Bay environments with corresponding land use changes (before and after scenario) in the San Cristobal Watershed: An effect of the regional to the local.

6.7 Summary

The industrialization policies in Rizal and Laguna Provinces created gaps and overlaps with existing environmental policies in the lake region. The changes in land use started from the decrease in the prime agricultural lands around the lake, producing land use types that are more consumptive than productive. The changes moved to more upland regions of the watersheds with rapid conversions of forests and landscapes under recovery. These changes made the Laguna de Bay region surpass the carrying capacity of its land (measured through the production of rice). The changes also brought deterioration of biologically productive shore-land regions. Moreover, changes in land use have been approved with flawed estimates of required living spaces for an ever increasing population. Apart from the conversion of agricultural lands to non-agricultural use, the land prices have also skyrocketed to as high as 25 fold in the past 15 years, a result of increasing privatized infrastructure facilities and amenities. This has pushed the relatively poor of the populace to the ecologically vulnerable zones, such as the land-water interface regions. As space requirements for the urban development increase, with no more forest cover available, in the year 1980, the areas of upland forest conservation lost their status. Meaning, these areas are still conserved, but without any forests. Conservation areas in an upland erosive watershed with negligible forest cover cannot be called a conservation area. This reflects that conservation in the area is on paper only rather than on the ground.

Recent changes in the hydrologic regime of the San Cristobal's watershed are caused by agricultural and urban land uses. Extensive fields of pineapple are chosen for vital cash crops in the upland. This impairs cohesiveness of soil in the upper reaches. The indiscriminate burnings of the land for high-end residential subdivisions replace landscapes under recovery with landscapes for urban or semi-urban use with either built up areas or bare soils and grassy fields. These are the first steps of urbanization in peri-urban areas, similar to the conversions of grasslands around Metro Manila during the 1940s. This reflects that in the past 70 years, with the issues of resource depletion, deterioration of water resources, food security and sustainability, mechanisms for land conversions in the lake basin have changed very little. The consequences can be seen in the in-channel deposition in the upper reaches of the San Cristobal. Clogging of irrigation channels with construction materials in the lower reaches is another example. These facts reflect that the San Cristobal is presently undergoing physical changes in its river regime, which impairs its equilibrium and such changes are in fact human induced. These physical changes came as an addition to the chemical changes in the river produced by the industrialization of outer Manila. Together, they altered the biophysical health of the stream and the Laguna Lake, by extension. Despite the presence of plans and governing agencies, the river basin has not seen any meaningful sustainable management due to a combination of these factors, which have destabilized the lake system by severely impairing ecological functions of the tributary river.

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Chapter 7

Conclusions and Further Research

The Laguna Lake represents a unique and pulsed (fluctuating water-level) ecosystem that is sustained by tidal inflows and outflows of saltwater and freshwater. While the intrusion of saltwater is adversely affected by the Napindan Hydraulic Control Structure, reducing the nutrient influx in the lake to considerable extent; the outflow of freshwater is affected by land conversions in the lake's micro-watersheds. However, studies on these micro-watersheds and their changing land uses have been extremely limited. This makes the Laguna de Bay region as an interesting case to study integrated land and water resource management as affected by development policies and pathways. The main research problem was to determine how economic and social development of the Laguna de Bay region affects the change in land use in a micro watershed. Based on the arguments and the analyses presented in this research, key points can be made to summarize the principal conclusions regarding land use and the state of the surface water resource in the Laguna de Bay Basin.

The practical utility of the findings is to create landscapes of conservation (especially to those one which are under 'no conservation') in the Laguna de Bay environment. The primary step for an integrated management of any resource complex starts from the co-existence of economic activities with the ecological ones. However, since economy and ecology cannot co-exist in complete harmony, the creation of conservation spaces is necessary in this sense. The two suggested conservation spaces are (a) the brushlands, which represent regeneration of forestlands, and (b) the shoreland regions which are vital for the lake's ecosystem productivity. It is to be noted that the deterioration of the former land use type remains relatively unaddressed in the planning literature for sound development of the Laguna de Bay region. A watershed based land use zoning and management is appropriate for environmentally sound management of Lake Basin. Based on the research findings, it is recommended that a comprehensive basin management plan based on a watershed approach be implemented. The answers to the research questions are provided below:

1. What major changes in the land use have taken place in the selected study area (San Cristobal Watershed) of the Laguna de Bay watershed for the past 59 years (1944-2003)?

The extent of built up areas in the watershed has increased from 217.5 hectares in 1944 to 2995 hectares. The amount of forestlands has decreased from 2950 hectares to 7.5 hectares. The woodlands and forests of 1944 have been changed to brushlands and built-up areas, the latter located in small pockets. The grasslands and brushlands of 1944 have been changed to built-up areas and croplands with plantations as the main land use. The marshland areas of 1944 have disappeared altogether with cultivation of rice and sprawls settlement areas by 2003. The small pockets of plantations of banana, abaca and bamboo, observed in 1944, have changed into plantations of coconut, banana and pineapple in 2003.

The overall land use change in the watershed, in relation to land use change literature from 1966 to 2004 in the Laguna de Bay basin, is consistent with the case of change in forestlands, built-up areas and agricultural lands. However, the watershed land use changes shows inconsistency in the case of brushlands, grasslands and open lands with the land use change literature, as contrary to the literature, they all show a decreasing trend (open lands have become nonexistent).

2. What are the mechanisms of changes in land use and what kinds of landscapes have been affected?

Assessment of changes in the landscape in the San Cristobal since 1944 to 2003 shows the increase of urbanized land in the watershed. The decreasing trends of brushlands, grasslands and open lands show the extent of urbanization in the landscape. The literature referred to earlier shows an increase of brushlands while a trend of decreasing forests mean that these are spaces where landscapes are on the stages of recovery. These are the possible candidate areas to serve as conservation corridors. Such landscapes still exist in the San Cristobal Watershed, but are being threatened and diminished by growing urbanization. However they need to be managed not by introducing selective species in order to create a forested landscape, but by allowing the landscape to recover towards a well vegetated state not exclusive of human activities. However, their effective management requires allowing the landscape to recover towards a well vegetated state inclusive of human activities, and not wanton introduction of selected plant species to create a forested landscape. Furthermore, the fact that secondary forests have reclaimed a large part of eastern margin of the lake basin despite population increase[56] indicates that such landscapes have ample potential to be protected despite peri-urbanization.

With the Calabarzon project put into effect, the issue of regional and local food security has been pushed out of the river basins; the same is true for the San Cristobal Watershed. The watershed can be divided into three types of land uses, the upper reaches, with privatized residential subdivisions for the rich and the lower reaches with residential divisions for the middle class and the relatively poor. The middle portions are

[56] See chapter 4 figure 4.11

occupied by industrial establishments. The plan for the residential areas show a land use based on high amount of built-up areas, large residential establishments, which have altered the nature of local land cover by introducing impermeable layers. The conversions of land by the industries are much lesser in terms of area, compared to the residential areas. The burnings of land are the first step towards urbanization in these areas. They are indiscriminate in the sense that landscapes are burnt regardless of their ecological value. Woody vegetation is burnt along with grasslands, implying that the burnt areas are brushlands (landscapes of recovery) either naturally or by spontaneous human actions[57]. These lands should be devoted to conservation and not to be subjected to indiscriminate burning. Such brushlands have decreased from 8243 ha to 3503 ha[58] in the San Cristobal Watershed in the past 59 years. Moreover, the burnings take place in much shorter time period leading to rapid changes in the landscape. The space requirement of urban establishments in the policies is also wrongly assumed. It was seen that the actual processes of urbanization need far greater amount of land than the expected during the planning period. These types of conversions are more efficient for changing the landscape than traditional practices like forest burnings for charcoal making and slash and burn agriculture. The adverse consequences of slower processes

[57] 'Spontaneous human actions' here means selection of tree species and helping their distribution in the landscape without being implemented by a reforestation project etc.
[58] See Chapter 4, section 4.3.2.

like charcoal making and swidden agriculture are often addressed in the literature on sustainable land management but the rapid changes by indiscriminate burning, which are the first steps of urbanization, are much more potent land conversion mechanisms. Lands are converted from the areas previously used for plantations (mainly coconut and banana) for high end residential subdivisions. The conversion of the hacienda land by Laguna Estate Development Corporation is such an example. Furthermore, these residential subdivisions for the rich represent city style land uses. In the case of San Cristobal Watershed, the Ayala land is set to replace the previous grassland and sugarcane plantation areas, which is similar to what the Ayala's did in the case of Makati city in the 1940s. These 'posh' or 'would be posh' areas stand as islands of cleanliness (at least visually) and aesthetic beauty, surrounded by areas strewn with garbage.

The relatively poor in the society occupy the shore-lands of the lake and the river; regions which affect the lake and river ecology more directly. These poor settlers are associated with two major processes. First, the incidence of poverty is related with the increased joblessness that affect the peri-urban areas like Calamba together even as job creation has increased in the national level. Second, these settlers originate from out migration of economically disadvantaged people from areas such as Mindoro, Marinduque, Romblon, and Palawan.

Generally in a river basin, downstream regions attract more urban development as the upstream land uses remain comparatively more directly related to the river. However in this case watershed represents an interesting trend of peri-urbanization, as the downstream parts are urbanized by processes that are based by agriculture and industries, the upland is urbanized mainly by the economically well off. This type of urban transitions on the San Cristobal watershed has detrimental effects on the watershed health as it has changed the protection zone of a watershed drastically. Furthermore, such land use transitions take place in the previously plantation based land uses, which are at greater risk of being converted to peri-urban land uses especially in the rural urban fringes.

Some of the peri-urban areas constitute the riparian areas of the lake and the lower reaches of the rivers that are less polluted. These areas in the shorelands are biologically rich but economically relatively poor. The management of the resources depends on the market value of the resources acquired (viz, the size of the fishes to be caught depends on the market value of a given size of fish). This represents that traditional knowledge is only used for alternative livelihoods when the market supports a higher return for the utilization of that knowledge (for harvesting of fishes). However, this traditional knowledge is maintained by the relatively poor of the society in a region which represents a relatively high biological diversity. However, such land use activities are highly susceptible to changes towards urbanization as the actors always look for a better alternative way to generate income, as the land uses cannot fully support the livelihoods of the people. These land uses cannot be maintained without recognition in policy agenda, which is not present in the Laguna de Bay environment as yet. Policymaking in the region puts emphasis on utilitarian land use options rather than internalizing conservation of ecological spaces vital for supporting ecosystem services. Nevertheless, the existence of these peri-urban areas reflects that landscapes with considerable biological diversity can exist in the urbanized landscapes.

The San Cristobal River has changed from a relatively pristine state just 30 years ago to being heavily polluted at present. The streams in the upper reaches are often reported to be clogged with sediments while the lower reaches are heavily silted. The Environmental User Fee System, as far as lowering pollution loads is concerned, is only partially effective in the watershed as industries allegedly discharge pollutants into the river during heavy rainfall. Moreover, the presence of relatively poor communities in the shore-lands is risky both for the environment and for the communities. They can increase the pollution in the lake through generated garbage and untreated sewer. The lives the inhabitants are also endangered by flooding during rainy months.

3. How are the social and economic processes related to the changes of land uses? How are the land use policies related to these land use patterns?

The implementation of Calabarzon project as a regional economic development policy had major effects on land use changes in the basin. It led to increase in population brought about by increased urbanization and employment opportunities in the lake basin. The rapid peri-urbanization in the outskirts of Metro-Manila resulted in massive and fast land conversions. With the Calabarzon project, new land use types characterized by infrastructure facilities and amenities appeared in the landscape resulting to phenomenal increase in land prices. This created a division in the watershed land uses as the richer communities and their facilities occupy and transform lands in the upper reaches of the watersheds while the relatively poor communities occupy the ecologically sensitive zones of land-water-interface. These led to more erosion in the upper catchment and deterioration of the ecological value of the downstream areas. The trend of land use changes in San Cristobal watershed and its vicinity proceeds with approval of the central government. Added to this are the social problems and political corruption under the regimes, vested interests of the local politicians, importance to economic valuation of land rather than its ecological value, and loss of food security etc. All these constitute a vicious cycle of land transition leading to marginalization of ecosystems leading to further transition and ecological poverty.

Furthermore, while the leading force of land use change has been due to the Calabarzon project, there are policies which support changes in land uses. Examples of such policies are the Presidential Decree 399 or the primarily top down approaches of land use policies even after the devolution by the Local Government Code. These leading and supporting forces of land use policies act together with age old practices such as alteration of lands by using fire or development of trail networks through the shoreland regions. Due to the interaction of the regional and more local land use policies and certain land use traits the ecological base for the sound management of land and water is increasingly being lost in the landscape thus affecting the integrated land and water resource management in the region.

4. Are the issues of land and water resources management reflected in the land use policies in the region?

The literature[59]reviewed indicates that sound management of water resources

[59] See Chapter 3 for more.

require unique and holistic solutions to address the problems related with the sustainable use and management of land and water resources. It is expected that resilience can be achieved through adaptive actions and approaches. Sadly, the management of land and water resources in the study area is a diversion from this scenario. The number of institutions accountable for the sound management of natural resources and creation of livable human environments in the lake basin have increased and so have policy agendas. However, water resources, and the ecological values of the land has been severely degraded, a trend which is very much continuing. This shows that IWRM has been either absent or defunct in land use policies of the region. Where efforts exist in pen and paper, the rhetoric has not been matched by actual practice.

5. To what extent does integration of policies related to sustainable land use decision-making exist in the selected watershed?

   Laguna de Bay environment as in the case of San Cristobal represents a top down approach in land use decision making in the watershed. Urbanization and the related processes of land use change in the San Cristobal watershed has been brought by Philippine regional development policies to invest in the less developed areas. Although the Calabarzon involves an array of organizations for the management of economy and environment in the region, these institutions failed to produce an integrated and sound management plan for the Laguna de Bay's micro watershed environments. Furthermore, land use policies are not integrated on the ground. Policies remain in pen and paper, and are not followed on the ground. Thus the integration of policies fails in its core objective. Conversions of land still take place in the same old ways as land is converted in the same way as in Makati City almost 70 years ago. This is a surprising fact as it indicates that basic processes of urbanized land conversion have not changed much in 70 years, despite constantly evolving land use policies and the organizations involved. Land conversions for urban uses are also done by force. The conversion of Hacienda land by Laguna Estate Development Corporation is an example of this. This does not fall under spontaneous or policy oriented human actions. However, the unlawful land conversions are possible because of gaps in the land use policies.

6. What are the challenges regarding integration of land and water resource management in the region? What issues remain unaddressed in the present case?

The main challenge for an integrated, sound management of land and water resources in the Laguna de Bay basin, lies in creating the conservation spaces within the peri-urban areas. This is applicable especially to the lowland riparian areas of the river basins the Laguna Lake, and the brushland areas in the upper catchments. Involvement of locals for sustainable land use decision making is needed. Especially conservation practices are needed in the Eastern tributary watersheds which has not undergone massive land conversions like the San Cristobal watershed. The lake water is being replenished in about 8 months[60] by these tributary watersheds. This means that the balance of freshwater in the lake's hydrological system is controlled by the tributary watersheds, giving the lake its unique character and its value as an ecosystem. Therefore, if the watersheds around the lake are deteriorated then the replenishment of freshwater will be cut off, and the Laguna Lake will be ecologically adversely altered.

The argument for a conservationist thinking for sustainable resource management and to bring back the lost carrying capacity can be addressed through the deep ecology platform by Naess (2007), where he notes that deep ecologists argue for the conservation of non-human nature, which has a value in itself as it is related to the generation of ecosystem services. The management of any natural resource is challenged by the dichotomy between utilitarian and the conservationist thinking and actions. Utilitarian notion puts appropriation of nature to human use; creating natural capital, and therefore, concentrating to those functions of nature which have direct values for the society. This utilitarian notion often alters ecosystem functions which are

[60] See chapter 2 section 2.7.

vital for generation of natural capital, giving rise to the conservationist ideas and actions. Restoration of forests for generating capital is a conservation effort stemming from utilitarian notion. More often than not, limited spatial units are left for conservation purposes to let the nature stay in its pristine form, to keep the ecosystem functions continue generating natural capitals. This is because the conservationist thinking comes only after the carrying capacity is either exceeded or has crossed the point of no return, which seems to be the case for the Laguna de Bay environments. Most of the conservation sites require command and control measures from the states to keep ecosystems in their pristine form. However, this approach also has its own problems such as:

- Deterioration of the ecosystems outside the spatial boundary of the conservation sites.
- Motivation to utilize the resources of the conservation sites to support the lost carrying capacity of the landscapes outside the spatial boundary of the conservation sites.
- Social groups living for ages within the conserved area are often denied access to resource; hence the approach misses the social sustainability in its core.

These above mentioned points show a necessity to both create, and protect spaces of intrinsic value through dissemination of local knowledge, a practice which is yet to take place in the Laguna de Bay Basin. This is cost effective as limited centralized decision making is needed to support these landscapes. Also, in relation to the deep ecology platform, the bio-physical attribute of a river is a vital function that is needed to be conserved as much as possible, despite the prevalence of utilitarian notion in the watershed land uses. This is because as the bio-physical attributes of rivers keep the watershed ecosystems healthy, the deterioration of this transfers the changed state of environments to the of larger system involved such as the Laguna Lake ecosystem.

Further research

The following are suggested as concerns for further research relevant to the management of the Laguna de Bay environment.

1. Constructing a detailed database on the characteristics of land use changes in the Laguna de Bay Basin area is important. Based on such micro scale studies, a basin wide plan for creating conservation landscapes will be possible.
2. Further in depth investigation of the relation between regional biodiversity and common people is needed to create viable areas of conservation for livable human environments.

3. More investigations are needed regarding hydrological and ecological changes due to stages of urbanization in urban and peri-urban rivers in the lake basin.
4. Current literature on the Laguna de Bay environments is mainly cross sectional; therefore investigations which prioritize environmental changes over time are necessary.
5. More policy research regarding effective management of land and water in the Laguna de Bay Environments is a necessity.

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Appendices

Appendix 1
Photographs: Visual Evidences from the Field

Explanation of photographs

1. Laguna de Bay scene from San Juan port, Municipality of Calamba.
2. Newly developed urbanized spaces near the San Juan port near the confluence of San Juan River.
3. Signs of clearance of vegetation by burning as seen from the San Juan port towards the river basins of Santa Cruz and Pagsanjan. The upper case of burning is related to slash-and-burn or even *kainging* agriculture. The lower case is associated with hunting of snakes such as Philippines' reticulated python or *sawa*.
4. Fish pens in the foreground with *Jala-Jala* peninsula in the background. Cultivation of milk fish or *bangus* introduced by Laguna Lake Development Authority was a huge success in Laguna Lake. Nevertheless, the selective breeding and production of *bangus* reduced the fish diversity in the lake. However, the problem of loss of fish diversity is not only a factor of fish pens. Gathering of fish feed for the fish pens.
5. Gathering of fish feeds for the fish pens.
6. Even if the status of the lake has been put as 'dying', life goes on normally with everyday recreations in the lake waters. However, the level of pollution especially near the lake shore areas can be understood by the amount of solid waste suspended in the waters (foreground). The water gives a foul smell from the rotting fish corpses and the open and untreated sewage which are put into the lakewater from the adjacent lands. Such environments pose health risks and poor livable conditions around the lake. Yet swimming and playing are present by the village people, especially the children, in these waters.
7. The level of lake pollution near the shore land areas seen from village Looc. The darker waters near the shore indicate heavy siltation and pollution loads brought by the San Cristobal and San Juan River systems and miscellaneous run-offs from the adjacent lands. Such pollution is kept near the shore lands by the prevailing wind in the daytime which blows towards the land. However, this pollution is dispersed into the lake with a reversal of wind flow.
8. Views of the degraded riparian zones of the Laguna Lake.
9. Views of the degraded riparian zones of the Laguna Lake.
10. Views of the degraded riparian zones of the Laguna Lake.
11. Jala-Jala peninsula seen in the background once hosted a vibrant fishermen

community. Not only the number of fishermen in Jala-Jala peninsula has decreased but also the lower part of the peninsula has been severely striped of its vegetation cover (lighter in color). The three processes can be mixed together. The rapid conversion of low land vegetation around Laguna Lake as a result of peri-urbanization processes has changed the lake ecology to a significant extent. The peri-urbanization processes have also increased fish demand asking for a primarily instrumental approach of using the lake's resources.

12. Settlements replacing degraded riparian zones of the Laguna Lake at village Looc.
13. A scene from degrade riparian zone of the Laguna Lake from village Looc.
14. The degraded riparian zones of the lake are littered with dead fishes, which is the result of eutrophication.
15. Researcher with three local school children of the village Looc. Children such as these are the frequent dwellers of the landscape. The lakeshore environments are areas of their social affairs and recreation. The continuously deteriorating lakeshore environments, which started from heavy urbanization around manila, has spread itself outward as far as 60 or more kilometers away from the urban core deteriorating the livable human environments around the lake. Questions arise about what kind of landscapes the new generation will work for and manage in the future around the Laguna Lake.
16. Children gathering mollusk in the lakeshore. In spite of its deteriorating state, the Laguna Lake holds considerable livelihood opportunities. Ecosystems which is severely stressed by the processes of urbanization, has a considerable biological diversity which is expected to deteriorate further if the present practices of land use continue. This may deteriorate the livable human environments in the lake basin further.
17. A lone fishing boat going towards the Laguna Lake through the Pagsanjan River at Midday. Pagsanjan is the biggest river in the Lake Basin after the Marikina. The Pagsanjan Watershed is considerably forested in its upper course with vast agricultural and plantation fields in the downstream, pouring relatively cleaner water to the lake. The number of fish deaths from eutrophication is much lower in the Pagsanjan's confluence. The number of open water fishermen is also more than in the western lakeshores.
18. Plantation of squash with irrigation in the riparian zones of the Pagsanjan Delta.
19. The lakeshore regions of the Pagsamjan River have much cleaner waters compared to the western tributaries of the lake such as the San Cristobal and San Juan.
20. Another view of the cleaner water of the lake near the Pagsanjan River.

21. The riparian zone of the lake at the Pagsanjan Delta.
22. The land water interface at Pagsanjan Delta. The land slopes toward the lake and is inundated by water during the rainy season or during extreme rainfall events.
23. A farmers shelter for the night to watch over his crops for the prevention of theft.
24. A more decent makeshift house for night watching.
25. The Pagsanjan Delta.
26. According to the Laguna Lake Development Authority, the Pagsanjan Delta is increasing in size due to erosion of soil caused by denudation of upland forests.
27. A picturesque farmland in Calauan. Cultivation of wet rice , often with fish ponds is the main agricultural livelihood here, whereas plantation follows in the uplands.
28. An Agricultural village with Mt. Makilling in the Background.
29. Fishes on their way to cross a waterhole. Fishes are still found in abundance in the close vicinity of marshlands of river mouths and in the riparian zones of the lake.
30. A fisherman in land. Fishes from the wetlands of the river mouths and the riparian zones of the lake are caught by electrocution using a special device made for such purpose. Smaller fishes having low market value are released both to spawn and to gain in size.
31. Shorelands of Laguna de Bay near Manila. Water spinach is cultivated in the riparian zones of the lake which is seen in the foreground, whereas water hyacinth dominates the inner riparian zone. Water hyacinth cleanses water from its pollutants and thus their sprawl is supported by the LLDA. A market value is put also through local handicraft making.
32. Informal settlements to the both sides of the Pasig River. The river was an important channel in bringing nutrient from the Manila Bay to the Laguna Lake to make the lake an ecologically rich pulsed system. The deterioration of the Pasig River after 1960s, has reduced the life blood of the lake to a great extent.
33. Making of provincial roadways along the lake. Informal settlements often sprawl to the both sides of these roads. Many of the dwellers work in the local construction and road making activities.
34. An esteros littered by solid waste in Manila. Runoffs from Manila’s urban watershed are draind to the Laguna Lake which is the main cause of lake pollution in its northwestern part.
35. Coconut plantations near Caliraya Lake.
36. Plantations of coconut and pineapple in the upper reaches of the San Cristobal River basin. Pineapple has been known to cause soil erosion in their earlier stages of maturity. This farming practice therefore makes the in-situ soil of the upper San

Cristobal to become vulnerable to erosion.

37. Banana and coconut plantations in Silang.
38. Large tracts of land, stripped of their vegetative cover lay idle in the upper San Cristobal Watershed. Such lands have considerable contributions in the soil erosion.
39. The newly developed Nuvali land for creation of rich residential subdivisions.
40. Lands available for erection of private apartments. An example of the single family apartments that will dominate the landscape in these areas can be seen on the advertisement board of the electric post.
41. The creation of rich residential sub divisions is carried out by indiscriminate burnings of the land.
42. Such burnings alter landscapes regardless of their ecological values. Here, woody vegetation is burned as well in order to clear the land. These are the brush lands or the landscapes which are towards recovery from the previous clearances, and need to be preserved.
43. A rich residential subdivision in Tagaytay city called Madrigal Estates.
44. A huge *dipterocarp* in the forests of Mt. Banahaw
45. The base of a *dipterocarp* hosts a number of epiphytes and lianas along with other types of vegetation which prefers shade. They all help the soil to retain moisture throughout the year and produce waters that are crystal clear.
46. A giant fern. A species particularly found near the riparian zones of forest streams, plays a significant role in retaining soil moisture.
47. Children playing in the water at Mt. Banahaw Reserve Forest.
48. A tributary of the Langas River at Mt Banahaw Reserve Forest.
49. An un-spoilt riverscape in Mt. Banahaw Reserve Forest.
50. The waters in the densely forested Banahaw Reserve Forest are so clear that a depth of about 1 meter can be seen very clearly.
51. A pool in a mountain stream in the Mt. Banahaw Reserve Forest
52. A tiny machine set for the making of cement in the stream. This was the only tiniest form of industrial activity found in the Langas River tributary in Mt Banahaw Reserve Forest. To the author, the case looked just the opposite of the San Cristobal River Basin in terms of human interventions on the watershed.


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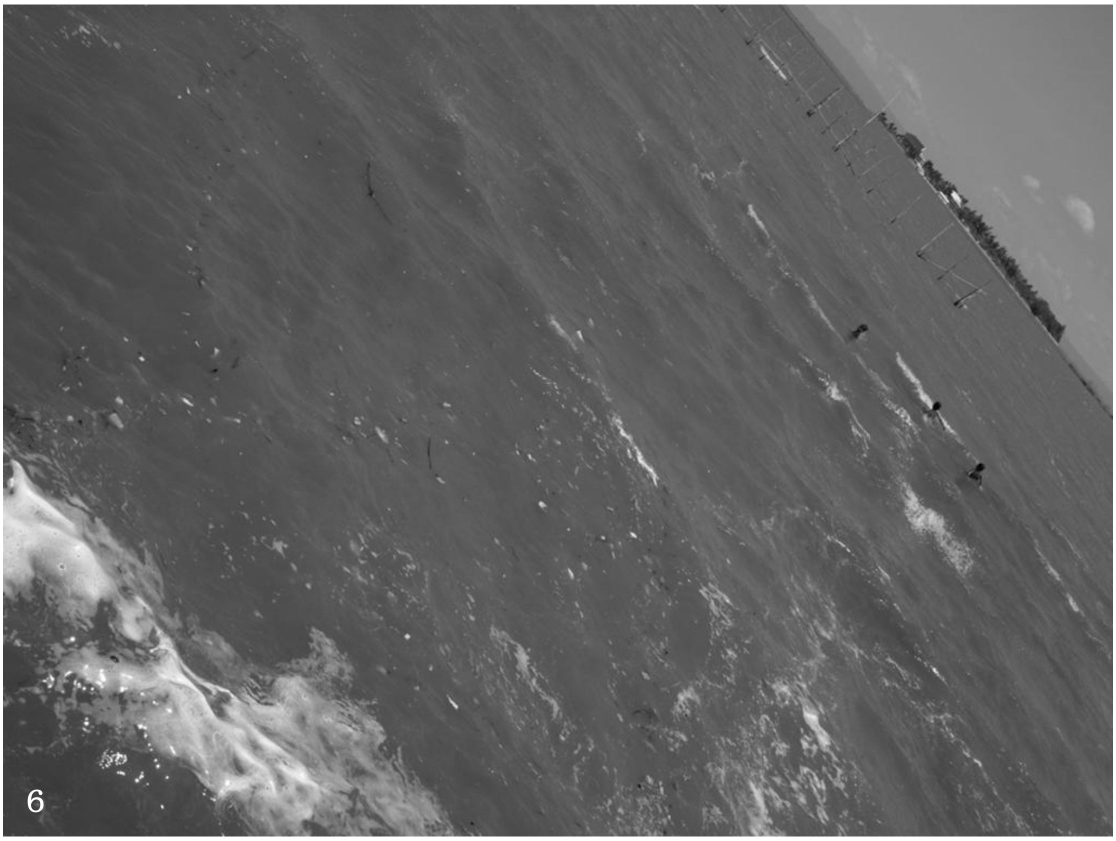
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Appendix 2

Questions asked during fieldworks (1)

I am researching on the integrated water resource management scenario in the Laguna Lake Basin region particularly concentrating on the resource governance in the formal and informal sectors and their interplay particularly concentrating on the less studied river basin regions. I am approaching the case through the changes in the land use and resource use, taking them as two vital indicators of the state of the resource use in LLB ecoregion.

Number of respondents: 2.

On resource conflicts in the LLBs watershed/catchment

1. Based on your own experiences what kind of conflicting land uses are in the most acute stage in the lake's watershed regions?
2. In which areas of LLB watershed are these land uses are roughly distributed?
3. Which of the land uses have higher potential to become more acute from now on in the lake's watershed regions?
4. How do these cases differ?
5. Why do you think these conflicting land uses are there?
6. What can be the possible pathways for resolving these conflicting land uses?
7. What are the resources in the LLBs watershed that most of the resource user communities are concerned of in terms of use?

8. Provided that LLDA is a quasi-governmental authority that has profound experiences in the management of the lake for the past 40 years, does it keep a track of any changes in the resource uses?
9. If yes then what is the past scenario of this resource use (where such data can be availed)?

On the institutionalization of formal land use zones in the informal resource users

10. Are there any land use zones that the resource users are entitled to follow, both to avoid conflicts and for sustainable use of the land? Are these zones strictly controlled?
11. Who prepares these land use zones?
12. Who controls these land use zones?
13. To what extent they are successful?
14. Can you shed some light on some of the reason(s) behind their success as well as failures?
15. Which of the informal resource user communities follow these land use zones?
16. If there are cases that these land use zones are not followed then whom among the LLBs stakeholders do not follow these land use zones?
17. What are the possible reasons for the above as far as LLDAs experiences are concerned?
18. Did these phenomena occur in the LLB in the past? If yes, then how often?
19. How often these phenomena are occurring in the most recent past?

On land conversion by the formal institutions and their possible effects

20. The existing literatures say that land conversion is a key factor for the LLBs water resources. What are the mechanisms of such land conversions? Which conversion practices are not institutionalized?
21. What kinds of land uses are most sustainable in the LLB watershed according to you?
22. There are projects like the CALABARZON project which are aimed at developing certain regions of LLB. What kind of projects they are and what kind of land uses they are supposed to push aside to establish themselves?
23. Do you know any other kind of projects like the CALABARZON which are in swing?
24. There are some vacant lands in LLB especially in the north, north-east and eastern region of the watershed. Are these lands under development agenda? If so then what kind of land uses they are expected to have?

On actions and projects of LLDA

25. What are LLDA's efforts regarding the evaluation of likely ecosystem stresses due to these development projects?
26. We know that LLDA by itself runs several projects in order to sound management of the LLB watershed like the LISCOP, river rehabilitation, river trekking and information gathering etc. Do the other agencies carry out such

efforts and information from them is tapped by LLDA also in addition to LLDA's own efforts?

27. Which of the LLBs formal stakeholders carry out such activities most vigorously (apart from LLDA)?
28. Can you mention about some of the main problems faced by LLDA in its river rehabilitation/LISCOP programs for their implementation?
29. How can a shared vision for the Laguna lake Basin watershed be developed in your opinion?

Questions asked during fieldworks (2)

The following questions were asked to the residents of the lowland areas of the Calauan watershed confluence. Calauan watershed was chosen due to the following reasons;

- It is a primarily rural watershed near to the San Cristobal and thus offers considerable opportunity to catch a glimpse of the landscapes that once characterized the similar geographic areas of the San Cristobal.
- The researcher stayed in Barangay Bangyas, which is in the Calauan watershed. Thus it was relatively easier to make acquaintances with the locals and ask them questions in an approach which is informal but in depth.
- Number of respondents: 15 (15 farmer and/or fishermen).

1. How long you have been staying here?
2. How many family members do you have?
3. How do you find the shorelands of the lake and the rivers as far as support for your daily livelihoods are concerned?
4. Are their fishing activities in the river confluences and the watery grasslands in the lowlands areas?
5. How many different kinds of fishes can you find in these regions?
6. How many of these fishes are consumable?
7. How do you catch fish from these regions?
8. Are the fishes only for your/your family’s consumption or do you sell them as well?

9. How and where do you sell them? How much economic return do you get from selling them?
10. What other activities people do here except fishing and agriculture?
11. To what extent do you find fishing and food gathering from the shorelands of rivers and the lake supportive for you and your family?
12. What kind of additional economic activities you do in order to support your family/ yourself?
13. How many different bird species can you find in these regions? How many of them can you see making nests in these areas?
14. I can see there are areas that have been recently and previously burned, what are the purpose of these burnings?
15. Are you a permanent resident of these areas?
16. How, according to you, is the change in the shoreland regions since, 20 or 30 years back/ your youth?
17. Provided that you work throughout the day in close vicinity of the river basins, do you find any changes in the rivers? If yes, then, what kinds of changes are there?
18. Who are responsible according to you for such changes?
19. Do you find any change in the distribution of fishes, and snakes 20 or 30 years back or your youth?
20. What may be the causes of the changes in distribution of fishes and other animals according to you?

Questions asked during fieldworks (3)

The following questions were asked to the members of LLDA, Staffs of environmental management division of the Calamba City Office, the Barangay Captains of Tartaria, Lumil, and Kabangaan and local residents of the villages in Tartaria, Lumil, and Looc. The questions were asked after two field visits in the San Cristobal's watershed to have a rough idea about the general picture of land use in the watershed. The respondents were chosen based on their long term residency in the San Cristobal Watershed to bring an in depth viewpoint of the changes which are often anecdotal.

Number of respondents: 29 (19 villagers and 10 public servants).

1. For how many years are you staying here?
2. Can you explain the changes in the San Cristobal River as far as you can remember since your child hood?
3. According to your experience do you think that there is any change in the volume of the flow of the river?
4. If so what may be the possible cause of such changes?
5. How the use of the land has changed in the river basin according to your experience?
6. It is said that there were major changes in the land development activities since the Calabarzon project. Can you mention some of the adverse effects of such developmental activities inthe river?

7. The introduction of the Environmental User Fee System by the LLDA has been a success in reducing industrial pollution in the rivers and the lake. Instead of this why do you think that the rivers in the industrial areas remain to be heavily polluted?
8. Who are responsible for producing the majority of the pollution in the river?
9. What are the major sources of drinking water in the basin of the San Cristobal?
10. Is the river water drinkable in any areas? Where are these areas?
11. I have found out from the old maps, of the San Cristobal Basin, which I have been consulting before the fieldwork, that there were forested areas in the upland of the river. These forests are not shown in the present maps. Can you shed some insight about what happened to these forests? What is their status now?
12. How does the forest look like now (if there is any left)? As for example its density and whether there are existence of grasslands around them?
13. I have seen; during some of my field visits to the upland villages of the river that there are big lots of residential areas, some have been completed, and others await completion. Can you give any information about the residents of such higher scale public housing estates?
14. What is the most recent of such housing developments in the area? Where is it located in the river basin?
15. Are there fishing activities present in the river? If so, then which areas are known for such activities?
16. Is there any specific location or area where in the course of the San Cristobal where more pollution than the usual can be observed?
17. I have observed during the crossing of the bridge over the San Cristobal near the village Looc, that there are informal settlements very close to the river shores, which

often extend to into the water. Who are the residents who occupy these settlements? Are they local or they come from other areas in the Philippines?

18. What kinds of occupation they are involved in for their livelihood?
19. Have come to know from the literatures on the pollution of the Laguna Lake, that the informal settlers have a considerable role in the lake water pollution, how is the case with such informal settlements in the San Cristobal?
20. What is your general impression about the future of San Cristobal River in regard to river degradation and pollution?

Appendix 3

Water quality data of San Cristobal, San Juan, Sta Cruz, and Pagsanjan Rivers (Data after Laguna Lake Development Authority, 2009)

T3 - San Cristobal River	BOD	09-Jan-96	20.5
T3 - San Cristobal River	BOD	06-Feb-96	102
T3 - San Cristobal River	BOD	05-Mar-96	12
T3 - San Cristobal River	BOD	01-Apr-96	24
T3 - San Cristobal River	BOD	07-May-96	17.5
T3 - San Cristobal River	BOD	03-Jun-96	5
T3 - San Cristobal River	BOD	01-Jul-96	20
T3 - San Cristobal River	BOD	05-Aug-96	10
T3 - San Cristobal River	BOD	03-Sep-96	7.6
T3 - San Cristobal River	BOD	01-Oct-96	20.5
T3 - San Cristobal River	BOD	05-Nov-96	23.5
T3 - San Cristobal River	BOD	04-Dec-96	7.5
T3 - San Cristobal River	BOD	07-Jan-97	118
T3 - San Cristobal River	BOD	03-Feb-97	39
T3 - San Cristobal River	BOD	03-Mar-97	114
T3 - San Cristobal River	BOD	01-Apr-97	170
T3 - San Cristobal River	BOD	25-May-97	22
T3 - San Cristobal River	BOD	02-Jun-97	32
T3 - San Cristobal River	BOD	06-Jul-97	10
T3 - San Cristobal River	BOD	05-Aug-97	33
T3 - San Cristobal River	BOD	02-Sep-97	90
T3 - San Cristobal River	BOD	07-Oct-97	15
T3 - San Cristobal River	BOD	04-Nov-97	8
T3 - San Cristobal River	BOD	05-Dec-97	37
T3 - San Cristobal River	BOD	06-Jan-98	26
T3 - San Cristobal River	BOD	03-Feb-98	15
T3 - San Cristobal River	BOD	03-Mar-98	38
T3 - San Cristobal River	BOD	06-Apr-98	42
T3 - San Cristobal River	BOD	05-May-98	22
T3 - San Cristobal River	BOD	02-Jun-98	36
T3 - San Cristobal River	BOD	07-Jul-98	8

T3 - San Cristobal River	BOD	04-Aug-98	15
T3 - San Cristobal River	BOD	01-Sep-98	5
T3 - San Cristobal River	BOD	06-Oct-98	10
T3 - San Cristobal River	BOD	03-Nov-98	2
T3 - San Cristobal River	BOD	01-Dec-98	16
T3 - San Cristobal River	BOD	05-Jan-99	5
T3 - San Cristobal River	BOD	02-Feb-99	8
T3 - San Cristobal River	BOD	02-Mar-99	16
T3 - San Cristobal River	BOD	05-Apr-99	13
T3 - San Cristobal River	BOD	04-May-99	59
T3 - San Cristobal River	BOD	08-Jun-99	5
T3 - San Cristobal River	BOD	06-Jul-99	6
T3 - San Cristobal River	BOD	11-Aug-99	15
T3 - San Cristobal River	BOD	07-Sep-99	41
T3 - San Cristobal River	BOD	05-Oct-99	18
T3 - San Cristobal River	BOD	03-Nov-99	16
T3 - San Cristobal River	BOD	01-Dec-99	9
T3 - San Cristobal River	BOD	11-Jan-00	14
T3 - San Cristobal River	BOD	01-Feb-00	7
T3 - San Cristobal River	BOD	07-Mar-00	5
T3 - San Cristobal River	BOD	04-Apr-00	6
T3 - San Cristobal River	BOD	02-May-00	8
T3 - San Cristobal River	BOD	06-Jun-00	7
T3 - San Cristobal River	BOD	04-Jul-00	25
T3 - San Cristobal River	BOD	01-Aug-00	8
T3 - San Cristobal River	BOD	05-Sep-00	6
T3 - San Cristobal River	BOD	03-Oct-00	12
T3 - San Cristobal River	BOD	07-Nov-00	4
T3 - San Cristobal River	BOD	05-Dec-00	5
T3 - San Cristobal River	BOD	06-Feb-01	-
T3 - San Cristobal River	BOD	06-Mar-01	-
T3 - San Cristobal River	BOD	03-Apr-01	-
T3 - San Cristobal River	BOD	02-May-01	-
T3 - San Cristobal River	BOD	05-Jun-01	-
T3 - San Cristobal River	BOD	03-Jul-01	-

T3 - San Cristobal River	BOD	07-Aug-01	14
T3 - San Cristobal River	BOD	04-Sep-01	13
T3 - San Cristobal River	BOD	02-Oct-01	10
T3 - San Cristobal River	BOD	06-Nov-01	20
T3 - San Cristobal River	BOD	04-Dec-01	11
T3 - San Cristobal River	BOD	07-Jan-02	10
T3 - San Cristobal River	BOD	04-Feb-02	16
T3 - San Cristobal River	BOD	04-Mar-02	5
T3 - San Cristobal River	BOD	01-Apr-02	17
T3 - San Cristobal River	BOD	06-May-02	38
T3 - San Cristobal River	BOD	03-Jun-02	11
T3 - San Cristobal River	BOD	03-Jul-02	88
T3 - San Cristobal River	BOD	06-Aug-02	18
T3 - San Cristobal River	BOD	09-Sep-02	68
T3 - San Cristobal River	BOD	07-Oct-02	8
T3 - San Cristobal River	BOD	11-Nov-02	23
T3 - San Cristobal River	BOD	09-Dec-02	5
T3 - San Cristobal River	BOD	13-Jan-03	3
T3 - San Cristobal River	BOD	10-Feb-03	19
T3 - San Cristobal River	BOD	10-Mar-03	12
T3 - San Cristobal River	BOD	08-Apr-03	27
T3 - San Cristobal River	BOD	12-May-03	11
T3 - San Cristobal River	BOD	04-Jun-03	6
T3 - San Cristobal River	BOD	07-Jul-03	5
T3 - San Cristobal River	BOD	11-Aug-03	6
T3 - San Cristobal River	BOD	03-Sep-03	11
T3 - San Cristobal River	BOD	13-Oct-03	10
T3 - San Cristobal River	BOD	10-Nov-03	11
T3 - San Cristobal River	BOD	08-Dec-03	8
T3 - San Cristobal River	BOD	12-Jan-04	5
T3 - San Cristobal River	BOD	09-Feb-04	19
T3 - San Cristobal River	BOD	09-Mar-04	6
T3 - San Cristobal River	BOD	19-Apr-04	11
T3 - San Cristobal River	BOD	11-May-04	51
T3 - San Cristobal River	BOD	14-Jun-04	4

T3 - San Cristobal River	BOD	12-Jul-04	3
T3 - San Cristobal River	BOD	09-Aug-04	37
T3 - San Cristobal River	BOD	06-Sep-04	6
T3 - San Cristobal River	BOD	11-Oct-04	8
T3 - San Cristobal River	BOD	16-Nov-04	22
T3 - San Cristobal River	BOD	13-Dec-04	5
T3 - San Cristobal River	BOD	10-Jan-05	5
T3 - San Cristobal River	BOD	14-Feb-05	16
T3 - San Cristobal River	BOD	07-Mar-05	8
T3 - San Cristobal River	BOD	11-Apr-05	3
T3 - San Cristobal River	BOD	10-May-05	22
T3 - San Cristobal River	BOD	14-Jun-05	9
T3 - San Cristobal River	BOD	11-Jul-05	4
T3 - San Cristobal River	BOD	02-Aug-05	9
T3 - San Cristobal River	BOD	12-Sep-05	6
T3 - San Cristobal River	BOD	17-Oct-05	9
T3 - San Cristobal River	BOD	14-Nov-05	5
T3 - San Cristobal River	BOD	13-Dec-05	9
T3 - San Cristobal River	BOD	16-Jan-06	16
T3 - San Cristobal River	BOD	13-Feb-06	8
T3 - San Cristobal River	BOD	13-Mar-06	12
T3 - San Cristobal River	BOD	17-Apr-06	6
T3 - San Cristobal River	BOD	15-May-06	7
T3 - San Cristobal River	BOD	13-Jun-06	15
T3 - San Cristobal River	BOD	10-Jul-06	14
T3 - San Cristobal River	BOD	07-Aug-06	18
T3 - San Cristobal River	BOD	11-Sep-06	14
T3 - San Cristobal River	BOD	11-Oct-06	8
T3 - San Cristobal River	BOD	13-Nov-06	8
T3 - San Cristobal River	BOD	11-Dec-06	4
T3 - San Cristobal River	BOD	15-Jan-07	4
T3 - San Cristobal River	BOD	13-Feb-07	10
T3 - San Cristobal River	BOD	12-Mar-07	13
T3 - San Cristobal River	BOD	16-Apr-07	4
T3 - San Cristobal River	BOD	15-May-07	8

T3 - San Cristobal River	BOD	12-Jun-07	8
T3 - San Cristobal River	BOD	09-Jul-07	19
T3 - San Cristobal River	BOD	13-Aug-07	123
T3 - San Cristobal River	BOD	17-Sep-07	-
T3 - San Cristobal River	BOD	02-Oct-07	3
T3 - San Cristobal River	BOD	12-Nov-07	8
T3 - San Cristobal River	BOD	10-Dec-07	12
T3 - San Cristobal River	BOD	14-Jan-08	7
T3 - San Cristobal River	BOD	11-Feb-08	26
T3 - San Cristobal River	BOD	10-Mar-08	16
T3 - San Cristobal River	BOD	14-Apr-08	24
T3 - San Cristobal River	BOD	12-May-08	33
T3 - San Cristobal River	BOD	10-Jun-08	13
T3 - San Cristobal River	BOD	14-Jul-08	74
T3 - San Cristobal River	BOD	06-Aug-08	53
T3 - San Cristobal River	BOD	08-Sep-08	29
T3 - San Cristobal River	BOD	13-Oct-08	55
T3 - San Cristobal River	BOD	10-Nov-08	32
T3 - San Cristobal River	BOD	08-Dec-08	52
T5 - San Juan River	BOD	09-Jan-96	2.5
T5 - San Juan River	BOD	06-Feb-96	1.9
T5 - San Juan River	BOD	05-Mar-96	1.2
T5 - San Juan River	BOD	01-Apr-96	3.5
T5 - San Juan River	BOD	07-May-96	2.3
T5 - San Juan River	BOD	03-Jun-96	1.6
T5 - San Juan River	BOD	01-Jul-96	1.8
T5 - San Juan River	BOD	05-Aug-96	12
T5 - San Juan River	BOD	03-Sep-96	1.8
T5 - San Juan River	BOD	01-Oct-96	1.8
T5 - San Juan River	BOD	05-Nov-96	3.2
T5 - San Juan River	BOD	04-Dec-96	2.5
T5 - San Juan River	BOD	07-Jan-97	2.4
T5 - San Juan River	BOD	03-Feb-97	3.5
T5 - San Juan River	BOD	03-Mar-97	2.4
T5 - San Juan River	BOD	01-Apr-97	19

T5 - San Juan River	BOD	25-May-97	3.5
T5 - San Juan River	BOD	02-Jun-97	3.5
T5 - San Juan River	BOD	06-Jul-97	11
T5 - San Juan River	BOD	05-Aug-97	3.1
T5 - San Juan River	BOD	02-Sep-97	50
T5 - San Juan River	BOD	07-Oct-97	6
T5 - San Juan River	BOD	04-Nov-97	2
T5 - San Juan River	BOD	05-Dec-97	2.5
T5 - San Juan River	BOD	06-Jan-98	2
T5 - San Juan River	BOD	03-Feb-98	4
T5 - San Juan River	BOD	03-Mar-98	7
T5 - San Juan River	BOD	06-Apr-98	13
T5 - San Juan River	BOD	05-May-98	4
T5 - San Juan River	BOD	02-Jun-98	4
T5 - San Juan River	BOD	07-Jul-98	2
T5 - San Juan River	BOD	04-Aug-98	6
T5 - San Juan River	BOD	01-Sep-98	5
T5 - San Juan River	BOD	06-Oct-98	4
T5 - San Juan River	BOD	03-Nov-98	3
T5 - San Juan River	BOD	01-Dec-98	3
T5 - San Juan River	BOD	05-Jan-99	2
T5 - San Juan River	BOD	02-Feb-99	15
T5 - San Juan River	BOD	02-Mar-99	2
T5 - San Juan River	BOD	05-Apr-99	2
T5 - San Juan River	BOD	04-May-99	4
T5 - San Juan River	BOD	08-Jun-99	7.5
T5 - San Juan River	BOD	06-Jul-99	15
T5 - San Juan River	BOD	11-Aug-99	2
T5 - San Juan River	BOD	07-Sep-99	3
T5 - San Juan River	BOD	05-Oct-99	2
T5 - San Juan River	BOD	03-Nov-99	2
T5 - San Juan River	BOD	01-Dec-99	2
T5 - San Juan River	BOD	11-Jan-00	2
T5 - San Juan River	BOD	01-Feb-00	2
T5 - San Juan River	BOD	07-Mar-00	4

T5 - San Juan River	BOD	04-Apr-00	1
T5 - San Juan River	BOD	02-May-00	2
T5 - San Juan River	BOD	06-Jun-00	2
T5 - San Juan River	BOD	04-Jul-00	5
T5 - San Juan River	BOD	01-Aug-00	2
T5 - San Juan River	BOD	05-Sep-00	3
T5 - San Juan River	BOD	03-Oct-00	2
T5 - San Juan River	BOD	07-Nov-00	2
T5 - San Juan River	BOD	05-Dec-00	1
T5 - San Juan River	BOD	06-Feb-01	-
T5 - San Juan River	BOD	06-Mar-01	-
T5 - San Juan River	BOD	03-Apr-01	-
T5 - San Juan River	BOD	02-May-01	-
T5 - San Juan River	BOD	05-Jun-01	-
T5 - San Juan River	BOD	03-Jul-01	-
T5 - San Juan River	BOD	07-Aug-01	5
T5 - San Juan River	BOD	04-Sep-01	4
T5 - San Juan River	BOD	02-Oct-01	4
T5 - San Juan River	BOD	06-Nov-01	6
T5 - San Juan River	BOD	04-Dec-01	2
T5 - San Juan River	BOD	07-Jan-02	2
T5 - San Juan River	BOD	04-Feb-02	0.5
T5 - San Juan River	BOD	04-Mar-02	2
T5 - San Juan River	BOD	01-Apr-02	2
T5 - San Juan River	BOD	06-May-02	3
T5 - San Juan River	BOD	03-Jun-02	6
T5 - San Juan River	BOD	03-Jul-02	4
T5 - San Juan River	BOD	06-Aug-02	2
T5 - San Juan River	BOD	09-Sep-02	2
T5 - San Juan River	BOD	07-Oct-02	2
T5 - San Juan River	BOD	11-Nov-02	2
T5 - San Juan River	BOD	09-Dec-02	0.8
T5 - San Juan River	BOD	13-Jan-03	2
T5 - San Juan River	BOD	10-Feb-03	3
T5 - San Juan River	BOD	10-Mar-03	3

T5 - San Juan River	BOD	08-Apr-03	2
T5 - San Juan River	BOD	12-May-03	2
T5 - San Juan River	BOD	04-Jun-03	3
T5 - San Juan River	BOD	07-Jul-03	5
T5 - San Juan River	BOD	11-Aug-03	2
T5 - San Juan River	BOD	03-Sep-03	7
T5 - San Juan River	BOD	13-Oct-03	14
T5 - San Juan River	BOD	10-Nov-03	-
T5 - San Juan River	BOD	08-Dec-03	1
T5 - San Juan River	BOD	12-Jan-04	4
T5 - San Juan River	BOD	09-Feb-04	1
T5 - San Juan River	BOD	09-Mar-04	2
T5 - San Juan River	BOD	19-Apr-04	1
T5 - San Juan River	BOD	11-May-04	11
T5 - San Juan River	BOD	14-Jun-04	3
T5 - San Juan River	BOD	12-Jul-04	2
T5 - San Juan River	BOD	09-Aug-04	1
T5 - San Juan River	BOD	06-Sep-04	4
T5 - San Juan River	BOD	11-Oct-04	3
T5 - San Juan River	BOD	16-Nov-04	11
T5 - San Juan River	BOD	13-Dec-04	1
T5 - San Juan River	BOD	10-Jan-05	2
T5 - San Juan River	BOD	14-Feb-05	3
T5 - San Juan River	BOD	07-Mar-05	1
T5 - San Juan River	BOD	11-Apr-05	2
T5 - San Juan River	BOD	10-May-05	6
T5 - San Juan River	BOD	14-Jun-05	1
T5 - San Juan River	BOD	11-Jul-05	4
T5 - San Juan River	BOD	02-Aug-05	6
T5 - San Juan River	BOD	12-Sep-05	4
T5 - San Juan River	BOD	17-Oct-05	4
T5 - San Juan River	BOD	14-Nov-05	5
T5 - San Juan River	BOD	13-Dec-05	3
T5 - San Juan River	BOD	16-Jan-06	8
T5 - San Juan River	BOD	13-Feb-06	4

T5 - San Juan River	BOD	13-Mar-06	4
T5 - San Juan River	BOD	17-Apr-06	6
T5 - San Juan River	BOD	15-May-06	2
T5 - San Juan River	BOD	13-Jun-06	4
T5 - San Juan River	BOD	10-Jul-06	4
T5 - San Juan River	BOD	07-Aug-06	8
T5 - San Juan River	BOD	11-Sep-06	2
T5 - San Juan River	BOD	11-Oct-06	-
T5 - San Juan River	BOD	13-Nov-06	6
T5 - San Juan River	BOD	11-Dec-06	5
T5 - San Juan River	BOD	15-Jan-07	2
T5 - San Juan River	BOD	13-Feb-07	8
T5 - San Juan River	BOD	12-Mar-07	3
T5 - San Juan River	BOD	16-Apr-07	2
T5 - San Juan River	BOD	15-May-07	3
T5 - San Juan River	BOD	12-Jun-07	3
T5 - San Juan River	BOD	09-Jul-07	4
T5 - San Juan River	BOD	13-Aug-07	4
T5 - San Juan River	BOD	17-Sep-07	10
T5 - San Juan River	BOD	02-Oct-07	1
T5 - San Juan River	BOD	12-Nov-07	5
T5 - San Juan River	BOD	10-Dec-07	3
T5 - San Juan River	BOD	14-Jan-08	3
T5 - San Juan River	BOD	11-Feb-08	6
T5 - San Juan River	BOD	10-Mar-08	4
T5 - San Juan River	BOD	14-Apr-08	3
T5 - San Juan River	BOD	12-May-08	3
T5 - San Juan River	BOD	10-Jun-08	2
T5 - San Juan River	BOD	14-Jul-08	10
T5 - San Juan River	BOD	06-Aug-08	5
T5 - San Juan River	BOD	08-Sep-08	21
T5 - San Juan River	BOD	13-Oct-08	3
T5 - San Juan River	BOD	10-Nov-08	4
T5 - San Juan River	BOD	08-Dec-08	3
T6 - Sta. Cruz River	BOD	09-Jan-96	1.2

T6 - Sta. Cruz River	BOD	06-Feb-96	1.3
T6 - Sta. Cruz River	BOD	05-Mar-96	1
T6 - Sta. Cruz River	BOD	01-Apr-96	4
T6 - Sta. Cruz River	BOD	07-May-96	8
T6 - Sta. Cruz River	BOD	03-Jun-96	7
T6 - Sta. Cruz River	BOD	01-Jul-96	4
T6 - Sta. Cruz River	BOD	05-Aug-96	5
T6 - Sta. Cruz River	BOD	03-Sep-96	1.2
T6 - Sta. Cruz River	BOD	01-Oct-96	1.2
T6 - Sta. Cruz River	BOD	05-Nov-96	1.1
T6 - Sta. Cruz River	BOD	04-Dec-96	1.7
T6 - Sta. Cruz River	BOD	07-Jan-97	2.7
T6 - Sta. Cruz River	BOD	03-Feb-97	2
T6 - Sta. Cruz River	BOD	03-Mar-97	1.6
T6 - Sta. Cruz River	BOD	01-Apr-97	2.1
T6 - Sta. Cruz River	BOD	25-May-97	1.8
T6 - Sta. Cruz River	BOD	02-Jun-97	1.8
T6 - Sta. Cruz River	BOD	06-Jul-97	2
T6 - Sta. Cruz River	BOD	05-Aug-97	3.7
T6 - Sta. Cruz River	BOD	02-Sep-97	4
T6 - Sta. Cruz River	BOD	07-Oct-97	3
T6 - Sta. Cruz River	BOD	04-Nov-97	2
T6 - Sta. Cruz River	BOD	05-Dec-97	1.6
T6 - Sta. Cruz River	BOD	06-Jan-98	4
T6 - Sta. Cruz River	BOD	03-Feb-98	2
T6 - Sta. Cruz River	BOD	03-Mar-98	8
T6 - Sta. Cruz River	BOD	06-Apr-98	1
T6 - Sta. Cruz River	BOD	05-May-98	2
T6 - Sta. Cruz River	BOD	02-Jun-98	2
T6 - Sta. Cruz River	BOD	07-Jul-98	1
T6 - Sta. Cruz River	BOD	04-Aug-98	2
T6 - Sta. Cruz River	BOD	01-Sep-98	6
T6 - Sta. Cruz River	BOD	06-Oct-98	2
T6 - Sta. Cruz River	BOD	03-Nov-98	2
T6 - Sta. Cruz River	BOD	01-Dec-98	2

T6 - Sta. Cruz River	BOD	05-Jan-99	0.8
T6 - Sta. Cruz River	BOD	02-Feb-99	3
T6 - Sta. Cruz River	BOD	02-Mar-99	1
T6 - Sta. Cruz River	BOD	05-Apr-99	2
T6 - Sta. Cruz River	BOD	04-May-99	4
T6 - Sta. Cruz River	BOD	08-Jun-99	2.1
T6 - Sta. Cruz River	BOD	06-Jul-99	1
T6 - Sta. Cruz River	BOD	11-Aug-99	4
T6 - Sta. Cruz River	BOD	07-Sep-99	2
T6 - Sta. Cruz River	BOD	05-Oct-99	2
T6 - Sta. Cruz River	BOD	03-Nov-99	2
T6 - Sta. Cruz River	BOD	01-Dec-99	1
T6 - Sta. Cruz River	BOD	11-Jan-00	1
T6 - Sta. Cruz River	BOD	01-Feb-00	1
T6 - Sta. Cruz River	BOD	07-Mar-00	2
T6 - Sta. Cruz River	BOD	04-Apr-00	0.9
T6 - Sta. Cruz River	BOD	02-May-00	2
T6 - Sta. Cruz River	BOD	06-Jun-00	1
T6 - Sta. Cruz River	BOD	04-Jul-00	3
T6 - Sta. Cruz River	BOD	01-Aug-00	5
T6 - Sta. Cruz River	BOD	05-Sep-00	2
T6 - Sta. Cruz River	BOD	03-Oct-00	0.8
T6 - Sta. Cruz River	BOD	07-Nov-00	0.9
T6 - Sta. Cruz River	BOD	05-Dec-00	0.95
T6 - Sta. Cruz River	BOD	06-Feb-01	-
T6 - Sta. Cruz River	BOD	06-Mar-01	-
T6 - Sta. Cruz River	BOD	03-Apr-01	-
T6 - Sta. Cruz River	BOD	02-May-01	-
T6 - Sta. Cruz River	BOD	05-Jun-01	-
T6 - Sta. Cruz River	BOD	03-Jul-01	-
T6 - Sta. Cruz River	BOD	07-Aug-01	2
T6 - Sta. Cruz River	BOD	04-Sep-01	1
T6 - Sta. Cruz River	BOD	02-Oct-01	1
T6 - Sta. Cruz River	BOD	06-Nov-01	1
T6 - Sta. Cruz River	BOD	04-Dec-01	2

T6 - Sta. Cruz River	BOD	07-Jan-02	1
T6 - Sta. Cruz River	BOD	04-Feb-02	2
T6 - Sta. Cruz River	BOD	04-Mar-02	2
T6 - Sta. Cruz River	BOD	01-Apr-02	2
T6 - Sta. Cruz River	BOD	06-May-02	2
T6 - Sta. Cruz River	BOD	03-Jun-02	2
T6 - Sta. Cruz River	BOD	03-Jul-02	2
T6 - Sta. Cruz River	BOD	06-Aug-02	8
T6 - Sta. Cruz River	BOD	09-Sep-02	4
T6 - Sta. Cruz River	BOD	07-Oct-02	2
T6 - Sta. Cruz River	BOD	11-Nov-02	2
T6 - Sta. Cruz River	BOD	09-Dec-02	3
T6 - Sta. Cruz River	BOD	13-Jan-03	0.9
T6 - Sta. Cruz River	BOD	10-Feb-03	8
T6 - Sta. Cruz River	BOD	10-Mar-03	2
T6 - Sta. Cruz River	BOD	08-Apr-03	1
T6 - Sta. Cruz River	BOD	12-May-03	3
T6 - Sta. Cruz River	BOD	04-Jun-03	2
T6 - Sta. Cruz River	BOD	07-Jul-03	6.3
T6 - Sta. Cruz River	BOD	11-Aug-03	6
T6 - Sta. Cruz River	BOD	03-Sep-03	5
T6 - Sta. Cruz River	BOD	13-Oct-03	5
T6 - Sta. Cruz River	BOD	10-Nov-03	1
T6 - Sta. Cruz River	BOD	08-Dec-03	0.57
T6 - Sta. Cruz River	BOD	12-Jan-04	1
T6 - Sta. Cruz River	BOD	09-Feb-04	0.9
T6 - Sta. Cruz River	BOD	09-Mar-04	1
T6 - Sta. Cruz River	BOD	19-Apr-04	1
T6 - Sta. Cruz River	BOD	11-May-04	4
T6 - Sta. Cruz River	BOD	14-Jun-04	1
T6 - Sta. Cruz River	BOD	12-Jul-04	1
T6 - Sta. Cruz River	BOD	09-Aug-04	1
T6 - Sta. Cruz River	BOD	06-Sep-04	7
T6 - Sta. Cruz River	BOD	11-Oct-04	1
T6 - Sta. Cruz River	BOD	16-Nov-04	2

T6 - Sta. Cruz River	BOD	13-Dec-04	0.8
T6 - Sta. Cruz River	BOD	10-Jan-05	0.5
T6 - Sta. Cruz River	BOD	14-Feb-05	2
T6 - Sta. Cruz River	BOD	07-Mar-05	1
T6 - Sta. Cruz River	BOD	11-Apr-05	1
T6 - Sta. Cruz River	BOD	10-May-05	4
T6 - Sta. Cruz River	BOD	14-Jun-05	5
T6 - Sta. Cruz River	BOD	11-Jul-05	1
T6 - Sta. Cruz River	BOD	02-Aug-05	3
T6 - Sta. Cruz River	BOD	12-Sep-05	2
T6 - Sta. Cruz River	BOD	17-Oct-05	2
T6 - Sta. Cruz River	BOD	14-Nov-05	2
T6 - Sta. Cruz River	BOD	13-Dec-05	2
T6 - Sta. Cruz River	BOD	16-Jan-06	2
T6 - Sta. Cruz River	BOD	13-Feb-06	1
T6 - Sta. Cruz River	BOD	13-Mar-06	1
T6 - Sta. Cruz River	BOD	17-Apr-06	2
T6 - Sta. Cruz River	BOD	15-May-06	1
T6 - Sta. Cruz River	BOD	13-Jun-06	4
T6 - Sta. Cruz River	BOD	10-Jul-06	2
T6 - Sta. Cruz River	BOD	07-Aug-06	1
T6 - Sta. Cruz River	BOD	11-Sep-06	1
T6 - Sta. Cruz River	BOD	11-Oct-06	1
T6 - Sta. Cruz River	BOD	13-Nov-06	2
T6 - Sta. Cruz River	BOD	11-Dec-06	2
T6 - Sta. Cruz River	BOD	15-Jan-07	1
T6 - Sta. Cruz River	BOD	13-Feb-07	2
T6 - Sta. Cruz River	BOD	12-Mar-07	1
T6 - Sta. Cruz River	BOD	16-Apr-07	1
T6 - Sta. Cruz River	BOD	15-May-07	2
T6 - Sta. Cruz River	BOD	12-Jun-07	1
T6 - Sta. Cruz River	BOD	09-Jul-07	2
T6 - Sta. Cruz River	BOD	13-Aug-07	1
T6 - Sta. Cruz River	BOD	17-Sep-07	2
T6 - Sta. Cruz River	BOD	02-Oct-07	1

T6 - Sta. Cruz River	BOD	12-Nov-07	3
T6 - Sta. Cruz River	BOD	10-Dec-07	2
T6 - Sta. Cruz River	BOD	14-Jan-08	2
T6 - Sta. Cruz River	BOD	11-Feb-08	4
T6 - Sta. Cruz River	BOD	10-Mar-08	2
T6 - Sta. Cruz River	BOD	14-Apr-08	1
T6 - Sta. Cruz River	BOD	12-May-08	2
T6 - Sta. Cruz River	BOD	10-Jun-08	2
T6 - Sta. Cruz River	BOD	14-Jul-08	4
T6 - Sta. Cruz River	BOD	06-Aug-08	3
T6 - Sta. Cruz River	BOD	08-Sep-08	2
T6 - Sta. Cruz River	BOD	13-Oct-08	1
T6 - Sta. Cruz River	BOD	10-Nov-08	2
T6 - Sta. Cruz River	BOD	08-Dec-08	3
T8 - Pagsanjan River	BOD	09-Jan-96	0.6
T8 - Pagsanjan River	BOD	06-Feb-96	0.7
T8 - Pagsanjan River	BOD	05-Mar-96	1
T8 - Pagsanjan River	BOD	01-Apr-96	1.6
T8 - Pagsanjan River	BOD	07-May-96	1.9
T8 - Pagsanjan River	BOD	03-Jun-96	3
T8 - Pagsanjan River	BOD	01-Jul-96	2.5
T8 - Pagsanjan River	BOD	05-Aug-96	19
T8 - Pagsanjan River	BOD	03-Sep-96	0.9
T8 - Pagsanjan River	BOD	01-Oct-96	1
T8 - Pagsanjan River	BOD	05-Nov-96	1.2
T8 - Pagsanjan River	BOD	04-Dec-96	0.5
T8 - Pagsanjan River	BOD	07-Jan-97	1.4
T8 - Pagsanjan River	BOD	03-Feb-97	1.5
T8 - Pagsanjan River	BOD	03-Mar-97	1.5
T8 - Pagsanjan River	BOD	01-Apr-97	1.8
T8 - Pagsanjan River	BOD	25-May-97	2.2
T8 - Pagsanjan River	BOD	02-Jun-97	8.6
T8 - Pagsanjan River	BOD	06-Jul-97	2
T8 - Pagsanjan River	BOD	05-Aug-97	1.4
T8 - Pagsanjan River	BOD	02-Sep-97	4

T8 - Pagsanjan River	BOD	07-Oct-97	5
T8 - Pagsanjan River	BOD	04-Nov-97	2
T8 - Pagsanjan River	BOD	05-Dec-97	2.8
T8 - Pagsanjan River	BOD	06-Jan-98	3
T8 - Pagsanjan River	BOD	03-Feb-98	2
T8 - Pagsanjan River	BOD	03-Mar-98	4
T8 - Pagsanjan River	BOD	06-Apr-98	3
T8 - Pagsanjan River	BOD	05-May-98	5
T8 - Pagsanjan River	BOD	02-Jun-98	1
T8 - Pagsanjan River	BOD	07-Jul-98	1
T8 - Pagsanjan River	BOD	04-Aug-98	3
T8 - Pagsanjan River	BOD	01-Sep-98	2
T8 - Pagsanjan River	BOD	06-Oct-98	1
T8 - Pagsanjan River	BOD	03-Nov-98	1
T8 - Pagsanjan River	BOD	01-Dec-98	2
T8 - Pagsanjan River	BOD	05-Jan-99	2
T8 - Pagsanjan River	BOD	02-Feb-99	1
T8 - Pagsanjan River	BOD	02-Mar-99	0.55
T8 - Pagsanjan River	BOD	05-Apr-99	2
T8 - Pagsanjan River	BOD	04-May-99	2
T8 - Pagsanjan River	BOD	08-Jun-99	1.8
T8 - Pagsanjan River	BOD	06-Jul-99	1
T8 - Pagsanjan River	BOD	11-Aug-99	1
T8 - Pagsanjan River	BOD	07-Sep-99	2
T8 - Pagsanjan River	BOD	05-Oct-99	0.9
T8 - Pagsanjan River	BOD	03-Nov-99	2
T8 - Pagsanjan River	BOD	01-Dec-99	5
T8 - Pagsanjan River	BOD	11-Jan-00	0.8
T8 - Pagsanjan River	BOD	01-Feb-00	1
T8 - Pagsanjan River	BOD	07-Mar-00	1
T8 - Pagsanjan River	BOD	04-Apr-00	0.85
T8 - Pagsanjan River	BOD	02-May-00	8
T8 - Pagsanjan River	BOD	06-Jun-00	1
T8 - Pagsanjan River	BOD	04-Jul-00	1
T8 - Pagsanjan River	BOD	01-Aug-00	2

T8 - Pagsanjan River	BOD	05-Sep-00	5
T8 - Pagsanjan River	BOD	03-Oct-00	0.6
T8 - Pagsanjan River	BOD	07-Nov-00	0.6
T8 - Pagsanjan River	BOD	05-Dec-00	0.9
T8 - Pagsanjan River	BOD	06-Feb-01	-
T8 - Pagsanjan River	BOD	06-Mar-01	-
T8 - Pagsanjan River	BOD	03-Apr-01	-
T8 - Pagsanjan River	BOD	02-May-01	-
T8 - Pagsanjan River	BOD	05-Jun-01	-
T8 - Pagsanjan River	BOD	03-Jul-01	-
T8 - Pagsanjan River	BOD	07-Aug-01	2
T8 - Pagsanjan River	BOD	04-Sep-01	0.6
T8 - Pagsanjan River	BOD	02-Oct-01	3
T8 - Pagsanjan River	BOD	06-Nov-01	1
T8 - Pagsanjan River	BOD	04-Dec-01	2
T8 - Pagsanjan River	BOD	07-Jan-02	4
T8 - Pagsanjan River	BOD	04-Feb-02	0.9
T8 - Pagsanjan River	BOD	04-Mar-02	1
T8 - Pagsanjan River	BOD	01-Apr-02	2
T8 - Pagsanjan River	BOD	06-May-02	1
T8 - Pagsanjan River	BOD	03-Jun-02	1
T8 - Pagsanjan River	BOD	03-Jul-02	2
T8 - Pagsanjan River	BOD	06-Aug-02	5
T8 - Pagsanjan River	BOD	09-Sep-02	2
T8 - Pagsanjan River	BOD	07-Oct-02	0.9
T8 - Pagsanjan River	BOD	11-Nov-02	2
T8 - Pagsanjan River	BOD	09-Dec-02	0.8
T8 - Pagsanjan River	BOD	13-Jan-03	1
T8 - Pagsanjan River	BOD	10-Feb-03	1
T8 - Pagsanjan River	BOD	10-Mar-03	2
T8 - Pagsanjan River	BOD	08-Apr-03	1
T8 - Pagsanjan River	BOD	12-May-03	1
T8 - Pagsanjan River	BOD	04-Jun-03	0.4
T8 - Pagsanjan River	BOD	07-Jul-03	2
T8 - Pagsanjan River	BOD	11-Aug-03	2

T8 - Pagsanjan River	BOD	03-Sep-03	1.5
T8 - Pagsanjan River	BOD	13-Oct-03	1
T8 - Pagsanjan River	BOD	10-Nov-03	0.8
T8 - Pagsanjan River	BOD	08-Dec-03	0.5
T8 - Pagsanjan River	BOD	12-Jan-04	1
T8 - Pagsanjan River	BOD	09-Feb-04	0.8
T8 - Pagsanjan River	BOD	09-Mar-04	13
T8 - Pagsanjan River	BOD	19-Apr-04	1
T8 - Pagsanjan River	BOD	11-May-04	2
T8 - Pagsanjan River	BOD	14-Jun-04	0.8
T8 - Pagsanjan River	BOD	12-Jul-04	0.8
T8 - Pagsanjan River	BOD	09-Aug-04	2
T8 - Pagsanjan River	BOD	06-Sep-04	0.8
T8 - Pagsanjan River	BOD	11-Oct-04	10
T8 - Pagsanjan River	BOD	16-Nov-04	2
T8 - Pagsanjan River	BOD	13-Dec-04	3
T8 - Pagsanjan River	BOD	10-Jan-05	0.5
T8 - Pagsanjan River	BOD	14-Feb-05	0.9
T8 - Pagsanjan River	BOD	07-Mar-05	3
T8 - Pagsanjan River	BOD	11-Apr-05	1
T8 - Pagsanjan River	BOD	10-May-05	3
T8 - Pagsanjan River	BOD	14-Jun-05	1
T8 - Pagsanjan River	BOD	11-Jul-05	1
T8 - Pagsanjan River	BOD	02-Aug-05	1
T8 - Pagsanjan River	BOD	12-Sep-05	1
T8 - Pagsanjan River	BOD	17-Oct-05	2
T8 - Pagsanjan River	BOD	14-Nov-05	2
T8 - Pagsanjan River	BOD	13-Dec-05	1
T8 - Pagsanjan River	BOD	16-Jan-06	1
T8 - Pagsanjan River	BOD	13-Feb-06	1
T8 - Pagsanjan River	BOD	13-Mar-06	1
T8 - Pagsanjan River	BOD	17-Apr-06	1
T8 - Pagsanjan River	BOD	15-May-06	1
T8 - Pagsanjan River	BOD	13-Jun-06	3
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T8 - Pagsanjan River	BOD	07-Aug-06	1
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T8 - Pagsanjan River	BOD	11-Oct-06	1
T8 - Pagsanjan River	BOD	13-Nov-06	2
T8 - Pagsanjan River	BOD	11-Dec-06	1
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T8 - Pagsanjan River	BOD	12-Mar-07	1
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T8 - Pagsanjan River	BOD	10-Dec-07	2
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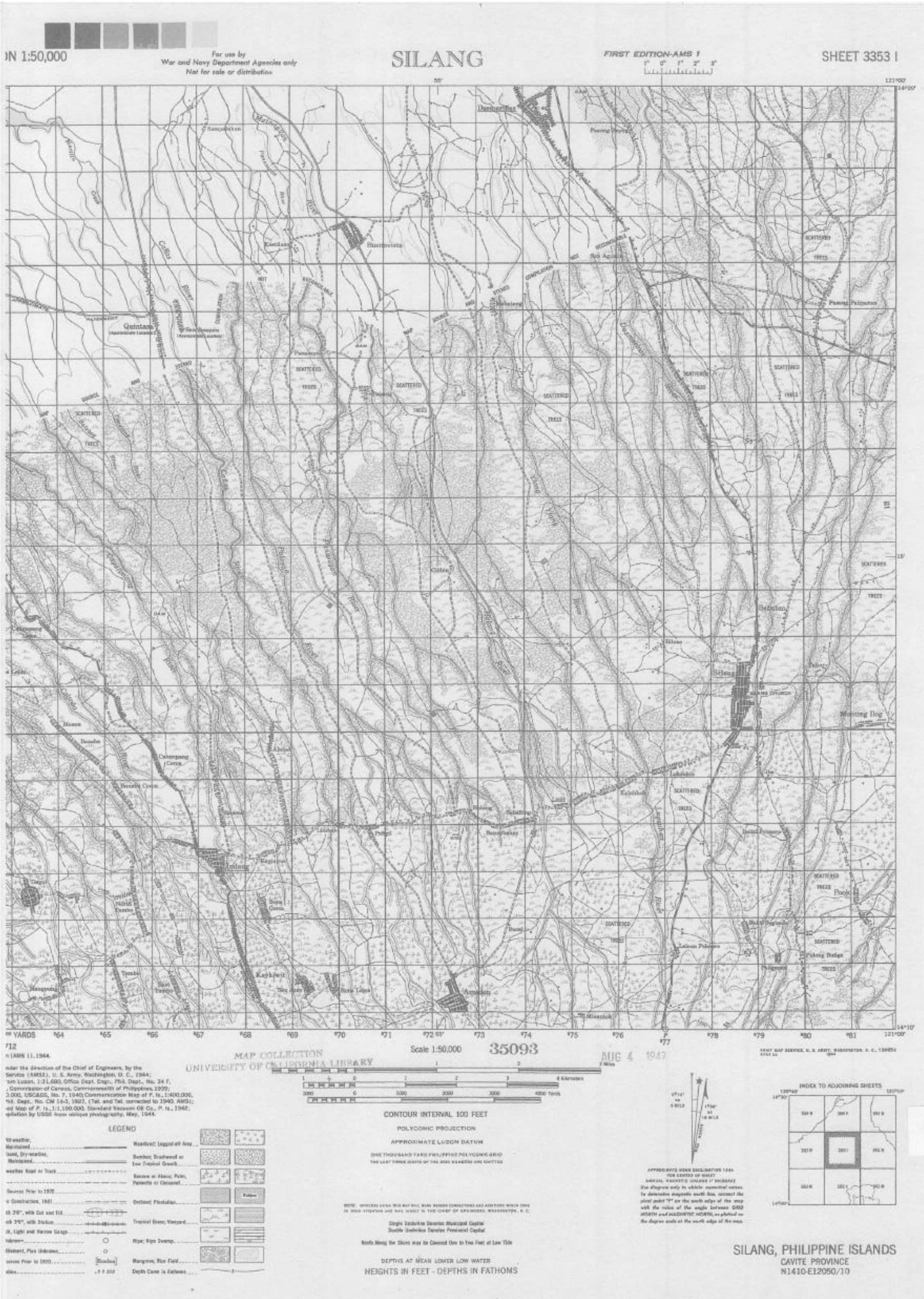
T8 - Pagsanjan River	BOD	06-Aug-08	2
T8 - Pagsanjan River	BOD	08-Sep-08	2
T8 - Pagsanjan River	BOD	13-Oct-08	1
T8 - Pagsanjan River	BOD	10-Nov-08	1
T8 - Pagsanjan River	BOD	08-Dec-08	2



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Amadeo
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APPROXIMATE LUZON DATUM
LEGEND
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DEPTHS AT MEAN LOWER LOW WATER
HEIGHTS IN FEET - DEPTHS IN FATHOMS
SILANG, PHILIPPINE ISLANDS
CAVITE PROVINCE
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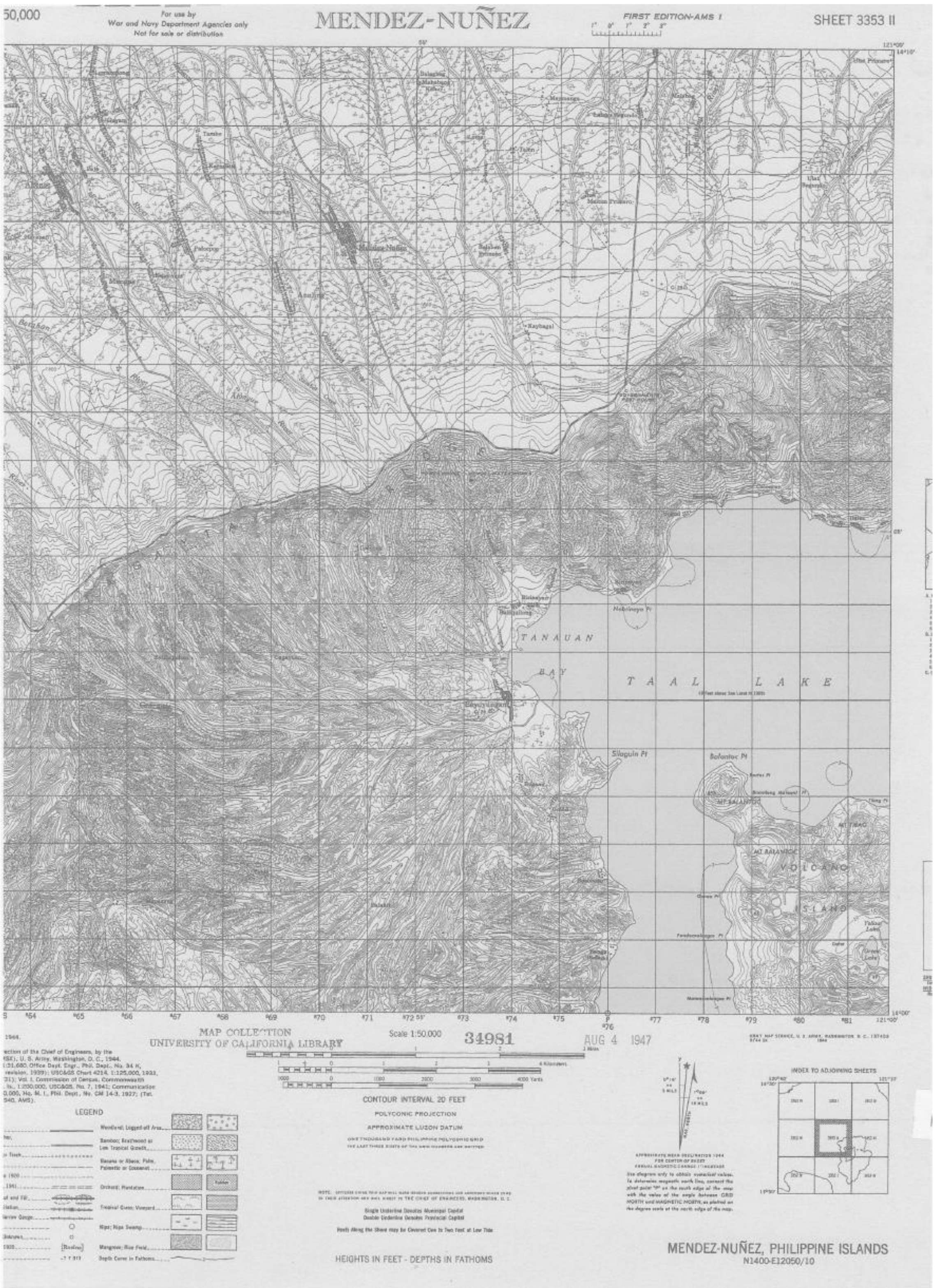
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MENDEZ-NUÑEZ, PHILIPPINE ISLANDS
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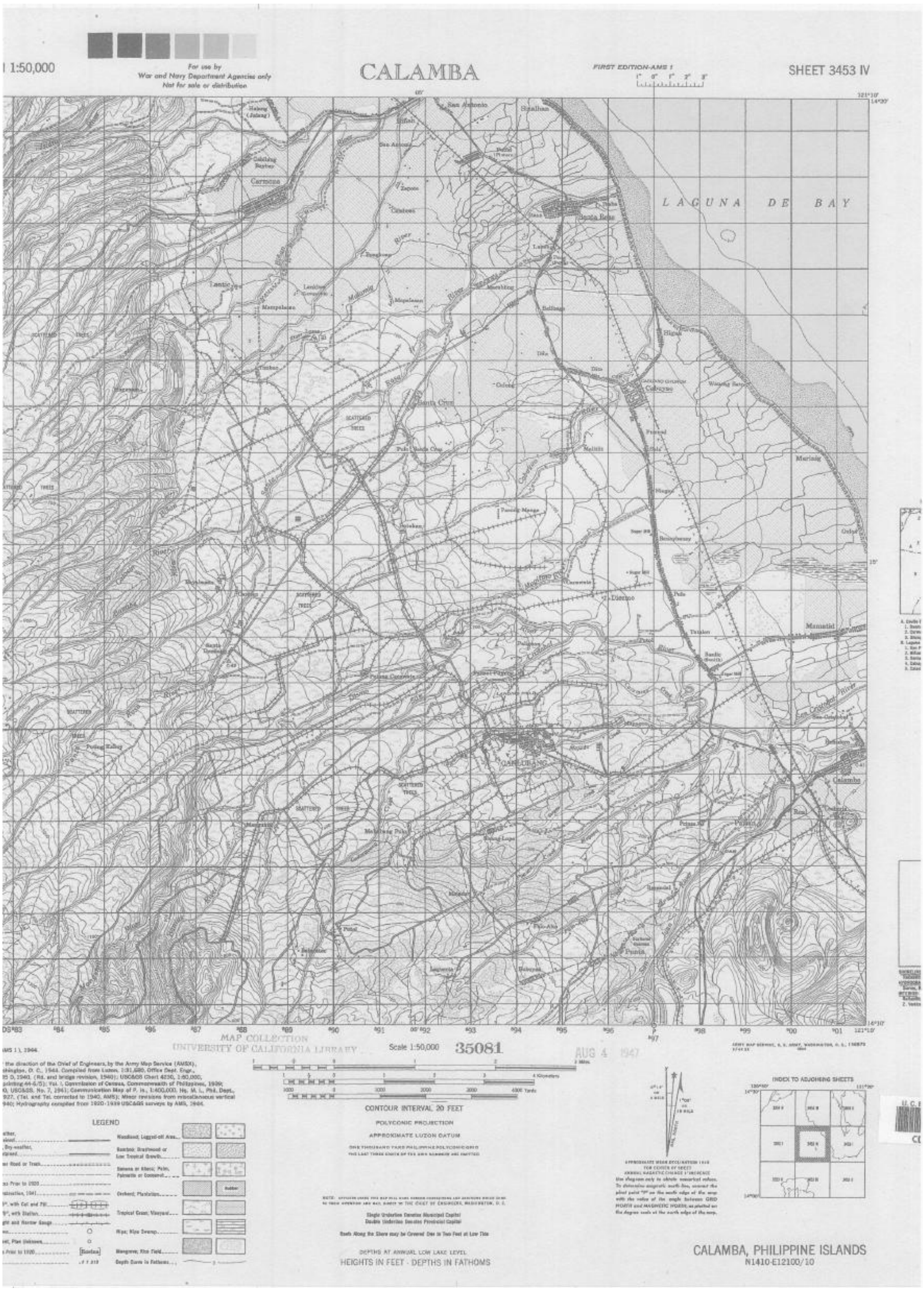
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SHEET 3453 IV
LAGUNA DE BAY
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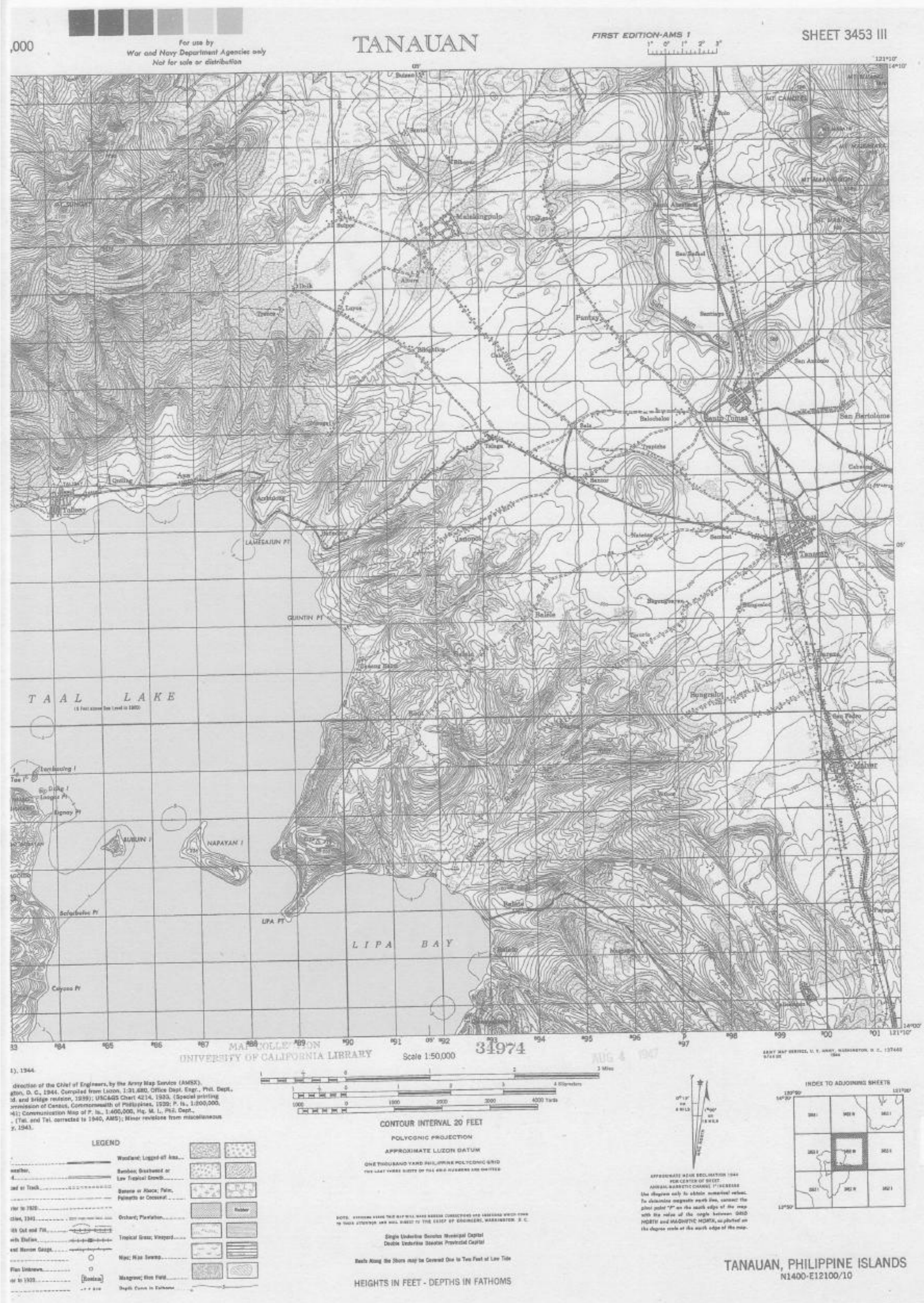
APPROXIMATE LUZON DATUM
LEGEND
INDEX TO ADJOINING SHEETS
DEPTHS AT ANNUAL LOW LAKE LEVEL
HEIGHTS IN FEET · DEPTHS IN FATHOMS
CALAMBA, PHILIPPINE ISLANDS
N1410-E12100/10



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FIRST EDITION-AMS 1
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LIPA BAY
Tanauan
Santo Tomas
Malvar
Scale 1:50,000
CONTOUR INTERVAL 20 FEET
POLYCONIC PROJECTION
APPROXIMATE LUZON DATUM
LEGEND
INDEX TO ADJOINING SHEETS
HEIGHTS IN FEET - DEPTHS IN FATHOMS
TANAUAN, PHILIPPINE ISLANDS
N1400-E12100/10
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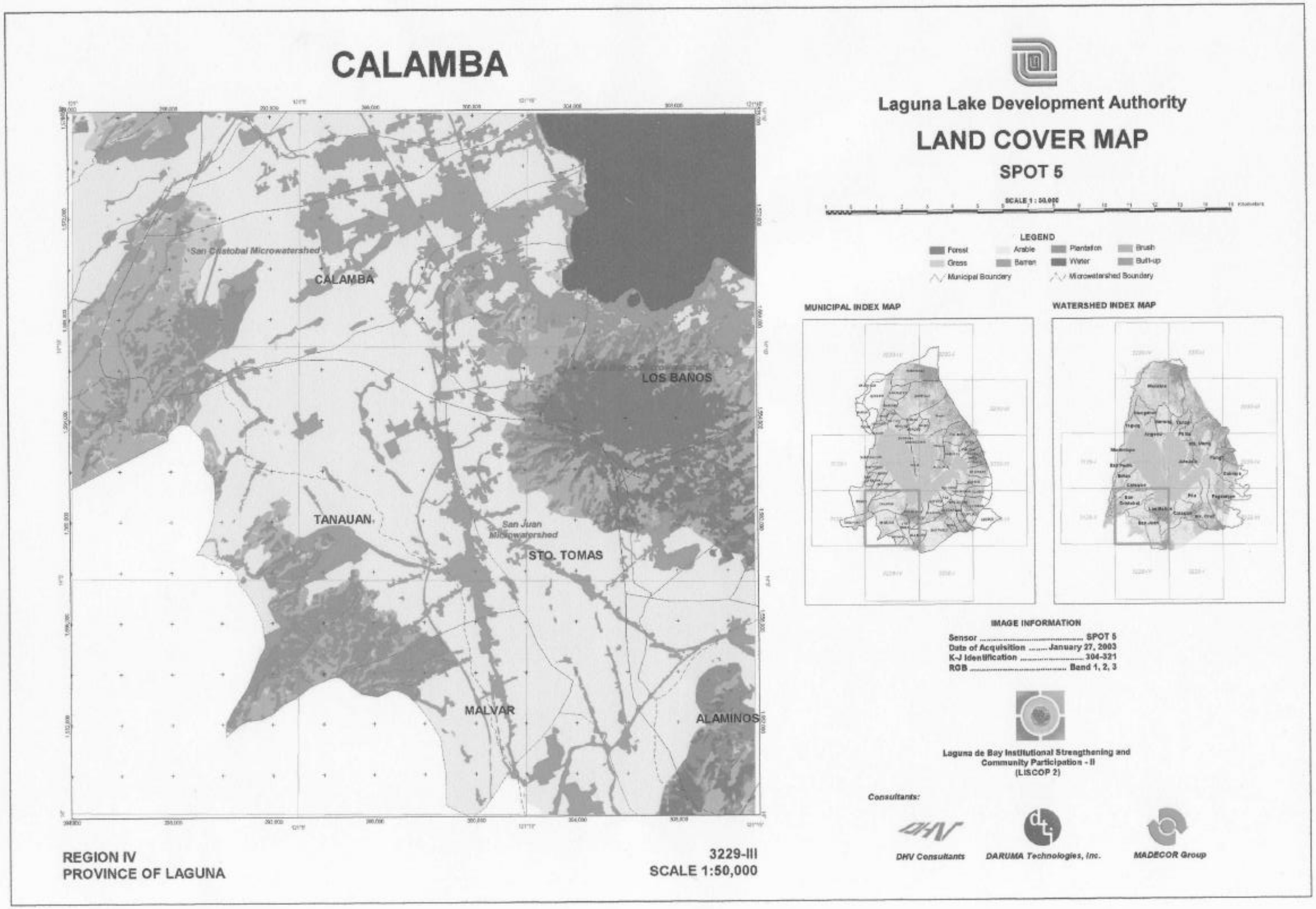
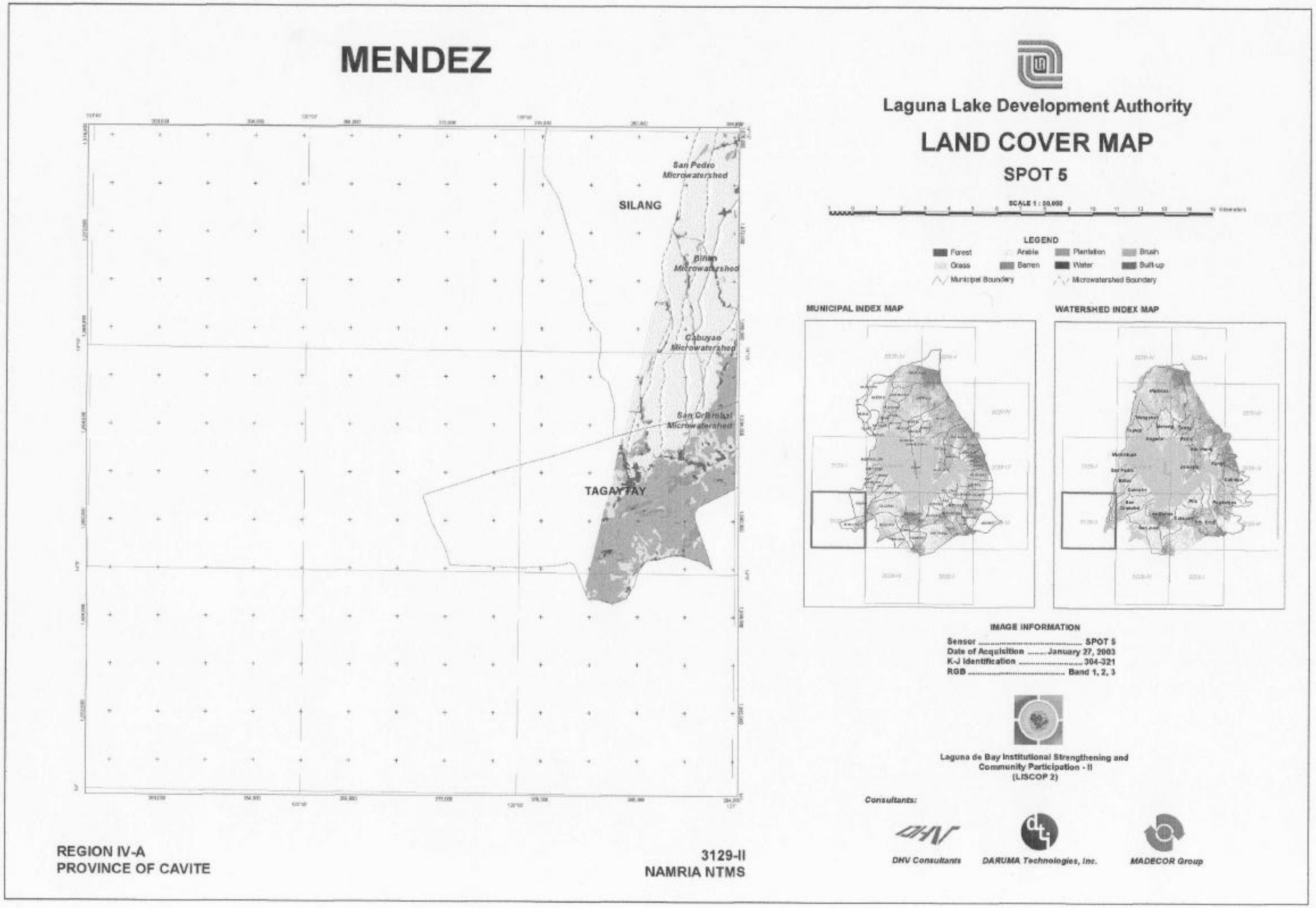

CALAMBA
Laguna Lake Development Authority
LAND COVER MAP
SPOT 5
SCALE 1 : 50,000
LEGEND
Forest
Arable
Plantation
Brush
Grass
Barren
Water
Built-up
Municipal Boundary
Microwatershed Boundary
MUNICIPAL INDEX MAP
WATERSHED INDEX MAP
San Cristobal Microwatershed
CALAMBA
LOS BAÑOS
TANAUAN
San Juan Microwatershed
STO. TOMAS
MALVAR
ALAMINOS
IMAGE INFORMATION
Sensor .... SPOT 5
Date of Acquisition .... January 27, 2003
K-J Identification 304-321
RGB .... Band 1, 2, 3
Laguna de Bay Institutional Strengthening and Community Participation - II
(LISCOP 2)
Consultants:
DHV Consultants
DARUMA Technologies, Inc.
MADECOR Group
REGION IV
PROVINCE OF LAGUNA
3229-III
SCALE 1:50,000


MENDEZ
Laguna Lake Development Authority
LAND COVER MAP
SPOT 5
SCALE 1 : 50,000
LEGEND
Forest
Arable
Plantation
Brush
Grass
Barren
Water
Built-up
Municipal Boundary
Microwatershed Boundary
MUNICIPAL INDEX MAP
WATERSHED INDEX MAP
San Pedro Microwatershed
SILANG
Biñan Microwatershed
Cabuyao Microwatershed
San Cristobal Microwatershed
TAGAYTAY
IMAGE INFORMATION
Sensor .... SPOT 5
Date of Acquisition .... January 27, 2003
K-J Identification 304-321
RGB .... Band 1, 2, 3
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DARUMA Technologies, Inc.
MADECOR Group
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PROVINCE OF CAVITE
3129-II
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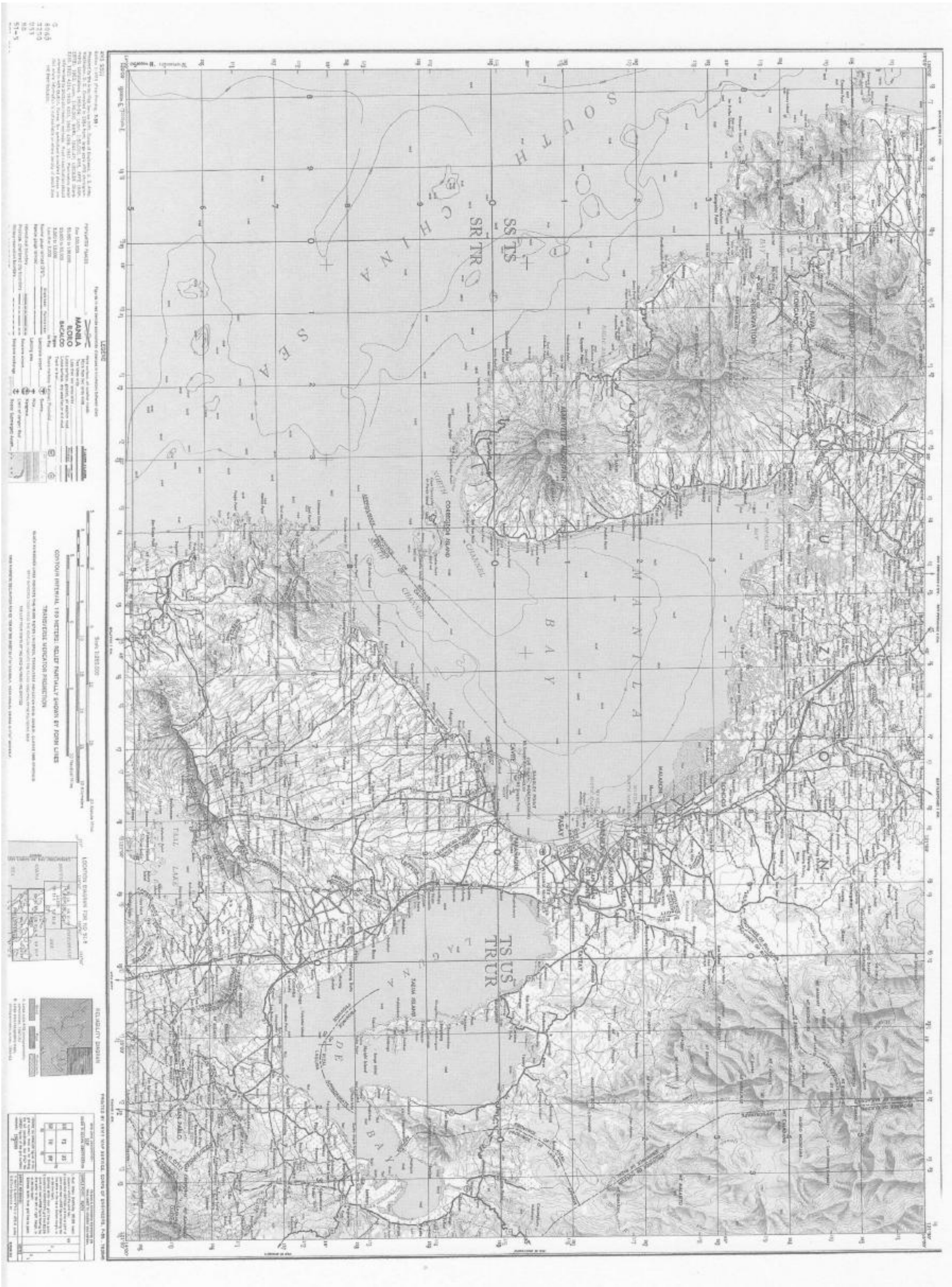
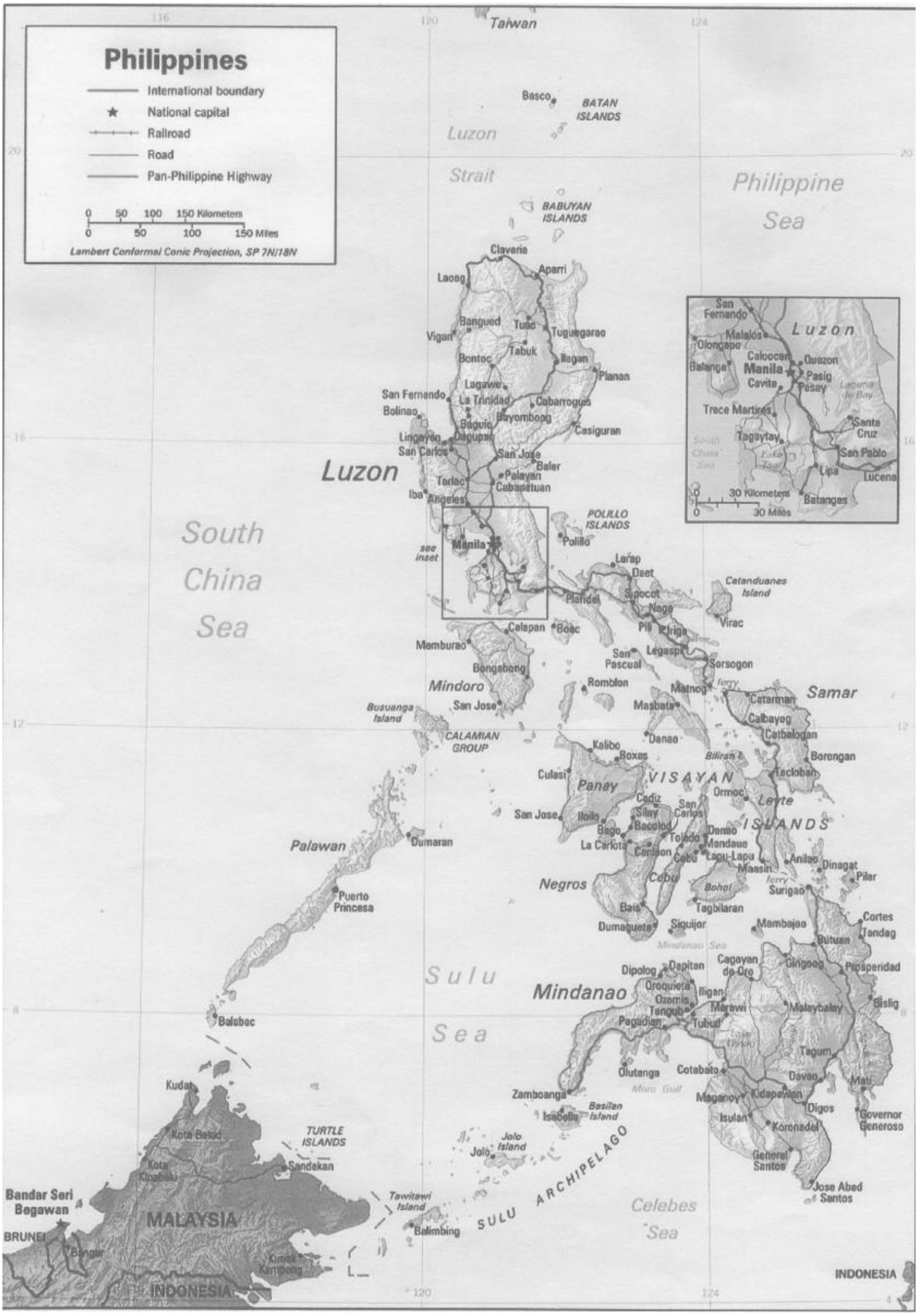
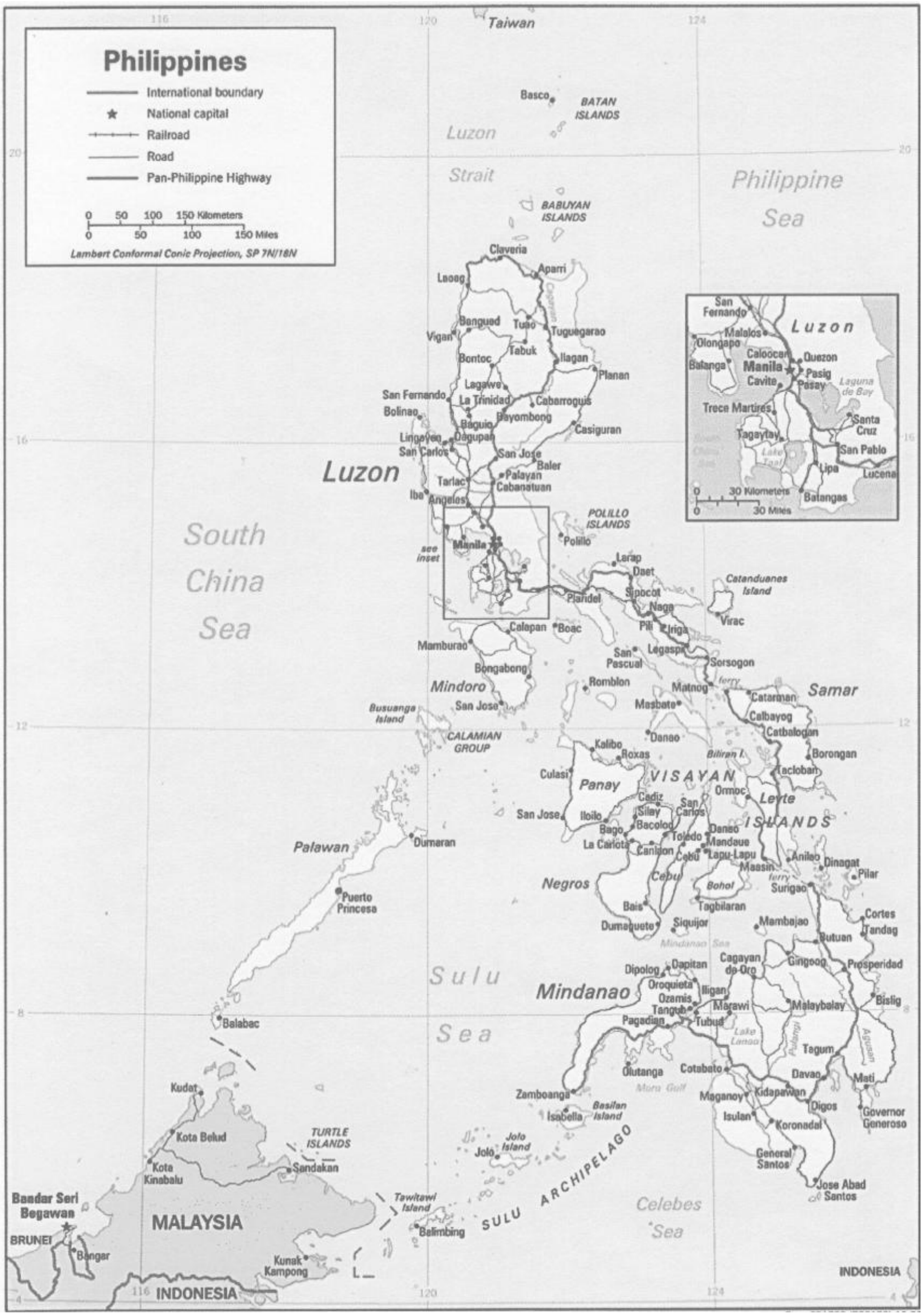



Philippines
International boundary
National capital
Railroad
Road
Pan-Philippine Highway
150 Kilometers
150 Miles
Lambert Conformal Conic Projection, SP 7N/18N
Taiwan
Basco
BATAN ISLANDS
Luzon Strait
BABUYAN ISLANDS
Philippine Sea
Claveria
Aparri
Laoag
Vigan
Bangued
Tuao
Tuguegarao
Tabuk
Bontoc
Ilagan
Palanan
Lagawe
San Fernando
La Trinidad
Cabarroguis
Bolinao
Baguio
Bayombong
Lingayen
Dagupan
Casiguran
San Carlos
San Jose
Baler
Luzon
Palayan
Tarlac
Cabanatuan
Iba
Angeles
POLILLO ISLANDS
Polillo
South China Sea
see inset
Manila
Daet
Catanduanes Island
Pandel
Naga
Virac
Calapan
Boac
Mamburao
Legaspi
San Pascual
Sorsogon
Bongabong
Mindoro
Romblon
Samar
San Jose
Masbate
Catarman
Busuanga Island
Calbayog
CALAMIAN GROUP
Catbalogan
Danao
Kalibo
Roxas
Borongan
Culasi
Panay
VISAYAN ISLANDS
Tacloban
Ormoc
Leyte
San Jose
Iloilo
Cadiz
Silay
Bacolod
Bago
La Carlota
Toledo
Mandaue
Cebu
Lapu-Lapu
Maasin
Dinagat
Palawan
Dumaran
Negros
Bohol
Surigao
Puerto Princesa
Bais
Tagbilaran
Dumaguete
Siquijor
Mambajao
Cortes
Tandag
Sulu Sea
Dipolog
Dapitan
Cagayan de Oro
Gingoog
Prosperidad
Mindanao
Oroquieta
Iligan
Ozamis
Marawi
Malaybalay
Bislig
Balabac
Pagadian
Tagum
Cotabato
Davao
Zamboanga
Basilan Island
Isabela
Mati
Digos
Kudat
Kota Belud
TURTLE ISLANDS
Jolo
Jolo Island
Isulan
Koronadal
Governor Generoso
Sandakan
Kota Kinabalu
General Santos
Jose Abad Santos
Bandar Seri Begawan
SULU ARCHIPELAGO
Celebes Sea
MALAYSIA
Tawitawi Island
BRUNEI
Bongao
Balimbing
INDONESIA
Luzon
San Fernando
Malolos
Olongapo
Caloocan
Quezon
Balanga
Manila
Pasig
Cavite
Pasay
Laguna de Bay
Trece Martires
Santa Cruz
Tagaytay
San Pablo
Lipa
Lucena
30 Kilometers
30 Miles
Batangas


Philippines
International boundary
National capital
Railroad
Road
Pan-Philippine Highway
0 50 100 150 Kilometers
0 50 100 150 Miles
Lambert Conformal Conic Projection, SP 7N/18N
Taiwan
BATAN ISLANDS
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Mindanao
Basilan Island
Jolo Island
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Tawitawi Island
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Celebes Sea
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BRUNEI
Bandar Seri Begawan
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Manila
Quezon
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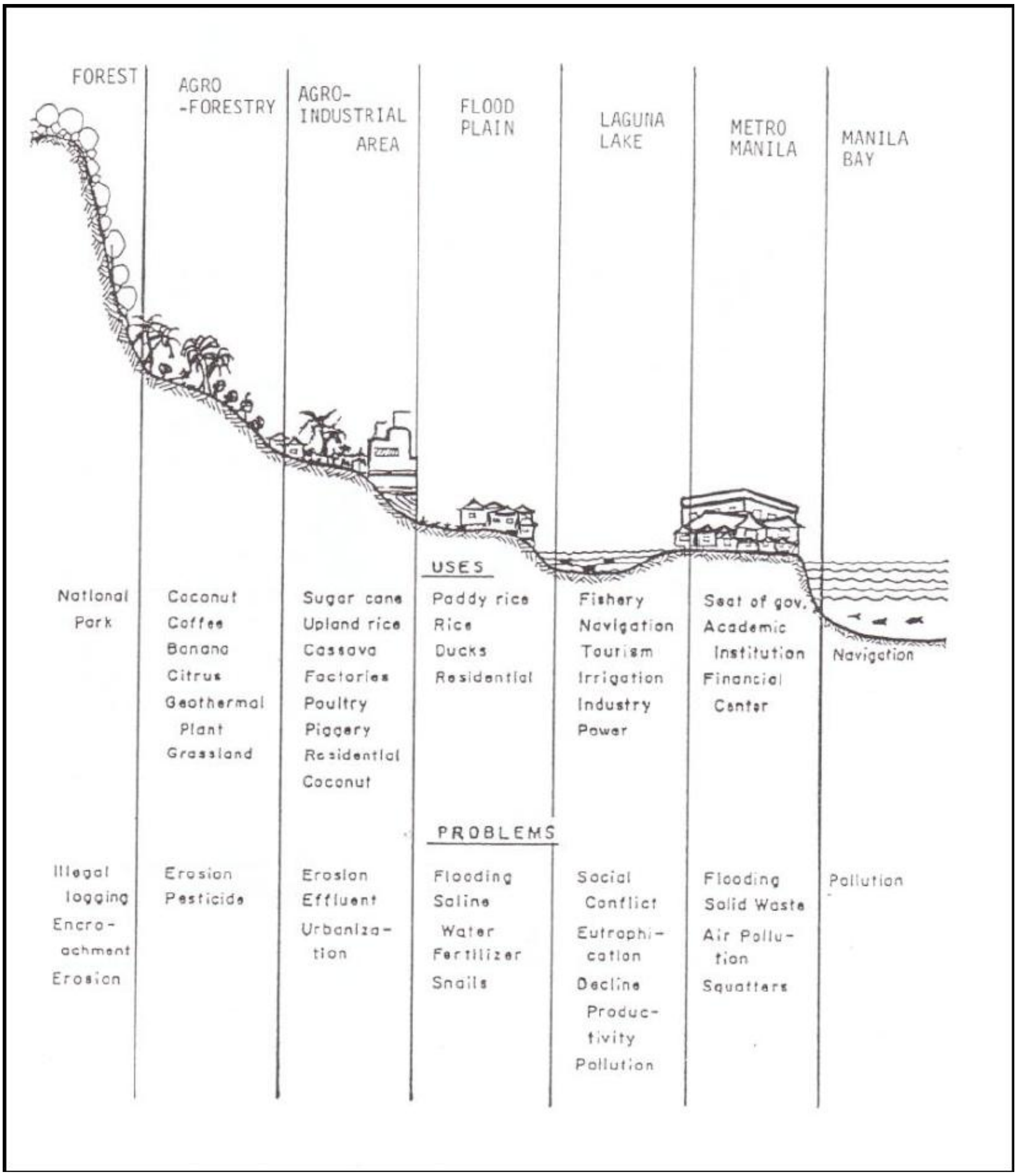
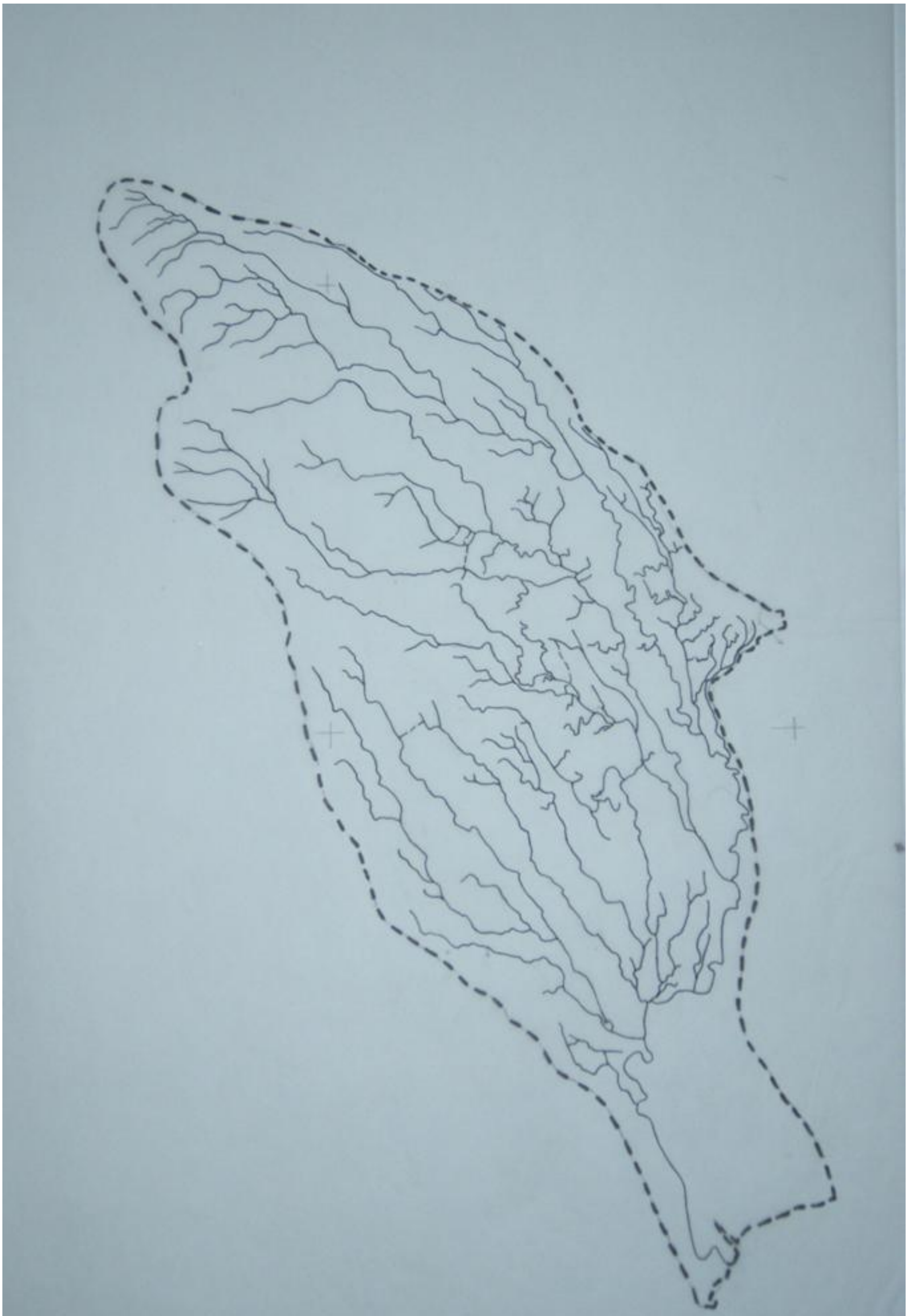
Zamboanga

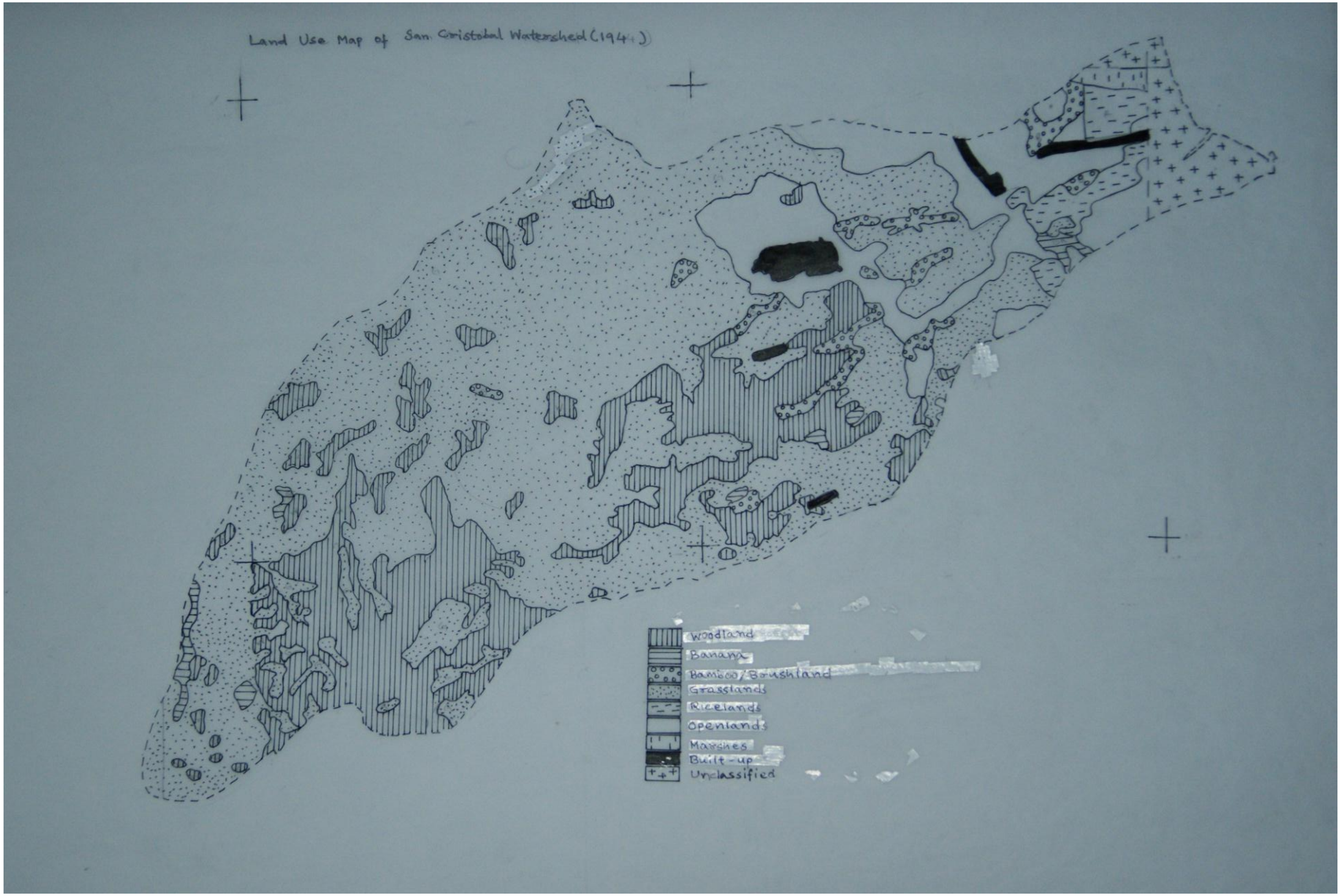

FOREST
AGRO -FORESTRY
AGRO- INDUSTRIAL AREA
FLOOD PLAIN
LAGUNA LAKE
METRO MANILA
MANILA BAY
USES
National Park
Coconut
Coffee
Banana
Citrus
Geothermal Plant
Grassland
Sugar cane
Upland rice
Cassava
Factories
Poultry
Piggery
Residential
Coconut
Paddy rice
Rice
Ducks
Residential
Fishery
Navigation
Tourism
Irrigation
Industry
Power
Seat of gov.
Academic Institution
Financial Center
Navigation
PROBLEMS
Illegal logging
Encro-achment
Erosion
Erosion
Pesticide
Erosion
Effluent
Urbaniza-tion
Flooding
Saline Water
Fertilizer
Snails
Social Conflict
Eutrophi-cation
Decline Produc-tivity
Pollution
Flooding
Solid Waste
Air Pollu-tion
Squatters
Pollution

Lake Basin	In-lake						Basin origin						Regional/Global		
	① Unsustainable fishing practices	② Introduced faunal species	③ Salinity changes	④ Weed infestations	⑤ Nutrients from fish cages	⑥ Loss of wetlands	⑦ Excess sediment inputs	⑧ Non-point source nutrients	⑨ Agro-chemicals	⑩ Water abstraction and changes in run-off	⑪ Effluents and stormwater	⑫ Industrial pollution	⑬ Atmospheric nutrients	⑭ Atmospheric industrial contaminants	⑮ Climate change
Aral Sea			→			→				→					
Baikal							↓				↓	→		→	
Baringo	→						↓			↓					↓
Bhoj Wetland							→	→	→		→	↓			
Biwa				→		↓		→	→	↑	↑				↓
Chad						↓	↓			↓					↓
Champlain								↑			↑			→	
Chilika Lagoon			↑	↑			↓	↓	↓	↓	↓				
Cocibolca/Nicaragua							↓		↓		↓				
Constance		↓				→		→	→		→				
Dianchi					↑	↓	↓	↓	↓	↓	↓	→		→	
Great Lakes (N.Am.)		↓						↓	↓		↑	→		→	
Issyk-Kul		→					↓	↓	↓			↓			↓
Kariba Reservoir					↓			↓			→				↓
Laguna de Bay	→	↓	→	→	↓		↓	↓			↓	→			
Malawi/Nyasa	↓			↓			↓	↓	↓	↓	↓		↓		↓
Naivasha	↑	→		↑		→	↓			→	↓		↓		
Nakuru							→	→		↓	↓				
Ohrid	→	↓				↓	↓	↓	↓		↓				
Peipsi/Chudskoe	↓			→				→			↓	→			
Sevan	↓	↓				↓	↓			↓	↓				
Tanganyika	↓						↓				↓	↓			↓
Titicaca		↓					↓				↓	↓			
Toba	↓	↓		↓	↓	↓	→	→	↓	↓	↓		↓		
Tonle Sap	↓	↓					↑				↓				
Tucurui Reservoir				→			→								
Victoria	→	↓		↑		↓	↓	↓			↓	↓	↓		
Xingkai/Khanka	↓					↓	↓		↓		↓	↓			
Total	12	11	3	9	4	11	21	16	12	11	23	12	4	4	7



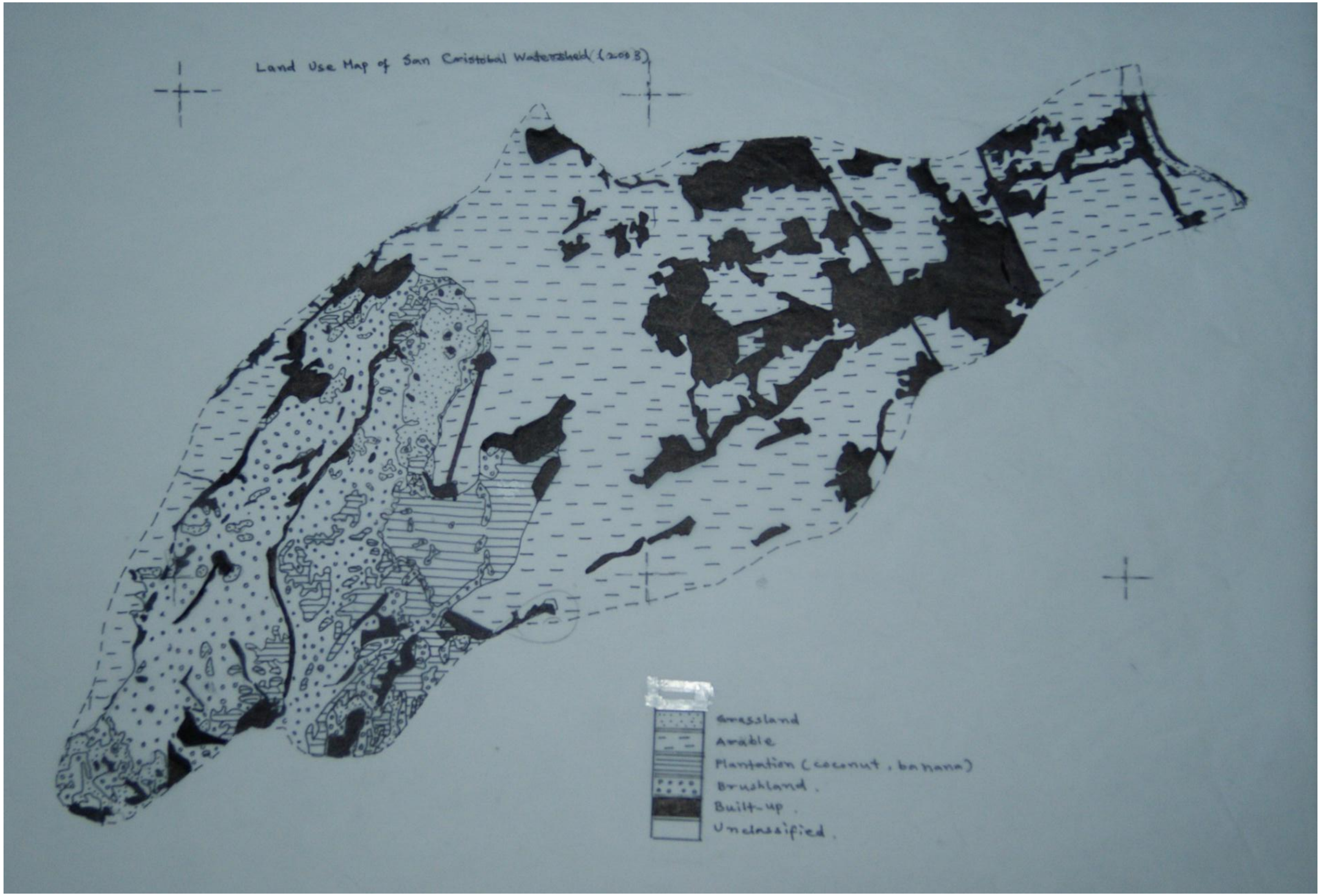
The San Cristobal Watershed

Land use in San Cristobal Watershed (1944)



Calculation of land use in San Cristobal Watershed (1944)

Land use in San Cristobal Watershed (2003)



Calculation of land use in San Cristobal Watershed (2003)

Administrative map of the Municipality of Calamba