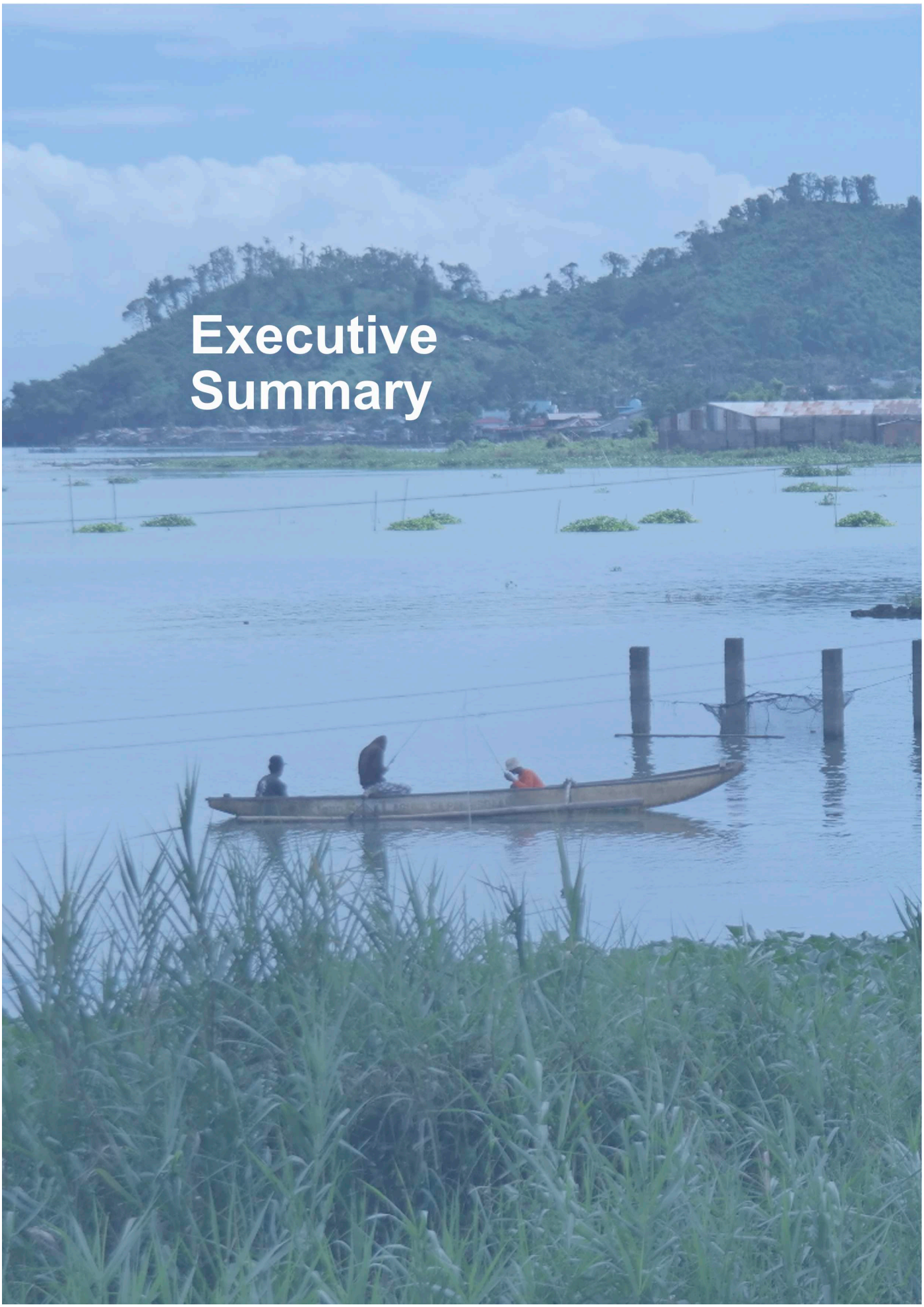
WAVES
Executive Summary
Philippines
May 2016

Laguna de Bay Basin Ecosystem Accounts

WAVES



Executive Summary

Technical Report: Experimental Ecosystem Accounts of Laguna de Bay

Introduction

Laguna de Bay, also known as Laguna Lake, is one of the two test sites in the Philippines for the Wealth Accounting and the Valuation of Ecosystem Services (WAVES) project, a global partnership led by the World Bank that aims to promote sustainable development by mainstreaming natural capital in development planning and national economic accounting systems. One of the objectives of WAVES is to pilot and test different methodologies of compiling ecosystem accounts based on the SEEA-Experimental Ecosystem Accounting framework. In particular, it needs to be tested if and how the SEEA-Experimental Ecosystem Accounting framework can provide science-based evidence and information to help assess the economic, environmental and social trade-offs of different natural resource use options and their implications for sustainable development.

The implementation of WAVES builds upon the Philippines efforts on Natural Capital Accounting (NCA) during the 1990s and early 2000s, which created the advantage that considerable capacity and technical skills still exist.

Laguna Lake Basin

Laguna Lake is the largest inland water body in the Philippines, occupying approximately 90,000 hectares. It provides for the domestic water needs of certain parts of Metro Manila, supports 14,000 fishermen, irrigates approximately 103,000 hectares of agricultural land, and supports hydropower production. The lake is also used for recreation, industrial cooling and as a waste sink.

However, the Lake is struggling under the pressures of a growing population, industrialization, deforestation, and rapid urbanization. These have resulted in its rapid degradation, causing massive changes in the Laguna de Bay catchment and lake, while also threatening water quality and ecology.

On a broader scale, this degradation may be attributed to intensified economic activities, open access to natural resources use, lack of economic resource pricing policies, and lack of common policy for management and development of the lake and its watershed.

The Laguna Lake Development Authority is the government agency tasked with the overall management and regulation of the Laguna de Bay and Laguna Lake Region.

Two areas were considered in the development of the accounts:

The Laguna de Bay ***Basin***, the physical watershed covering an area of 2920 km^2 and divided into 24 sub-basins and the Laguna de Bay ***Region***, including the provinces of Rizal and Laguna, several towns in Cavite, Batangas, Quezon and Metro Manila.

The ecosystem accounts developed for Laguna de Bay are based on the UN guidelines for Experimental Ecosystem Accounting, as well as guidance provided through the ongoing development of an Ecosystem Accounting Technical Guidance document.

The ecosystem accounts being developed for the Laguna de Bay are as follows:

Account	Explanation	Application to Laguna de Bay
Land Account	Contains information on land cover, land use and land titles	A land cover account was prepared for Laguna de Bay for 2003 and 2010
Water Account	Contains information on stocks of water and changes therein, as well as water quality	A water account was prepared for Laguna Lake, covering the period 2003-2012
Ecosystem Condition Account	Measures the physical condition of ecosystems (and trends in condition)	A condition account is created for the Laguna de Bay watershed including the lake itself and the surrounding area
Ecosystem Services Supply and Use Account	Measures flows in ecosystems services, per land cover/ecosystem unit and how ecosystem services are used by beneficiaries	Ecosystem Services Supply accounts are created for two ecosystem services provided by the lake (fisheries and water retention). For the terrestrial part, the erosion control services was mapped. The link to users is indicated in a generic manner (not specified per sector). Ecosystem use has been described, but not included in the account.

Natural Capital

The Philippine archipelago is rich in biodiversity, coastal and marine resources, minerals, timber and other forest products. This natural resource wealth underpins the livelihoods of farmers and fishermen and provides an important social safety net for the rural communities, especially during times of crisis. Responsible management of natural capital is also critical to ensure future profit streams for private enterprises in the tourism, agriculture and fisheries, and mining sectors, as well as revenues to local and national governments.

WAVES

Wealth Accounting and the Valuation of Ecosystem Services (WAVES) is a global partnership led by the World Bank that aims to promote sustainable development by ensuring that the national accounts used to measure and plan for economic growth include the value of natural resources.

How will WAVES help?

WAVES will help the Philippines measure the country's natural resources and evaluate how these can be used equitably and sustainably. WAVES will provide key decision makers with scientific-based evidence and information to assess the social, economic and environmental trade-offs of different resource-use scenarios and their implications on the achievement of sustainable development.

The Uses of the Ecosystem Accounting Approach

The ecosystem accounting approach is a practical and comprehensive tool to monitor changes in ecosystem condition and ecosystem use, providing information that can influence policy-making. They can be used for these purposes:

- to identify specific policy interventions needed to prevent environmental risks in the future (e.g. lack of connectivity to sewage systems that can endanger those in flood-prone areas)
- to define areas where specific policy interventions are needed (e.g. areas generating sedimentation, which should be prioritized for forest cover)
- to provide a benchmark for assessing the effectiveness of policy interventions, either through a long term monitoring system, and through a spatial information set that identifies different trends in different areas (e.g. closed forests inside and outside protected area boundaries)

This study of the ecosystem accounts will help policymakers make informed decisions that will lead to sustainable and inclusive development plans.

Land Account

Introduction

Population expansion, urbanization, deforestation and land conversion have led to massive changes in the Laguna de Bay basin and the lake itself, threatening its water quality and ecology. Understanding the implications of changes in land cover and land use is a fundamental part of planning for the sustainable development of ecosystems of Laguna de Bay Basin and monitoring how land assets contribute to the generation of economic benefits to the people living in the Laguna de Bay area.

Land account which include information on land cover and land classification can support the LLDA strategic environmental policy by providing information on the status of and trends in the land cover in the watershed, influencing both the quantity and quality of water flowing into Laguna Lake. The account can then provide guidance on efforts at land conversion that may not be aligned with development plans or planning laws, enabling better enforcement of such regulations.

Methodology

Land cover was analyzed using map data from National Mapping and Resource Information Authority (NAMRIA), supplemented with information from European Space Agency (ESA) on forest cover. The land cover maps are used in ecosystem accounting in a number of ways: to provide useful information in support of policy making; and to serve as a basis for calculating the supply of ecosystem services.

(i) Data scoping and selection of parameters and aggregation level of information (e.g., land classification system to be used, land cover units, land use, etc.)

(ii) Data collection including ground truthing of data, preparing remote sensing images for classification and processing of data;

(iii) Development of maps and tables of land cover units;

(iv) Calculation of land cover change over time, assessment of accuracy and conduct of validation activities

Results

Major land cover changes in the basin were observed from 2003 through 2010. Closed forest decreased by 35% while built-up areas increased by 116 %. These are due to rapid urbanization and industrialization in the lake region, especially in the Greater Metro Manila area; conversion of agricultural lands to residential uses; and the construction of new settlements close to the lake shore, in the zone vulnerable to flooding. (Figure 1)

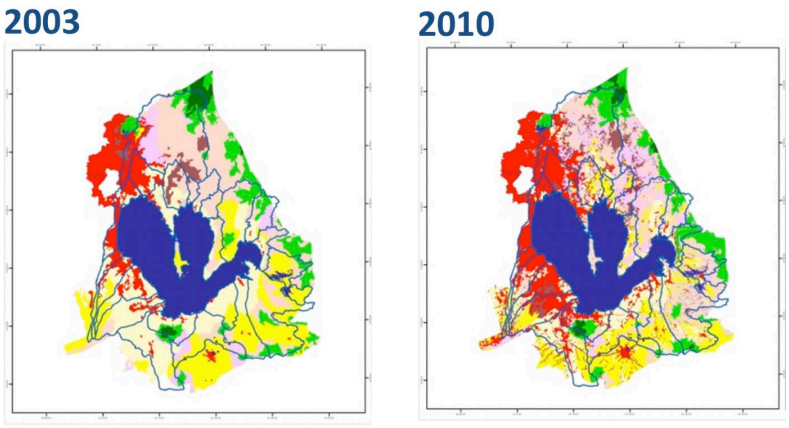
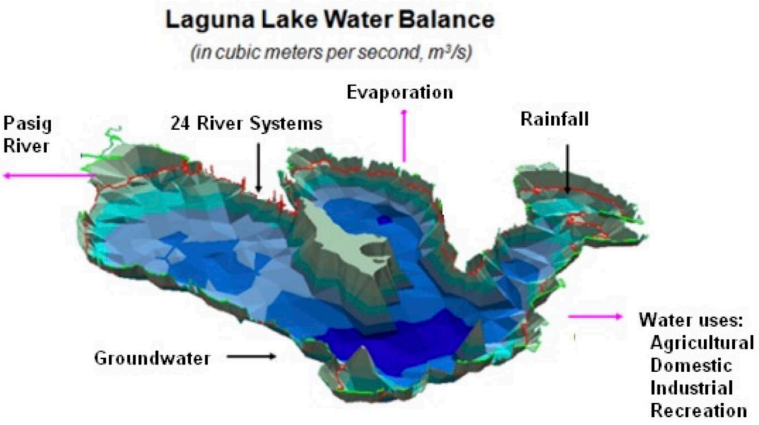


Figure 1. Areas in red illustrate the unplanned urban sprawl in the western part of the Laguna Bay region from 2003-2010

Closed forests decreased by 35% while built-up areas increased by 116%

The forest cover underwent a very rapid decline in the same period. All mangrove forest (except one 1-ha patch) disappeared, and closed forest decreased by 35%. Remaining forests in the Makiling Forest Reserve and Sierra Madre mountain ranges are home to illegal settlements. These remaining forest areas should be preserved as they maintain the ecological balance of the lacustrine region. In addition, there are still many parts of the region that should be reforested by law (P.D.705) such as the above-18-percent slopes and above-1000-meter elevations in the Sierra Madre Mountain foothills in Rodriquez, San Mateo, Antipolo, Tanay, Pagsanjan and Sta. Cruz.

Water Account



Introduction

Laguna de Bay suffers from a number of water management issues due to a variety of factors: rising demand from a growing population, increased aquaculture activities, and pollution. To further ensure the availability of surface waters for various users and minimize conflicts through systematic water allocation, there should be a firm basis for the amount of water allocated for certain users over a certain period of the year and location in the region.

The Water Account which records the physical stocks and flows of water was used to assess the water resources in the Laguna De Bay Basin for the years 2000 until 2012. The account can then support policy development on sustainable water resources management which entails monitoring activities of waterflows, water balance assessments, identification of constraints in water availability (in time, space and in terms of water quality) and prioritization of preferential use of water, among others

Methodology

The Laguna Lake water balance was produced with the support of Hydrology and Hydrodynamics Model of the LLDA Decision Support System (DSS). The DSS is a flexible tool consisting of an interconnected set of modeling tools which are refined by calibration using actual data. The LLDA DSS provides balanced decision making based on a comprehensive assessment including several modules.

Results

The stock of lake water varies considerably over the years. While there was an increase in stock in 2005, 2007 and 2010, the rest of the years show more water loss. This decrease in stock can be attributed to abstraction, evaporation and outlet discharges than replenishment (or inflows). Currently, there will be no issue on water quantity as the stock of water in the lake can be expected to remain relatively constant. This is because the lake will be replenished over time from rain water at low water levels while at high water levels, the outflow to Manila Bay will increase. However, there is a need to determine the optimum volume such that the lake can still support multiple uses to prevent over-abstraction.

Ecosystem Condition Account

Introduction

Ecosystem degradation can largely affect the components, processes and functioning of the ecosystems. The state of the terrestrial and aquatic condition of the Laguna de Bay basin are important in the analysis of the services (i.e., provisioning, regulating, cultural, supporting) that the ecosystem provides. The information on the key variables are useful in understanding the services provided by the uplands and in particular for modelling erosion and the sedimentation control services of the upland ecosystems.

The aquatic condition account, on the other hand, provides information about the changes on lake volume that can be linked to sedimentation. Pollution loading and water quality were analyzed, particularly estimation of BOD loadings from the different sources of pollution. The accounts may pave way for the determination and assessment of appropriate treatment and mitigation strategies to improve the condition of the Laguna de Bay basin.

Terrestial Condition

The key variables that were selected to assess the terrestrial condition and analyze ecosystem degradation include: (i) soil loss; (ii) hazards; (iii) key biodiversity areas; and (iv) forest cover. These indicators can provide insight into key ecosystem degradation processes that take place and potential consequences for people in addition to changes in ecosystem services supply.

Methodology

The data for the Condition Account were collected from international and local sources. The European Space Agency supported Gecomon project, implemented by GeoVille, mapped forest cover for the Laguna de Bay, which can be used to enhance the erosion modelling of the SedNet model.

Results

One of the major problems affecting Laguna de Bay is the accelerated soil erosion in the watershed, which is acknowledged to be the main contributor to siltation in the lake. The Pagsanjan River Basin followed by Marikina River Basin are the major contributors of sediment loadings in Laguna de Bay.

Accelerated soil erosion in the watershed is the major contributor of sediment loading of Laguna Lake

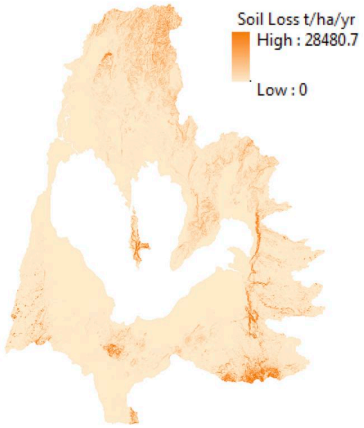


Figure 1. Soil Loss (t/ha/yr) using RUSLE

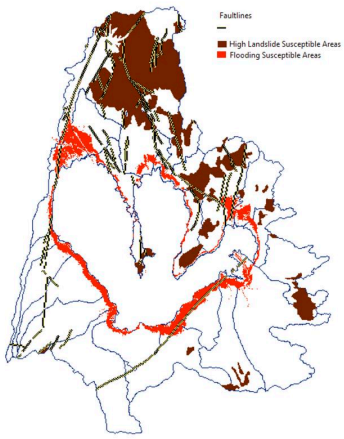


Figure 2. Hazard Prone Areas

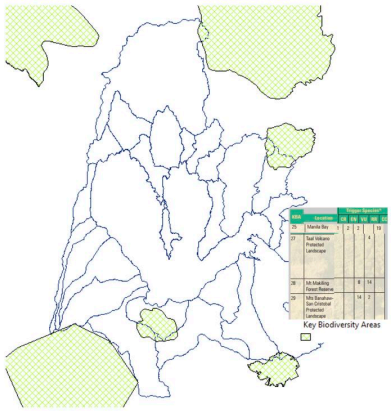


Figure 3. Key Biodiversity Areas

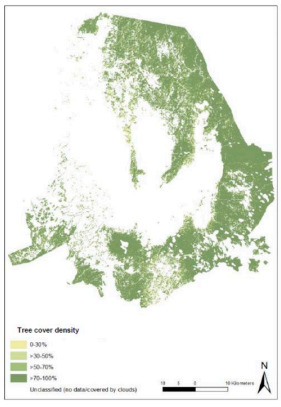


Figure 4 Forest Cover Source (Geoville,2015)

Aquatic Condition Account

Bathymetry

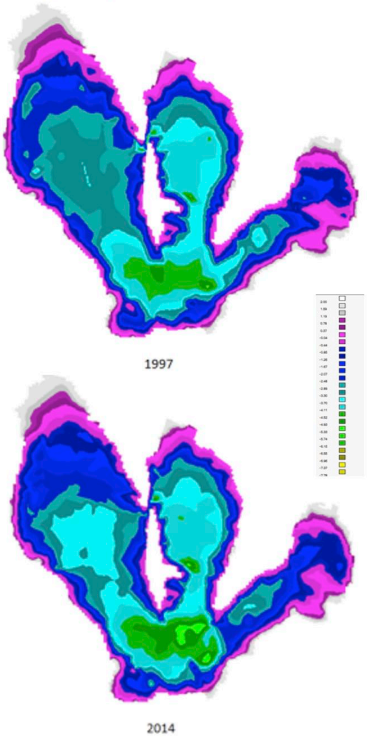
Bathymetry is analyzed to assess how the lake volume has changed over time, and to establish if and how sedimentation has affected the water storage volume of the lake.

Primary data was collected in the lake using an Echo-sounder (multi-beam), for two years. In 1997, around 350+ points of water depth were measured. In 2014, over 500 points were analyzed. Interpolation between points to model total depth of the basin was done using ArcGIS (Spline with barriers) and Delft3d (for comparison of results).

Results

The results show a small reduction in the lake volume in the period 1997 to 2014 (<5%). The main patterns of change is that the deeper parts of the lakes became somewhat deeper (1 to 2 cm) over time, in particular in the western and central part of the lake. Noticeable is the decrease of 10.5 m lake surface area, which can be attributed to sedimentation and land reclamation. It appears as if the overall volume of the lake to contain water and to drain water to the Pasig channel has not markedly changed in this period, but that the lake volume between 10.5 and 12.5m water level has decreased. This is mainly due to backfilling of the lake with sediments deposited nearby river outlets in the lake. The likely impact of shallowing of the periphery and decreasing water volume retention is increasing flood frequency in flood plains of the lake if the capacity of the Pasig River channels, the only outlet of the lake, is reduced.

Lake Depth Comparison 1997 and 2014



Water Pollution Loading in the Lake

Pollution from domestic, industrial and agricultural/forest sources that are discharged into the lake compromises water quality. Organic pollution was identified as one of the principal problems of the Laguna Lake in one of the studies conducted before the implementation of the Environmental User Fee System in 1997. Hence, this pilot account focused on the analysis of Biochemical Oxygen Demand (BOD) as an indicator of organic pollution loading in the lake. Other pollutants will be included in future reports. The water pollution loading could be linked to the results of the water quality analysis of the river systems within the Laguna de Bay Watershed, covering the period 2003 to 2014.

Methodology

Calculation of BOD loadings of industry, domestic, agriculture, solid wastes, etc. were based on actual available data. Data were also expanded and adjusted based on either actual figures and/or various scenarios of each sources of pollution for a particular year. Formulas and templates for the estimation of BOD loadings from domestic effluents, solid wastes, agricultural and forest run-off were based on the "Estimation of Annual BOD Loading in the Laguna Lake" study conducted by LLDA.

Industries were re-classified to 4 major categories: (1) Agriculture industry, (2) Accommodation and food services (hotel, motel, commercial establishments, etc.), (3) Manufacturing and others, and (4) Sewage treatment. Annual BOD loadings from industries and count per category were summarized.

Results

The account shows that BOD loading into the lake has increased over time, even though there has been an increase in sewage treatment in the last decade. The analysis shows that 81% of the BOD load comes from domestic wastes, 9% from industry, 5% from agriculture, 2% from forest and 3% from solid waste. This indicates that treating household discharges has a lot of potential for improving the water quality of Laguna Lake.

Water Quality

In order to assess the status of the lake under different circumstances, water quality monitoring has been part of monitoring activities of LLDA. The account then supports the evaluation of the lake's water quality and its tributary rivers through the years using the Biochemical Oxygen Demand of the different stations, and shows how the quality has changed during the years 2003, 2010, and 2013.

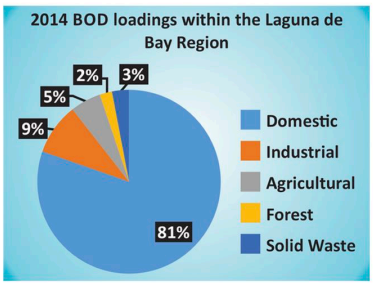
Methodology

Assessment of water quality was done by comparing the Actual BOD Loading (using 2013 data) versus the BOD Loading generated by Waste Load Model based on the actual BOD loading data for industries, domestic waste, and solid waste.

BOD was measured and streamflow for the river sampling stations was recorded as well. The Water Mondrian Model was used to determine the water quality classification of the rivers and lake while the Waste Load Model was used in the data processing, which measures the amount of BOD load produced by human activities and the amount of substances that ends up in the lake after passing through treatment facilities, sewer systems or natural processes in surface waters. The discharge rate of the river, the distance, section width, depth and average velocity are then measured and recorded.

Results

The water quality of the lake has not deteriorated strongly in the examined period, in spite of the increase in BOD loading. An increase in BOD concentration is however observed in some river stations such as Marikina, Cabuyao, Morong Downstream, San Cristobal, Tunasan Downstream. The stations showing the strongest decline in water quality are mostly located in the West Bay zone of the basin corresponding to the areas with the largest increase in population density over the same period.



Report Highlights - Ecosystem Services

Fisheries

Laguna de Bay is a multiple use resource, but the dominant use is for fisheries, i.e., capture fisheries and aquaculture through fishpens and fishcages. It is for this reason that the lake is classified as a Class C water body, i.e. its water quality needs to be suitable for fishery as per Department Administrative Order 34 (DAO 34) of the Department of Environment and Natural Resources. Fisheries revolves around several fish species.

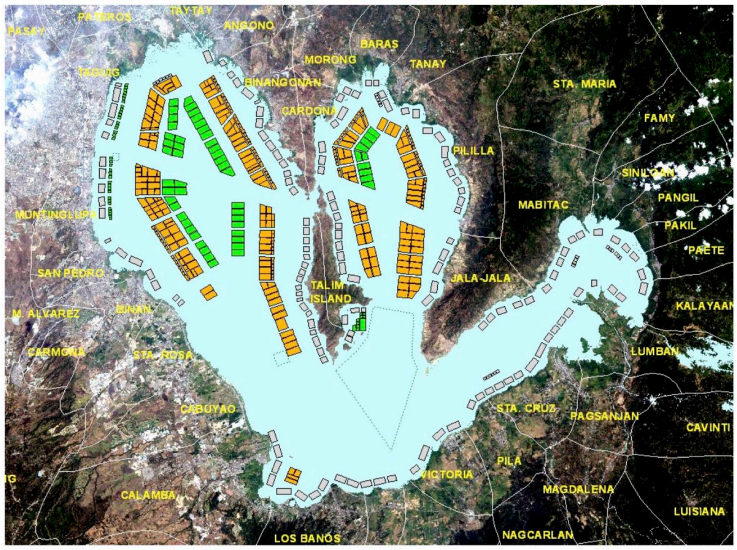
The Fisheries Account provides a comprehensive assessment of the use of the Laguna Lake for fisheries including open-water capture fisheries, and aquaculture with fish pens and fish cages, in both physical and monetary terms. No previous comprehensive assessment has yet been carried out for the lake. Further, the information is meant to serve as basis for formulating policies that would be crucial in addressing issues pertaining to the dominant use of the lake for fisheries and in rationalizing the fishpen fee and fishcage fee (resource user fees).

Methodology

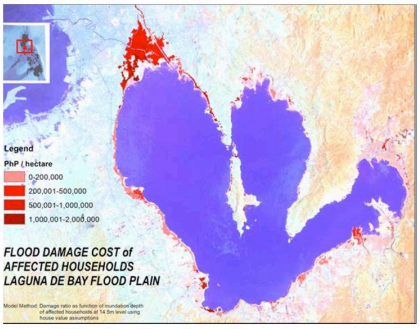
The assessment was conducted for the year 2014 and covers the whole Laguna Lake, subdivided into the West Bay, Central Bay and East Bay. A desk study on fish production type and their market value was done. A field survey was then undertaken covering the entire lake including the Metro Manila area to determine the production and the Resource Rent (RR) from fishpens, fishcages and capture fisheries. Two kinds of survey questionnaires were prepared, one for aquaculture operators and one for fishermen.

Results

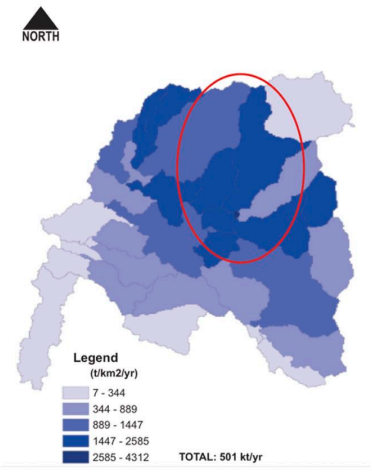
Considering the uncertainties and limitations, the account still shows that fishpens and fishcages generate a resource rent that is higher than capture fisheries, with fish cages generating a considerably higher resource rent than fishpens. Note that, generally, the fish cages are operated by small-holders and the fish pens by larger operators. However there is considerable uncertainty around these figures. Capture fisheries generates the highest total resource rent and employs around 14,000 people. The accounts also shows that there are important differences between the different parts of the Bay, with the western part the most profitable for both capture fisheries and the two types of aquaculture. This is due to the regular intrusion of salt water, creating a brackish water environment that is suitable for the highest value fish, i.e. milkfish.



ZOMAP 1999 showing fish pens and fish cages



Flood Risk Potential Damage Cost



Detailed information on areas generating sediment loads in the Marikina sub-basin

Flood Control

The flood control service of the lake refers to the capacity of the lake to store water that would otherwise have led to flooding of other areas. The flood control service is affected by the inflow of sediments in the lake. Sediments are deposited in the form of backfilling of the shores of the lake, which reduces the water retention volume of the lake. As a result, the water retention capacity of the lake is reduced by the settlement of people close to the mean annual high water level. In case of high rainfall events such as typhoons, these houses are at high risk of being flooded.

The account can provide a number of insights that are relevant for policy making such that it reflects the flood risks in the lake zone given the population in the lake shore.

Methodology

The flood retention service was analyzed in a number of subsequent steps: i) Analysis of the population density and number of houses in each 1m zone above the 12.5 m water level; ii) Calculation of the number of houses per flood zone; iii) estimation of the amount of damage based on inundation depth, the duration of the flood, the type of construction and materials used (wood, concrete, bricks, etc.) and the use of flood control measures; iv) Preparation of a simple spreadsheet model in order to relate flood level, in each year, to damage costs; and v) model calculations of the damage costs which allows predicting flood damages as a consequence of flood levels in the future.

Overall, the value of the ecosystem service 'water retention' can be approximated by comparing flood levels with and without the water storage volume of the lake.

Results

The Ecosystem Accounts show that the flood risks in the lake zone have substantially increased in the last decade, mainly because of an increasing population in the lake shore. Climate change may increase these problems in the future, due to both potential increases in extreme events and sea level rise making drainage from the lake to Manila Bay even harder.

The model developed for the account forecasts a specific number of houses that would be flooded in each municipality around the lake for any given flood level, which could be helpful for updating emergency response plans. A flood risk map was also developed.

Soil Erosion Control

The ecosystem service 'erosion control' was defined as the amount of sedimentation avoided because of the vegetation cover. This was calculated by comparing the erosion and sedimentation rates in the lake that would have taken place without vegetation cover with the actual erosion and sedimentation rates. Erosion control is important to maintain the water retention capacity of the lake and reduce flood risks.

Methodology

The modelling and mapping of sediment loads for the first seven sub-watersheds was conducted with the Sediment River Network Model (SedNet). SedNet is a GIS-based water quality modelling software package originally developed by CSIRO Land and Water as part of the Australian National Land and Water Resources Audit (Wilkinson et al., 2004). SedNet, which uses a simple annual mean conceptualization of transport and deposition processes in streams, identifies major erosion processes and constructs sediment budgets on a regional scale to identify patterns in the material fluxes under normal and simulated conditions. Spatial patterns of sediment sources, stream loads, and areas of deposition within the system can be produced. The resulting budget accounts for the major sources, storage and fluxes of sediment material.

Results

The accounts show that around 2 kilo tons of total suspended sediment was discharged to the lake in 2010. Despite the current state of the ecosystem, the forest and semi-natural ecosystems in the basin are still capable of preventing around 7 kilo tons of sediment per year from being deposited into the Laguna Lake. Ongoing deforestation can be expected to increase sedimentation rates over time. Efforts should therefore be made to reduce sedimentation in the lake by protecting the remaining forests, and by rehabilitating forest cover in the most erosion-prone areas. The modelling enabled identifying zones that are particularly important as a source for sediments and that are priority areas for ecosystem restoration.

Policy Issues and Implications

1. The population density has increased very rapidly in the Laguna de Bay basin in the last decades, leading to challenges in dealing with infrastructure development needs, sewage and waste, flood control, and facilitating fisheries production.

2. The Laguna Lake plays a major role in preventing flooding in Metro Manila. Hence, the capacity of the lake to retain water during cyclone events should be maintained, by avoiding increasing urbanization of the flood prone zones, and by reducing sediment loading in the lake through protection of the watersheds.

3. There should be no further settlements in the two most risk prone zones (<2 meters above lake level).

4. To reduce flood risks, the shorelines of the lake need to be urgently rehabilitated, preferably with the mangrove cover restored. The mangroves would contribute to flood control, would serve as nursery area supporting capture fisheries in the lake, and would act as sediment trap reducing siltation rates.

5. Management of the slopes and uplands of the Laguna de Bay basin is essential in maintaining the long term viability of the lake as water storage reservoir. Maintaining forest cover is essential to reduce sedimentation, which leads to backfilling and reduces water storage capacity. The areas that contribute most to sedimentation should be priority areas for rehabilitation.

6. Forests provide a flood control service and can be included in the next phase of the account.

Policy Issues and Implications

Fisheries is a major economic activity. The accounts point to the western part of the lake being the most productive, because they have a higher salt content required for milkfish production. The resource rent generated in the different production systems could be used for setting fair fees for fishpen and fishcage operators.

7

Water quality is a constant issue in the lake. BOD levels are acceptable during most of the year for the use of the lake for fisheries. Given the ongoing increase in population density around the lake, the local authorities need to increasingly connect households, the main source of BOD loading, to the sewage system. Further analysis of inorganic pollution loading in the lake is also required.

8

Continuous efforts are needed to improve the management of sewage and waste. The accounts show that the largest source of BOD is from households (especially untreated sewage), followed by industry. Further efforts are needed to ensure that an increasing proportion of people are connected to the sewage system.

9

The effects of reclamation projects in the lake should be considered in the conception stage, as this could potentially reduce the water storage service of the lake and increase flood risks on the low lying areas. The models developed for the Ecosystem Account can be used for this analysis.

10

A pro-active approach is required to understand how the Laguna Lake's resources are changing over time, vis-à-vis demand; how degradation of the resources is affecting people; and how trade-offs in natural resource management can be handled based on comprehensive information on costs and benefits of different environmental management options. It is recommended that the accounts be produced in the future, with regular updates every 2 to 3 years.

11

Continuous data collection and improvement of the data included in the accounts is essential. It is recommended for LLDA to develop a strategy and priority listing for improving data quality in the accounts.

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Facilitated by the World Bank, Wealth Accounting and the Valuation of Ecosystem Services is a global partnership that aims to promote sustainable development by ensuring that the national accounts used to measure and plan for economic growth include the value of natural resources.