



ASSESSMENT OF THE ENVIRONMENTAL DEGRADATION AND PROPOSED SOLUTIONS IN THE LOS BAÑOS SUBWATERSHED THROUGH PARTICIPATORY APPROACHES

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Abstract - The Los Baños subwatershed has very high biodiversity attributed to the Makiling Forest Reserve that houses most of the country's important plant and animal biota. It provides surface water, and is also the major recharge zone for ground water that supplies most of the water needed by surrounding lowland municipalities. An initial rapid assessment of patterns and drivers of land-use changes, aimed at developing an understanding of the interactions between land cover, economic intensification and river-catchment functioning, in the Laguna Lake watershed was done through the conduct of Participatory Rural Appraisal (PRA) approaches on three local communities within the Los Baños subwatershed.

The three study sites underwent various land use changes in the past eight decades. Land use changes in the subwatershed were driven by demand for food, income, policy intervention, and sustainability of agricultural system. In the upstream site, the main issue was the lack of livelihood sources. In the midstream site, landslides and flashfloods were the main problems. In the coastal site, the productivity and the quality of fish caught from the lake significantly shrank due to uncontrolled dumping of toxic, domestic and household wastes into the lake. Various solutions were proposed by the communities to address these various environmental problems.

The study demonstrated the effectiveness of PRA approaches in involving the local community in understanding the environmental problems they face and crafting solutions to address their problems. It is envisioned that the implementation of the various proposed solutions will be successful since these emanate from the community.

Keywords Los Baños Subwatershed, Participatory Rural Appraisal, PRA, environmental degradation, land use change, Laguna Lake.

Introduction

The Los Baños subwatershed encompasses the municipalities of Los Baños and Bay, and the city of Calamba. A total of 44 barangays are covered by the subwatershed. In 2000, the National Statistics Office (NSO) documented a total human population of 406, 935, with 58.3% living in urban settlements and 41.7% in rural settlements. The stakeholders are classified into four major groups, namely: local resource users (e.g. households, kaingineros, hunters, agro-industries), mediating institutions, economic interest groups, and civil society (LEAP, 2005).

A major portion of the Los Baños subwatershed is the Mt. Makiling Forest Reserve (MFR). It was identified as an extremely high critical area for conservation priority in the Philippines (DENR-

PAWB and UPCIDS, 2002). About four (4) types of vegetation are recognized in Mt. Makiling based on altitude: upper montane rain forest (above 1000 m), lower montane rain forest (above 750 m), lowland evergreen rain forest (100 – 500 m), and *Parang* vegetation consisting of a mixture of grassland and second-growth forest (Fernando et al., 2004). Mt. Makiling has a very rich biodiversity, hence listed as one of the hotspots in the Philippines. It was declared a forest reserve in 1910 to function as a training laboratory because of its educational and scientific values. An estimated 225 families, 949 genera, and 2, 038 species, 19 sub-species, 167 varieties, and many cultivars of flowering plants and ferns have been recorded from the Makiling Forest Reserve (Pancho 1983; LEAP 2005). Fernando (2004) has listed 15 endemic species of angiosperms found within the area. MFR is known internationally as the home of woody plants.

In terms of faunal diversity, Mt. Makiling has a remarkable record. It is home to an estimated 120 avian species, with recorded 59 endemics belonging to 26 families (Mallari et al. 2001; Gonzales 2000). It is also identified as very high mammal important area in the Philippines with bats and rodents as the most diverse groups. With references to reptilian and amphibian diversity, 52 and 25 species have been recorded in Mt. Makiling and the vicinity, respectively (LEAP, 2005). Although no exhaustive studies on insects, except perhaps for the butterflies (Cayabyab, 2000) and mealybugs (Lit and Calilung, 1994), Mt. Makiling appears to support a very high diversity of this faunal group. With such biodiversity, the subwatershed of Los Baños-Makiling clearly offers a wide range of ecosystem goods and services.

As an economic resource base, MFR provides farming and livelihood opportunities for those residing within and along its peripheries (CLUP-LB 2006). It is the primary source of water supply to surrounding agricultural lands and communities, including the UPLB complex, numerous resorts, and the geothermal power plant. Around 20% of the more than 1,000 families living inside the MFR depend on surface water from the creeks for their needs. MFR's watersheds are likely to be the major recharge zones for ground water that supply most of the water needed by Los Baños and Calauan town, and the City of Calamba in Laguna, and Sto. Tomas and Tanauan towns in Batangas. Areas close to major rivers, especially floodplains that are characterized by unconsolidated to loosely consolidated sand, gravel, silt and clay deposits, are susceptible to erosion, scouring or undercutting during heavy and/or continuous rains wherein runoff is usually above normal. Based on slope and vegetative cover, around 40% of the MFR has moderate to high erosion potential. Areas with high erosion potential are those currently occupied, cultivated and/or open grassland (CLUP-LB, 2006).

The Los Baños subwatershed drains into the largest lake of the Philippines, the Laguna de Bay. It has a surface area of 900 km² with an average depth of 2.5 m, classifying it into one of the shallowest lakes in Southeast Asia. The water volume is approximately 2.25 km³ and this high surface area to volume ratio accounts for the lake's characteristic turbidity (Santos-Borja & Nepomuceno, 2006). The lake is bordered by the province of Laguna in the east, west and southwest, the province of Rizal in the north to northeast, and Metropolitan Manila in the northwest (Guzman and Estiva, 2006). Its 285-km shoreline delineates three (3) distinct bays; namely, the west, central, and east bays. South bay has been referred to along the southwestern towns of Laguna which includes Los Baños, Pila, Victoria, and the city of Calamba, (Santos-Borja and Nepomuceno, 2006).

The lake vegetation generally has a low diversity of vascular plants with only 19 families and 26 genera and species of herbs, climbing plants and aquatic angiosperms (Fernando, 2004). In terms of fish diversity, about 33 species have been recorded by various authors (LEAP, 2005). Of this record, 9 are indigenous, 19 exotic or introduced, and 5 are migratory. Ten (10) species of snails have been recorded to inhabit the lake. An economically important feed bivalve (*Corbiculafluminea*) for duck industry thrives in most part of the lake. Other species of mollusk include the kohol, *Pilaluzonica* and the introduced large bivalve, *Soletellinaelongata*. These species are harvested for human consumption.

Agriculture in the Los Baños subwatershed is a relatively insignificant activity in the area. Although it accounts for a small percentage of income in the subwatershed, the status of this sector must be defined as it may have an impact on the quality of the natural resources. Activities, including animal and crop production, may generate income and food supply. However, these activities may also contribute to the degradation of land and water resources. Many stakeholders in the Los Baños subwatershed engage in raising backyard animals including broiler, duck, and swine. Waste disposal management has been identified necessary for this activity. For instance, backyard swine raising is compounded by the usual lack of waste treatment and the untreated wastes subsequently reach the lake. Rice production is another activity within the Los Baños subwatershed. However, the area is not self-sufficient in rice. Factors affecting rice production include poor farm management, natural calamities such as typhoon and flood, pests and diseases, and land use change. On the other hand, aquaculture which includes fish ponds, cages, and pens is the main activity in Laguna Lake. The vast fish pen area in Los Baños produces about 80% of the total fish pen output in the entire subwatershed (LEAP, 2005).

Anthropogenic activities such as land use change, settlements, agricultural activities, and aquaculture have brought environmental degradation of the Los Banos subwatershed. Landslide, soil erosion and floods occur during rainy season, while lake pollution resulted from improper waste disposal of liquid and solid wastes into the lake as well as aquaculture activities.

Participatory Rural Appraisal (PRA) is a growing family of approaches and methods to enable local people to express, enhance, share, and analyze their knowledge of life and conditions, and to plan and to act (Chambers, 1994). The PRA is capable of preserving the community's indigenous knowledge and, most importantly, it seeks to empower people. It offers information that is generated, analyzed, owned, and shared by local people.

Assessment of the environmental degradation and proposed solutions in the Los Baños subwatershed through participatory approaches

An initial rapid assessment of patterns and drivers of land-use changes aimed at developing an understanding of the interactions between land cover, economic intensification and river-catchment functioning in the Laguna Lake watershed was done through the conduct of Participatory Rural Appraisal (PRA) approaches on three local communities within the Los Baños subwatershed. The various PRA activities aimed to document observations and local ecological knowledge on the impacts of land-use change on biomass productivity, biodiversity, soil fertility, riverine, soil erosion, and groundwater dynamics and pollution. Local communities were also asked to suggest possible solutions to the observed problems. These solutions were analyzed with the local communities. This study serves as baseline information relevant to environmental restoration and proper management of the Los Baños subwatershed natural resources.

Methodology

Participatory Rural Appraisal (PRA) activities were conducted in three sites within the Los Baños subwatershed. These sites, selected based on geographic elevation, were Brgy. Bagong Silang as the upstream site; Brgy. Lalakay as the midstream site; and Brgy. Bayog as the lakeshore site (Fig. 1). About thirty participants joined the various PRA activities conducted at each site. The participants were the elderlies, farmers, housewives, local government officers, and other members of the community who are knowledgeable on the land use changes that occurred in the area and the impacts of land-use change on biomass productivity, soil fertility, biodiversity, soil erosion, riverine and groundwater dynamics and pollution.

The PRA activities included Key Informant and Focus Group Discussion, Time Line, Community Land-use Mapping, Resource Flow Mapping, Transect Line, Causal Mapping and SWOT analysis. Key Informant and Focus Group Discussions centered on significant events through time (Time Line) such as land-use change, cropping systems practiced, and crops and trees planted in the community. Community Land-use Mapping illustrated community-based knowledge on the land-uses in the community through time. The drivers of land-use changes and the impacts of these changes on the environmental, social, and economic aspects of the community were also tackled in the Focus Group Discussion. Resource Flow Mapping of Community Resources presented the flow of resources into the household and the expenditures to meet the household requirements. Village Transect Mapping involved walking through the community to capture the community's general bio-physical composition (e.g., elevation, topography, faunal and floral composition, land-uses). Causal Mapping showed the relations and interrelatedness of the

factors that caused the existing problems in the community. Identification and Ranking of Problems and Solution Formulation summarized the community's general pressing problems, which were ranked based on the degree on how these problems affected the community, as well as proposed solutions to these problems by the community. The Strengths, Weaknesses, Opportunities, and Threats (SWOT) Analysis of the best solution probed into the community's internal strengths and weaknesses to implement the solutions to the problems. Opportunities and Threats are external factors that may affect the successful implementation of the solutions to the problems.

Results and Discussion

The PRA Sites

Brgy. Bagong Silang, the upstream site, has a rolling topography with elevations ranging from 305 to 331 masl. It is a farming community with multi-storey agroforestry systems dominated by fruit trees including coconut, *Lansium* sp., *Nephelium* sp., papaya and coffee planted along the slopes. Aside from fruit trees, banana plantations are also maintained in the area. Vegetables including squash, bitter melon and string beans are produced in sustainable home gardens. Organic farming and vermiculture are practiced to produce fertilizer for the crops.

Brgy. Lalakay, the midstream site, has a rolling to undulating topography. This site is also a farming community practicing agroforestry and vegetable growing for the market. The multi-storey agroforestry system is composed of timber species and fruit trees including *Nephelium* sp. and *Lansium* sp. Dampalit Falls is a major water source and a local tourist attraction in the area.

Brgy. Bayog, the shoreline/coastal site is characterized by a flat topography. It is a fishing community and many of the members of the community have built their settlements along the coastline. Fish pen operation and open fishing are the most common fishing methods in the community. Cutflower farming is also practiced as secondary livelihood source.

Chronology of land use changes in the three PRA sites

The major land-use changes in the upstream and midstream sites (Brgys. Bagong Silang and Lalakay, respectively) were from forest to rice cultivation to agroforestry systems and then to organic farming. The coastal site (Brgy. Bayog) exhibited both land-use and lakeuse changes. There were three major land-use changes: rice cultivation, cutflower cultivation and subdivision establishment. On the other hand, the changes in the lake activities

involve duck-raising industry and fish pen operations (Fig. 2).

Land use changes in the subwatershed were driven by the following factors: demand for food, income, policy intervention, and sustainability of agricultural system. In the 1940s, migrants from neighboring areas arrived in the MFR (Brgys. Bagong Silang and Lalakay) as they sought refuge in the mountains during the Japanese occupation. They cut forest trees to build houses and cleared grassland areas to grow rice and sweet potato for subsistence (Fig. 2). During this period, paddy rice farming was being practiced in the coastal areas of Brgy. Bayog.

PRA participants from Brgy. Bayog reported that in the early decades until the 1950's, the lake had high quality water such that they could drink water from it. Also, fish diversity and productivity were very high. The fish species include *biya*, *ayungin*, *talilong* (*banak*), *kanduli* and native carp. By the 1960s to the 1970s, the lake still teemed with fish. The abundance of fish and maximum productivity in the lake were attributed to the Napindan Channel that was opened in the early 1960s. This channel was responsible for the mixing of salt water and freshwater that greatly improved the spawning of fish species in the lake, thus their abundance and diversity. Also, during this decade, ducks were introduced in Brgy. Bayog. The ducks were free ranging, and most areas along or near the shore were devoted for duck-raising.

In the 1960s, migrant settlers in the upstream (Fig. 3) and midstream sites (Fig. 4) cultivated upland rice for home consumption and relayed this with garlic during the dry season for income. However, soil erosion led to a decrease in soil productivity. Rice and corn cultivation ceased due to high cost of fertilizer inputs. Farmers shifted to agroforestry systems by planting fruit trees such as coconut, citrus, coffee and lanzones in their cropping areas. Perennial crops provided soil cover that controlled soil erosion and improved soil fertility through time.

The implementation of the logging ban policy in the 1970's controlled the cutting of trees and the clearing of new areas for crop production in the MFR. During this decade, rat and bird pest problems severely affected the upland rice cultivation areas in Brgy. Lalakay. Thus, land-use shifted from upland rice cultivation to agroforestry. Tree species including *Gliricidia* sp. and mahogany were planted along farm boundaries for property delineation and as wind breaks to shield the fruit trees and the vegetable crops. The establishment of the adjacent Makiling Heights Subdivision in 1970 caused flooding in the lower areas of the barangay.

After the decline in rice cultivation in Brgy. Bayog in the 1970's, the community turned to cutflower and ornamental production (Fig. 5), but

continued with vegetable farming. This was driven by the higher income return from cutflowers compared to vegetable crops and seasonal planting of rice and watermelon.

The population in Brgy. Lalakay swelled in the 1980s to 1990s due to resettlement migration. In 1985, *Nephelium* sp. was extensively grown due to the presence of markets for its fruits. Also, vegetable crops were planted such as mungbean, string beans, bitter gourd and eggplant.

Another significant change in the 1980s was the boom in fish pen/cage operations in the lake. This change was driven by the collapse of the duck industry when scraping snails from the lake's floor was banned. Since then, the duck industry relied on commercial feeds that were both costly and caused pollution in the lake. The high cost of feeds, contributed greatly to the duck industry's collapse, to be eventually replaced by fish cage operation.

In the 1980s the lake's quality deteriorated particularly in Brgy. Bayog. The number of fisherfolks increased due to the profitability of fishing. However, this increase had negative impacts especially the use of active fishing gears that greatly affected fish diversity and abundance. In particular, the active gear, *kahig*, involves fishing that scrapes the bottom of the lake to maximize fish catch. Although this method enhanced nutrient cycling at the bottom of the lake, it reduced fish diversity and abundance. Since most of the species in the lake were bottom feeders and layers, the overturn of the lake bottom meant disturbing the eggs that were laid there.

In 1990, an ordinance on community nursery establishment, seedling production and planting of tree species was implemented in Brgy. Bagong Silang. At present, organic farming is widely practiced for growing vegetables in backyard gardens. Farmers have gained knowledge on organic farming through participation in trainings and seminars. Organic farming is now favored since it is sustainable and organic products command higher market prices.

Also the 1990s, marketing of fruit trees and vegetables raised by the community reached its peak in Brgy. Lalakay. However, problems on pests also started, primarily fruit flies which stained the fruits and vegetables rendering them less marketable. To control the fruit flies, the community started to apply insecticide (Malathion).

In early 2000s, many of the idle rice lands in the coastal areas were converted to subdivisions and settlements. Further, many areas previously devoted for vegetable production along the coastline were reclaimed for settlements. The increased built-up areas worsened the solid waste problems that started in the early 1990s.

Analysis of the Drivers and Impacts of Land-Use Change

Meeting demands for food subsistence was the prime driver of cutting forest trees and converting grasslands into cultivated upland farms in the 1940's (Fig. 6). Earlier crops produced were simple food sources such as *Ipomea* spp., banana and coconut, which were also the major food sources of earlier settlers in the upstream and midstream sites. The sloping topography of Brgy. Bagong Silang (30-50%) and Brgy. Lalakay (18-30%) coupled with these cultivation practices made the sites highly prone to soil erosion and landslides during heavy rains.

Cutting of trees in both the upstream and midstream sites ceased due to the logging ban in the MFR in the 1980s. The communities stopped clearing the forests, but continued tilling the lands for the planting of subsistence food crops. In Brgy. Bagong Silang, extensive rice cultivation stopped when the capital inputs for production increased. On the other hand, Brgy. Lalakay shifted its land-use because of the logging ban, rice pests and increase in labor inputs for rice.

In Brgy. Bayog, lake activities also shifted from the time the lake was considered a valuable domestic water source to the time it became polluted. Duck raising peaked from the 1960s to the 1980s, but the industry collapsed in the 1980s. This industry was replaced by fish cages and fish pens.

Environmental and Livelihood Problems in the three PRA sites

The three PRA sites experienced different land-use changes. These land-uses brought forth environmental and livelihood problems (Table 1). In the upstream site, the main issue was the lack of livelihood resources. Although this site was a farming community, the income derived from farming alone was not enough for their daily requirements. Additional income was needed, particularly livelihood for the female residents.

In the midstream site, landslides and flashfloods were the main problems. These were primarily due to the site's physical characteristics including high elevation, sloping areas and land cover. The elevation in the area averaged 300-350 masl, and slopes ranged 18-30% with cliffs and waterfalls. These physical factors coupled with anthropogenic activities including tree cutting, land clearing, crop cultivation, and conversion into subdivision rendered the area susceptible to run-off, erosion, flashfloods and landslides.

In the coastal site, the problems were related to land and the lake activities. Being a fishing community, they were generally concerned with the lake's health. Accordingly, the productivity and the quality of fish caught from the lake significantly shrank due to uncontrolled dumping of toxic,

domestic and household wastes into the lake. Also, sand along the lake shore was quarried as construction material. A general concern was the lack of information dissemination in the community about meetings and trainings on the rehabilitation of the lake. .

Causal Mapping of Problems Experienced in Los Banos Watershed

The main environmental problem in Brgys. Bagong Silang and Lalakay was landslide (Fig. 7). A major landslide caused by Typhoon Milenyo (Xangsane) in 2006 brought massive destruction of natural resources and claimed numerous lives. The steepness of the slopes in the sites (30-50%), make the terrain even more susceptible to landslide. This was coupled with poor soil drainage and high soil erodibility that rendered portions of the lands prone to collapse even when covered with vegetation.

The overall diagram of the causes of the problems in the Los Baños subwatershed is shown in Fig. 7. The problems were categorized into natural factors and anthropogenic activities. Natural factors are related to the physical factors such as geophysical characteristics (topography, soil drainage and erodibility) and climatic factors such as typhoon events. These factors induced flash floods in the upland communities of the subwatershed, causing landslides, which led to siltation and pollution of the lake and its tributaries.

On the other hand, anthropogenic factors such as population increase, economic or market-driven opportunities, power plants and surrounding institutions contributed several problems in the subwatershed. Population increase induced the lands' conversion into settlements. Land use conversion caused erosion and top soil turn-over. This, in turn, contributed to the siltation and pollution of the lake. Moreover, the Caliraya power plant and surrounding institutions in the Los Baños scientific community produced solid and liquid wastes that polluted the lake. Factories released industrial wastes which directly contributed to the lake's pollution. Other causes of eutrophication in the lake include intensive fisheries and agriculture. Intensive fisheries used commercial feeds, while intensive agriculture involved the application of fertilizers and pesticides, which contributed inorganic nutrient and organic pollutants in the lake.

Formulation of Solutions to Address the Problems and SWOT Analysis

Given the different sets of problems in each site and the subwatershed in general, the communities were asked to propose for solutions to their problems. The different sets of solutions and the Strengths, Weaknesses, Opportunities and Threats (SWOT) analyses are presented below.

A. Brgy. Bagong Silang

The main and only problem in the community in general was the lack of livelihood sources for the female sector. The proposed livelihood sources were garment-making and sewing, food processing and preservation, and organic farming (Table 2).

The provision and development of additional livelihood sources is attainable because there are seed sources for vegetable cultivation in home gardens. The seeds will come from the Municipal Agriculture Office, with the assurance that seeds come from good sources. Also, organic farming through vermicomposting is possible because of the availability of worm sources. The community acquired knowledge on vermicomposting through participation in training courses.

The main disadvantage of the community in creating and developing livelihood sources is the lack of starting capital to purchase the needed raw materials for all the proposed additional livelihood activities. The community's income from the agroforestry practices is not sufficient for buying the raw materials. This problem is aggravated by the poor road systems. Farm-to-market roads are very rugged that only horses can be used to transport the produce. If the community would engage in full-scale organic farming, it might be unable to sell its mass-produce because of the poor road network.

To circumvent the lack of capital, the community may need to organize a local credit cooperative that will provide assistance to the community members. Also, the community has confidence that institutions will support the proposed livelihood through provision of trainings and seminars that will further equip the members with the appropriate knowledge.

B. Brgy. Lalakay

The main problems of the community are the landslides and flashfloods that can endanger human life and destroy crops. The community proposed two solutions to these problems, i.e., tree planting in landslide prone areas and the creation of an early warning system for typhoons. The first solution was considered ineffective since landslides could occur regularly even with the presence of land cover. The community was much more amenable to the creation of an early warning system (EWS) to avoid casualties during typhoons or storms (Table 3).

This mechanism was devised due to the devastation that typhoons or storms could bring. Typhoon Milenyo (Xangsane) in 2006 claimed lives in the community. This raised the community's awareness on the inevitable effects of typhoons. The community had to adapt measures on how to avoid casualties when a typhoon struck (Table 4). The main strength of this system was that the community members are well aware of the existence of the EWS. In addition, the community assigned a bell

ringer (presumably a member of the community near the river) to raise the alarm if evacuation was necessary especially during heavy rains and storms. Also, water levels in the river were regularly checked by the Brgy. Captain. If evacuation happens, the community will receive relief goods from the municipal office, thus ensuring their sustenance. Also, the community sees the presence of the Camp Eldridge military camp near the barangay as advantageous since the soldiers there can help in the evacuation process.

C. Brgy. Bayog

The coastal site experiences many problems, but the main issue is the lake's pollution which decreases fish productivity, quality and diversity (Table 5). The community proposed that government agencies coordinate and strengthen the linkages with other agencies to ensure job security for its qualified and able members. Also, it was proposed that short trainings from different government institutions such as TESDA and the barangay be conducted to prepare residents when jobs become available.

Another concern was the lack of information dissemination in the community about the importance of the lake. The community proposed to have more trainings and seminars on the lake's condition, to raise awareness among residents regarding the lake's present health and status. Also, more campaign materials should be disseminated in strategic locations around the barangay to reach a wider audience, thus further raising awareness in the community.

On the other hand, environmental problems identified in the site included quarrying, uncontrolled dumping of toxic wastes, solid wastes at the bottom of the lake, and reduction in fish quality and diversity. Quarrying operations involved the removal of sand from the lake shore for the construction of houses. This is prohibited by Republic Act 8550 or "The Philippine Fisheries Law of 1998". The community proposed the strict implementation of this law, as well as the local ordinances.

The uncontrolled dumping of toxic wastes in the lake was attributed to the factories surrounding the lake. The community proposed the strict implementation of laws and policies by concerned agencies such as the Laguna Lake Development Authority (LLDA) and the Department of Environment and Natural Resources (DENR) to manage and avoid direct toxic waste disposal into the lake. Likewise, solid wastes from livestock and domestic wastes were pressing problems for the community. The community proposed the instilment of discipline among its members, as well as their participation in the clean-up drives headed by the barangay council. The community also proposed a

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more creative way in launching clean-up projects, i.e., re-launching the inactive projects “*May Pera sa Basura*” (recycling of materials to profitable forms) and contests for the cleanest household with monetary rewards. Another proposal was the establishment of material recycling facilities (MRFs) in the barangay for the conversion of non-biodegradable materials into other utilizable forms.

Lastly, the major environmental problem addressed was the pollution in the lake. Both biological and chemical pollution significantly reduced the diversity and productivity of fish in the lake. Biological pollution involved the introduction of invasive species which displaced or preyed on the native fish populations. The community proposed the regulation of the release of fingerlings of introduced species in the open waters to avoid aggravating the condition of the lake’s fish diversity. On the other hand, chemical pollution came from the intensive inputs of commercial feeds for the fish cage operations. The community proposes the regulation of fish cage operations as well as the promotion of appropriate technologies to lessen the problems spawned by these operations.

All these problems were directed to the main problems on fish diversity reduction and fish kills. The community proposed the rehabilitation of the lake as the main solution to the problems mentioned (Table 6).

The strength of this proposed solution was the presence of strong people’s organizations in the community. The FARM-C in the barangay had been very tenacious in their participation on the alleviation and general upliftment of the fisherfolks’ lives. This tenacity invoked the maximum participation and cooperation of the local governance, thus improving the relationship of the barangay government with the people.

However, to fully realize the rehabilitation of the lake, the community needs all forms of aid from the national government, including funds and institutional support. Also, the community sees that the assistance of different institutions will definitely hasten the lake’s rehabilitation. These institutions include the Bureau of Fisheries and Aquatic Resources (BFAR) and academic institutions such as University of the Philippines Los Banos (UPLB) for technical assistance and technological transfer. In addition, assistance by the LLDA though the municipal government is vital for the realization of this solution. Being the primary institution that is concerned with the lake’s health, LLDA should properly implement the governing rules and regulations to sustainably achieve this solution and to avoid the problems and inequities on the use of the lake.

Summary and Conclusion

The three PRA sites experienced different land-use changes and had various environmental problems and concerns. Land use changes in the three sites were driven by various factors such as migration, food demand, soil erosion, policies (logging ban and scraping ban on the lake’s floor), and pollution. Environmental problems in the subwatershed were due to both natural events and anthropogenic activities. Natural events include flash floods in the upland communities in the subwatershed, causing landslides, which led to siltation and pollution of the lake and its tributaries. On the other hand, anthropogenic factors such as population increase, economic or market-driven opportunities, power plants and surrounding institutions contributed several problems. Population increase induced the lands’ conversion into settlements.

In the upstream site, the main issue was the lack of livelihood sources. In the midstream site, landslides and flashfloods were the main problems. These were primarily due to the site’s physical characteristics, i.e., elevations, slope percentage and land cover. In the coastal site, the problems were related to the quality of water in the lake. The productivity and the quality of fish caught from the lake significantly shrank due to uncontrolled dumping of toxic, domestic and household wastes into the lake.

The community in the upstream site proposed the provision and development of livelihood sources for its residents. The proposed livelihood sources were garment-making and sewing, food processing and preservation, and organic farming. The main problems of the midstream community are the landslides and flashfloods that can endanger human life and destroy crops, or simply, the safety of its members. The community proposed two solutions to these problems, i.e., tree planting in landslide prone areas and the creation of an early warning system for typhoons. The coastal site experiences many problems, but the main issue is the lake’s pollution which decreases fish productivity, quality and diversity. The uncontrolled dumping of toxic wastes in the lake from factories and wastes from livestock and domestic wastes are the major sources of pollution in the lake. Strict implementation of laws and policies, instilment of discipline among community members, clean-up drives, establishment of material recycling facilities (MRFs) in the barangay for the conversion of non-biodegradable materials into other utilizable forms, regulation of the release of fingerlings of introduced species in the open waters to avoid aggravating the condition of the lake’s fish diversity, and regulation of fish cage operations are the proposed solutions to these environmental problems.

The conduct of various PRA activities had been very effective in eliciting information to understand the major land use changes, driving forces, and environmental impacts of these changes in the Los Baños subwatershed. Both natural and anthropogenic factors contribute to the various environmental problems experienced by communities in the upstream, midstream and lakeshore communities. The upstream and midstream community areas are aware of the importance of the conservation of soil thus they shifted to agroforestry system. However, the benefits that they currently derive from their agroforestry systems are not sufficient to meet their daily needs. Thus, this community needs additional livelihood sources. The community in the lakeshore area is aware that pollution in the lake is the root cause of the decline in fish productivity, quality and diversity. They have proposed several measures to mitigate pollution of the lake. The conduct of SWOT analysis have empowered the community members to analyze their strengths and weaknesses and to identify opportunities that may be helpful in addressing their current environmental problems and livelihood needs.

This study demonstrated the effectiveness of PRA approaches in involving the local community in understanding the environmental problems they faced and crafting solutions to address their problems. It is envisioned that the implementation of the various proposed solutions will be successful since these solutions emanate from the community.

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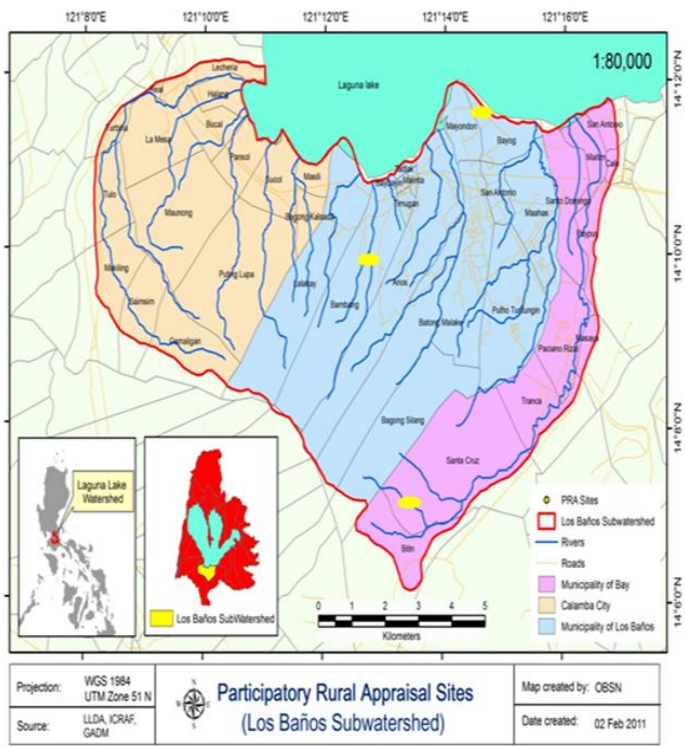


Figure 1. The Los Baños subwatershed showing the different PRA sites (highlighted with yellow dot).

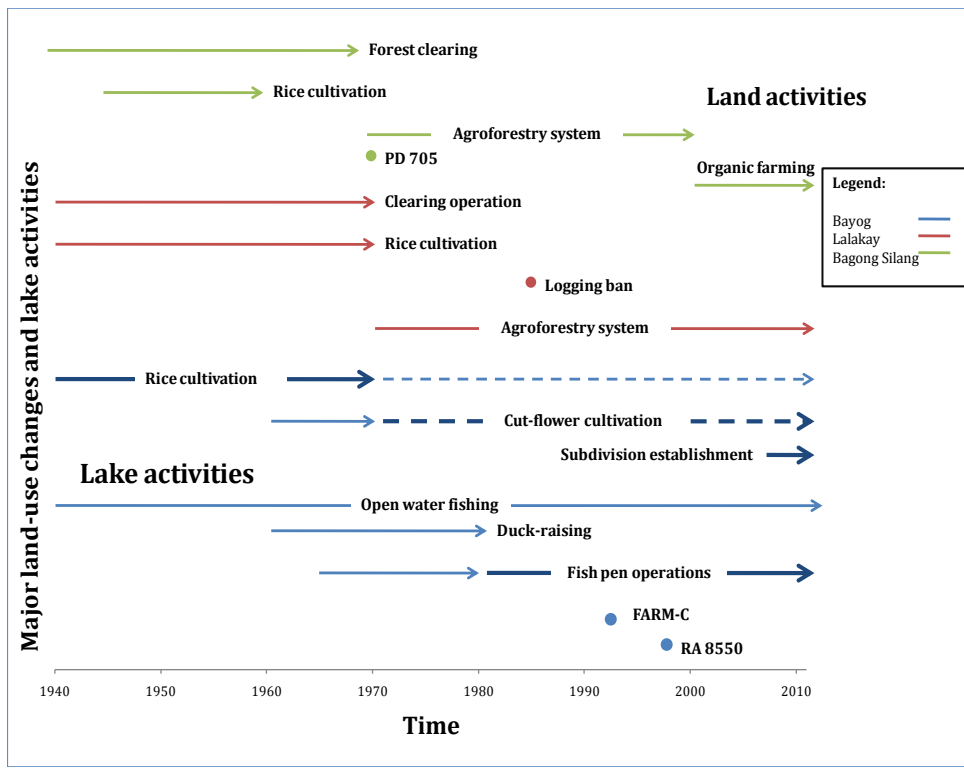


Figure 2. Chronology of the land-uses changes in the Los Baños subwatershed.

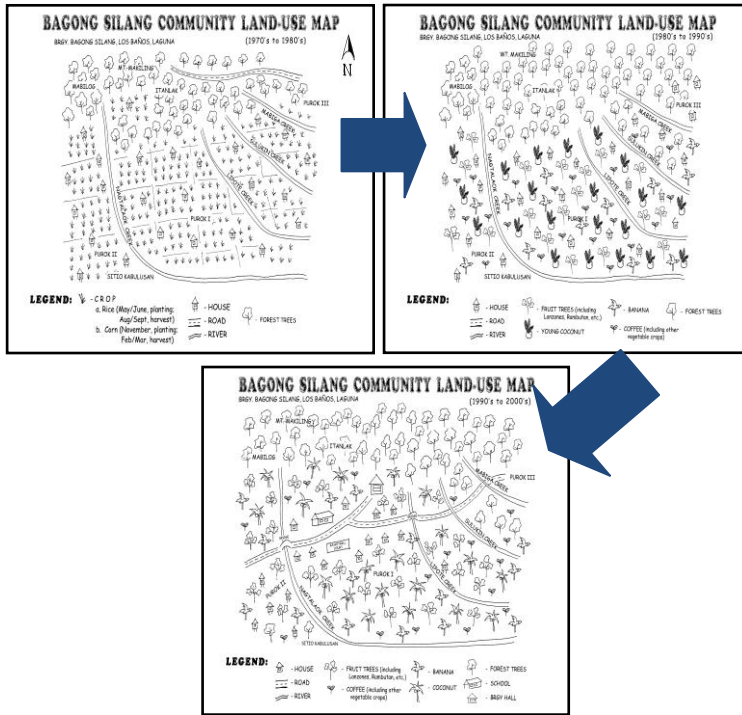


Figure 3. Community land-use maps of Brgy. Bagong Silang, Los Baños, Laguna in the 1970s-80s, 1980s-90s and 1990s-present.

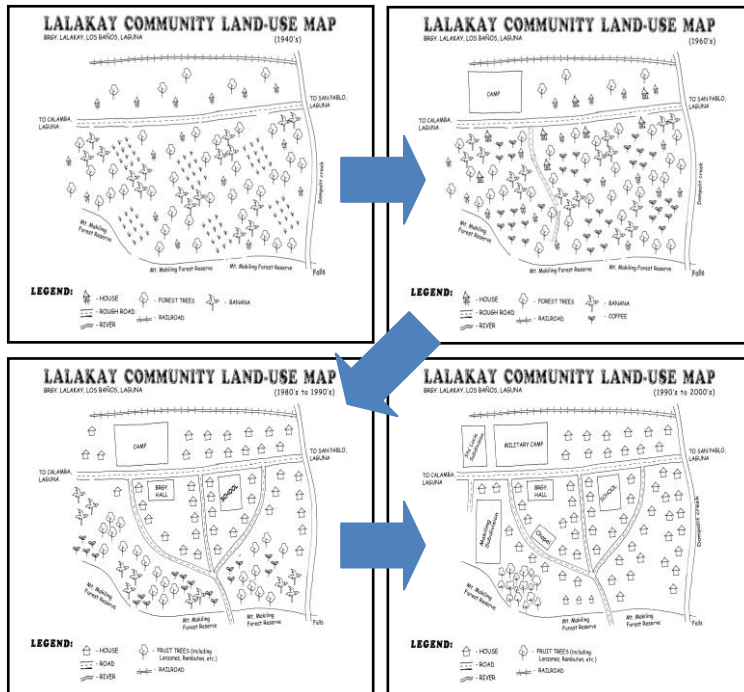


Figure 4. Community land-use maps of Brgy. Lalakay, Los Baños, Laguna in 1940s, 1960s, 1980s-1990s, and 1990s to present.

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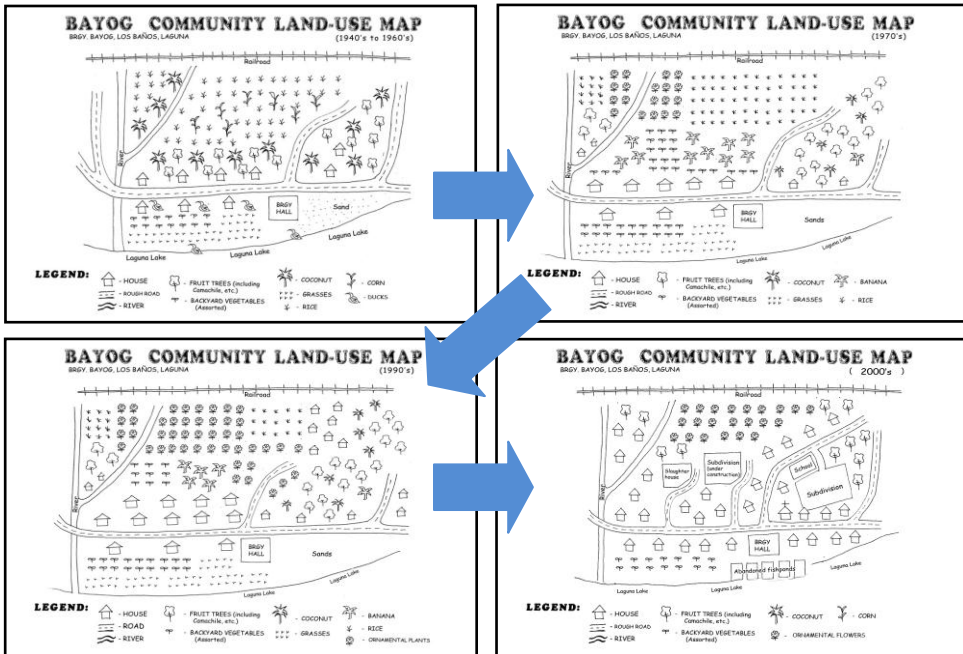


Figure 5. Community land-use maps of Barangay Bayog from the 1940s to present.

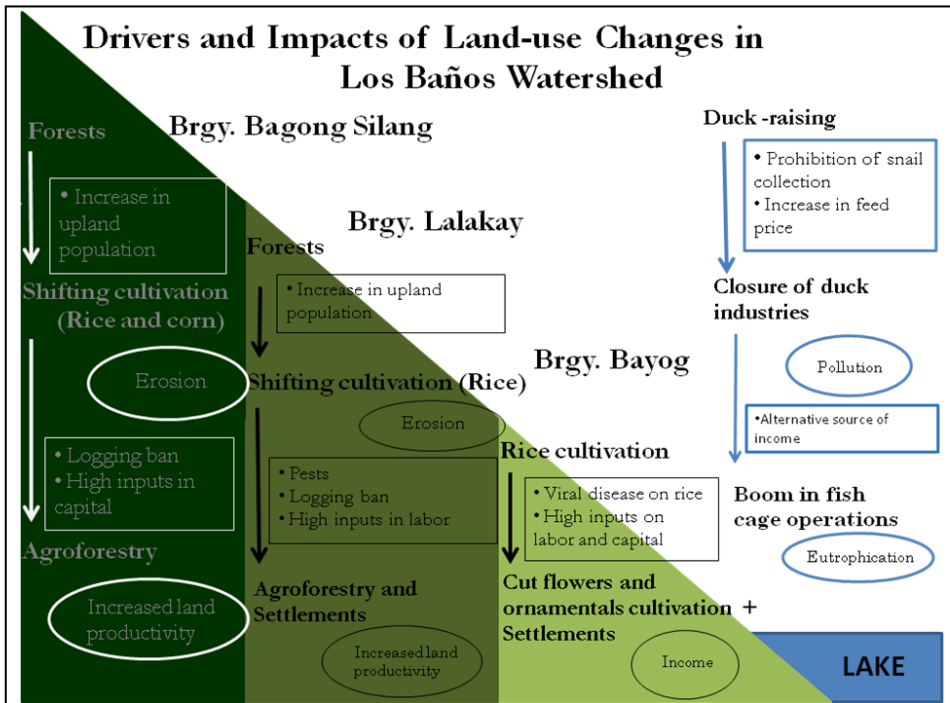


Figure 6. Analysis of the drivers and impacts of land-use change.

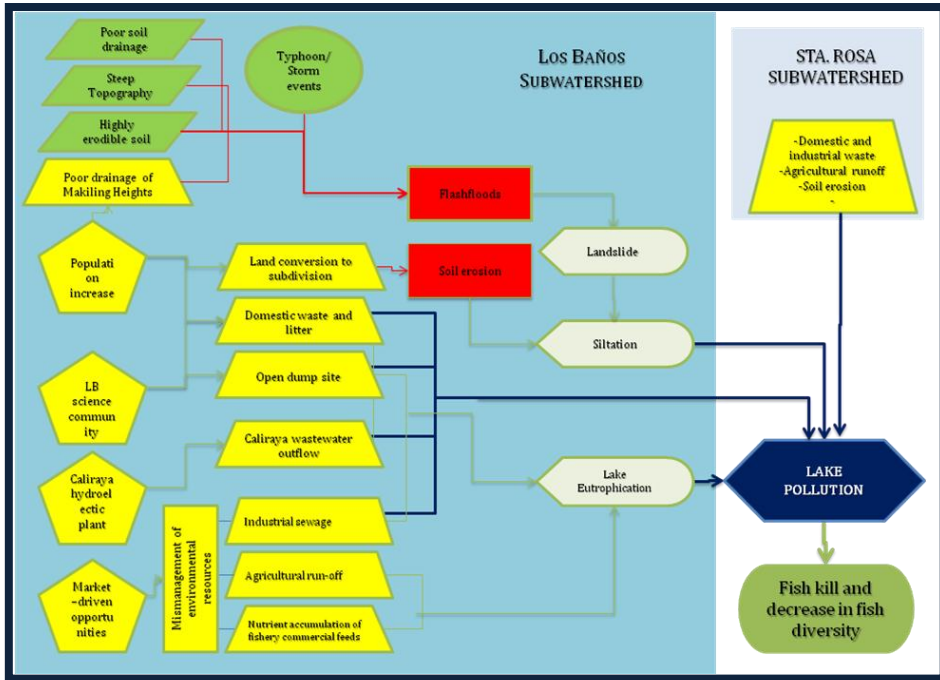


Figure 7. The causal map of the problems in the Los Baños Subwatershed.

Table 1. Identified problems of the different sites in the Los Baños Subwatershed.

Site	Problems
Bagong Silang (Upstream)	- Lack of livelihood sources
Lalakay (Midstream)	- Landslides and flashfloods
Bayog (Coastal)	- Lack of income sources - Uncontrolled dumping of toxic wastes into the lake - Lack of information dissemination - Quarrying - Waste (in the lake) - Reduction in fish productivity and diversity

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Table 2. The SWOT Analysis of the development and provision of livelihood as the best solution for the lack of livelihood in Brgy Bagong Silang.

<p>STRENGTHS</p> <ul style="list-style-type: none"> • Presence of seed sources for organic backyard farming/gardening from the Municipal Agriculture Office (MAO) under the Department of Agriculture • Worm sources for vermicomposting are available • Equipped with knowledge on organic farming from previous UPLB- and other institution-sponsored trainings and seminars attended by the community members 	<p>WEAKNESSES</p> <ul style="list-style-type: none"> • No market for vermicompost products • None or very little capital to purchase raw materials to produce products from the proposed livelihood sources • Lack of equipment/ machines such as swing machines, tools for gardening/farming, etc. • Poor market roads
<p>OPPORTUNITIES</p> <ul style="list-style-type: none"> • Seminars and trainings on all livelihood sources will add to the existing knowledge and widen options on suited livelihood source for every member of the community • Creation of a credit cooperative in the community to aid financially-strapped members 	<p>THREATS</p> <ul style="list-style-type: none"> • Absence of public transport • No markets yet for proposed products to be produced • No power source (electricity) to increase production volume • Length of transport (farm to market roads) • Wholesale prices in markets relatively lower than those to be set by the community

Table 3. Proposed function and mechanism of the Early Warning System (EWS).

Basis	Rise in river water levels	
Mechanism (Number of bell rings)	One ring	Prepare to evacuate; evacuation of children and elderly
	Two Rings	All should have prepared for evacuation
	Three Rings	All constituents should head to the nearest evacuation points such as the Lalakay Elementary School

Table 4. The SWOT Analysis of the EWS as the best solution to avoid landslides and flashfloods during typhoon incidences.

<p>STRENGTHS</p> <ul style="list-style-type: none"> • Community’s awareness of the existing EWS system • Brgy. Captain regularly checks water levels • During flash floods and typhoons, LGU provides relief goods • A bell ringer is assigned to signal people during evacuation 	<p>WEAKNESS</p> <ul style="list-style-type: none"> • Delayed warning from the assigned bell ringer
<p>OPPORTUNITY</p> <ul style="list-style-type: none"> • Help from the army of Camp Eldridge during evacuation 	<p>THREATS</p> <ul style="list-style-type: none"> • Abrupt rise in water level

Table 5. Summary of the overall problems in Brgy. Bayog.

Problems	Proposed Solutions
<ul style="list-style-type: none"> • Lack of income Sources <ul style="list-style-type: none"> ○ Lack of qualification or over-qualification ○ Unfit for jobs: education system as a social problem ○ Lack of employment opportunities 	<ul style="list-style-type: none"> - Trainings and seminars from government institutions such as TESDA, barangay - Job opportunities for women in the barangay - Linkage with government agencies on job security - Repeal the contractual law - Strengthen barangay policies on livelihood conception - Coordinated efforts and inter-agency linkages
<ul style="list-style-type: none"> • Lack of information dissemination 	<ul style="list-style-type: none"> - Trainings and seminars on the importance of Laguna Lake - Increase advertisement and campaign materials - Provision and dissemination of posters and signage in strategic places
<ul style="list-style-type: none"> • Quarrying of sand from the bay for household construction 	<ul style="list-style-type: none"> - Strict implementation of municipal ordinances and the Republic Act 8550 otherwise known as The Philippine Fisheries Law of 1998
<ul style="list-style-type: none"> • Uncontrolled dumping of toxic wastes 	<ul style="list-style-type: none"> - Proper and strict implementation of policies by government agencies (LLDA and DENR) - National and local government tie-ups on regulation and policy implementation
<ul style="list-style-type: none"> • Solid wastes at the bottom of the lake <ul style="list-style-type: none"> ○ Improper disposal of domestic and livestock wastes 	<ul style="list-style-type: none"> - Fisher folks should help in the clean-up of the lake - Devise action on garbage clean-up by LGU, i.e. Barangay contest on garbage collection - Self-discipline among the members of the community; more responsible individuals - Establishment of Material Recycling Facilities (MFRs) and re-launching of “<i>May Pera sa Basura</i>”
<ul style="list-style-type: none"> • Reduction of fish diversity and productivity 	<ul style="list-style-type: none"> • Regulate the number of fish pens by government agencies (LLDA) • Promotion and use of appropriate fishing technologies • Regulate dispersal of fingerlings in Laguna Lake in open waters

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Table 6. The SWOT Analysis of the lake rehabilitation as the best solution to the pollution, fish diversity decline and fish kills in Brgy. Bayog

<p style="text-align: center;">STRENGTHS</p> <ul style="list-style-type: none"> • Knowledge on the main problem, that is, lake degradation • Cooperation of the community officers • Very active FARM-C and Sangguniang Barangay on clean-up drives; <i>Linis Ilog</i> and <i>Lawa</i> • Presence of organized groups of NGO's – <i>Bantay Lawa</i>, <i>Samahang Mangingisda</i> (in every barangay) and other organizations of fisher folks 	<p style="text-align: center;">WEAKNESSES</p> <ul style="list-style-type: none"> • Lack of funding • Lack of cooperation among the community members • Irresponsibility towards small, visible problems (e.g., proper throwing of personal litter, picking up small litter along the way) • Lack of motivation from the LGU – food- for-work, incentive and reward systems • Laxed in the implementation of laws • Misunderstanding between the local government and organized groups (NGO's) • Bias in authorities
<p style="text-align: center;">OPPORTUNITIES</p> <ul style="list-style-type: none"> • All forms of support from the National government • Encouragement and counseling of the lake-affected community members by the LLDA on following rules and regulations • Indirect assistance from the LLDA thru the municipal government • Technical support from Bureau of Fisheries and Aquatic Resources (BFAR) and technological transfer from UPLB 	<p style="text-align: center;">THREATS</p> <ul style="list-style-type: none"> • Non-disbursement and misallocation of supposed budget for organized groups • Delays in all forms of support from the national government



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