society, environment, and development

THE MT. MALINDANG EXPERIENCE

Compendium of Papers Presented in Scientific Conferences by the Biodiversity Research Programme (BRP) Researchers and Collaborators

SEAMEO SEARCA

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Southeast Asian Regional Center for Graduate Study and Research in Agriculture (SEARCA)
Biodiversity Research Programme (BRP) for Development in Mindanao: Focus on Mt. Malindang and Environs

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The BRP

THE DEMAND-DRIVEN RESEARCH PROCESS: LESSONS LEARNED FROM THE JOINT PHILIPPINES-NETHERLANDS BIODIVERSITY RESEARCH PROGRAMME (BRP) FOR DEVELOPMENT IN MINDANAO [1]

Mariliza V. Ticsay[2], Rene van Veenhuizen[3], Perry S. Ong[4], and Marc Lammerink[5]

The Philippine-Netherlands Biodiversity Research Programme (BRP) for Development in Mindanao was a demand-driven, collaborative research programme initiated by the Dutch Government. The BRP was designed to develop innovative North-South research partnerships based on national research priorities.

Among the innovations of the BRP were the following: (a) a participatory and consultative nature that promotes multi-stakeholder participation, involving not only the scientific research community, but also, most importantly, local communities and stakeholders, including local governments and nongovernment organizations (NGOs); (b) location-derived and development-oriented; (c) systems-oriented and interdisciplinary, bringing together the natural and socioeconomic and cultural components and their interactions; and (d) uses an integrated ecosystems or landscape approach to research. BRP was designed to contribute to conservation, management, and sustainable use of biological resources, build and strengthen national capacity for biodiversity research, and promote North-South research cooperation on equal footing.

INTRODUCTION

Demand-driven, collaborative research programmes, which aimed to develop innovative North-South research partnerships, were initiated by the Netherlands Development Assistance Research Council (RAWOO) in the early nineties as a response to the Netherlands Ministry for Development Cooperation's (DGIS) interest on how to shift the emphasis of research cooperation more towards the needs of the South.

This shift in research collaboration entailed that:

- Developing countries draw up their own national research agenda following priorities in the selected policy area (e.g., biodiversity, health, etc.);
- Dutch research capacity is mobilized on the basis of concrete needs identified in the respective countries;
- Research activities are accompanied by support activities in the area of human resource development, networking, and institutional development; and
- There is active involvement of all key partners in the programme management.

In 1996, a fact-finding mission was commissioned by RAWOO to assess the possibilities for setting up a long-term collaborative research programme in the Philippines[i] in the field of biodiversity and sustainable development, involving resource users in the formulation of research questions. Accordingly, the context of the Philippines both in terms of government support, NGO activities, and universities' interests and research gaps offer good opportunities for RAWOO to formulate a collaborative research programme in the field of biodiversity and sustainable development.

RAWOO found a ready ally in the Southeast Asian Regional Center for Graduate Study and Research in Agriculture (SEARCA), whose concern is the promotion of sustainable agriculture through natural resource management and environmental protection in the Philippines and in Southeast Asia. These two institutions jointly prepared and packaged the programme for funding by the Dutch government and other possible donors. SEARCA facilitated and organized the activities in the Philippines of a group of environmental practitioners known as the Philippine Working Group (PWG) and university researchers involved

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[4] Chair, BRP Joint Programme Committee
[5] Co-Chair, BRP Joint Programme Committee

in the endeavor. RAWOO mobilized professional and material resources in the Netherlands and advised the Dutch government on the implementation of the programme. The Dutch government, through the Ministry for Development Cooperation (DGIS), had since approved the Biodiversity Research Programme (BRP) for Development in Mindanao: Focus on Mt. Malindang and Environs in 2001. Funds in the form of a grant had been awarded to SEARCA to implement the programme over a five-year period.

PROGRAMME OBJECTIVES

As a programme for biodiversity research, BRP was conceived by its proponents for several reasons. First was to contribute to the conservation, management, and sustainable use of biological and genetic resources in a specific site in the Philippines through research. Mt. Malindang in Mindanao island, considered to be a good example of the state of biodiversity in the Philippines, was chosen over other sites because of the comparatively few and disjointed conservation and development efforts placed there (where possibly the highest incidence of biodiversity was combined with the least scientific activity [Lammerink 1998]). The urgency of the situation required an immediate response from research, i.e., to provide findings and information that would guide purposive and sustained action by local stakeholders in preventing the destruction of this "hotspot's" remaining natural resources.

The second concern of the BRP was to develop a comprehensive approach to integrating support for collaborative research, as well as for building and strengthening national capacity for biodiversity research, to include support for (a) research training and making better use of existing but often underutilized capacity, (b) developing methodologies for assessing needs and setting priorities through participatory approaches, workshops, and networking, (c) building up and strengthening research institutes and infrastructure of biological collection, libraries, databases, information and communication facilities, and (d) development of mechanisms for linking research, policy and practice through networks, seminars, and workshops.

Finally, the third purpose of the BRP was to change the traditional manner, which may eventually demonstrate a paradigm shift in the traditional manner of a "collaborative" research programme that is conducted between a developed (North) country, which is the donor, and a developing (South) country, which is the recipient – a partnership that is not so easy to achieve, not when the North is in control of funding and has all the necessary organizational capacity and access to information including donor preference or specifications in terms of the research agenda, programme design, and research implementation, while the South is short of funds, capacity and access, but nevertheless has its own priorities and in-depth understanding of it's own context (RAWOO 2001). The BRP aimed to promote equal-footing or true partnership between the North and South partners, whether in terms of the management/administration or technical expertise requirement of the research.

THE DEMAND-DRIVEN PROCESS APPROACH

Biodiversity research for development is relatively a new approach in the Philippines, particularly one that is participatory, interdisciplinary, and multistakeholder (Ganapin 2002). Given the programme's objectives and the importance of the consultative process that the objectives imply, several activities were undertaken in coming up with the programme framework. Figure 1 shows the chronology of events in the development of the Programme.

A national workshop was held in July 1997 in Los Baños, Philippines, which brought together more than 50 participants representing different sectors, regions, and areas of expertise to produce a biodiversity research agenda for the Philippines, and to come up with recommendations for a management structure and implementation mechanisms for the proposed programme of biodiversity research.

In September that year, RAWOO conducted a workshop in Leidschendam, The Netherlands to discuss the policy principles and organizational framework of a proposed Philippine-Dutch collaborative effort on biodiversity research. The Philippine research agenda served as the major input for this workshop, which was attended by about 40 participants coming from various organizations involved in biodiversity research, policy makers, and NGO representatives.

The main conclusion of the workshop was that it was possible to develop such a joint programme on the basis of the directions set out in the Philippine agenda. However, the need for special activities in order to further elaborate the Mindanao research agenda into specific, detailed research projects was emphasized. A Pre-Implementation Phase (PIP) was needed to serve the purpose of determining exactly where, what, how, and with whom specific research project are to be carried out. At the same time, the PIP served to build further consensus and commitment among the key actors who would be involved

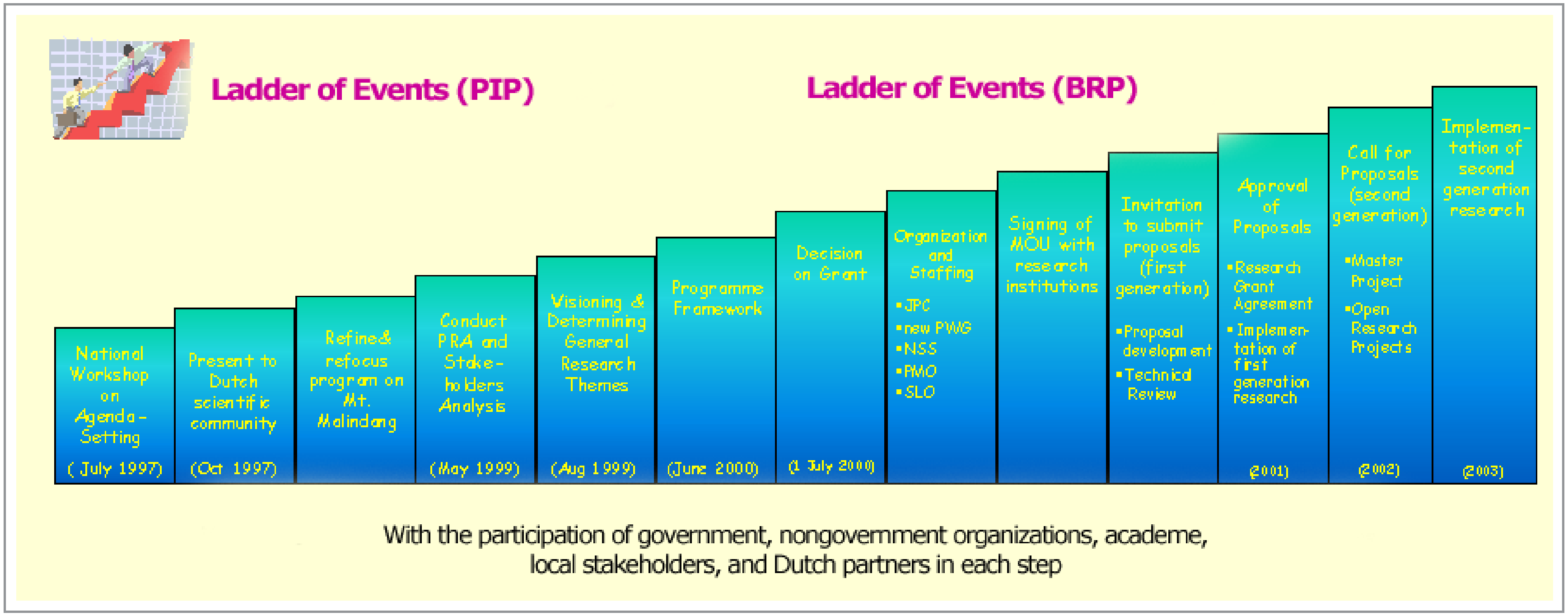

Figure 1. Milestone activities in the development of the BRP.

in the different activities. Four teams of Mindanao researchers, with inputs from Dutch experts, conducted a Participatory Rapid Appraisal (PRA) and a Stakeholders' Analysis in the upland, lowland, and coastal ecosystems of Mt. Malindang during this period. The PIP aimed to develop the research agenda into specific projects while providing the exercise to establish rapport and leveling off between partners from different scientific communities, i.e., the Philippines and the Netherlands.

The Biodiversity Research Programme (BRP) officially started on 1 July 2000. Fourteen Mindanao and seven Dutch institutions[ii] carried out the research activities. A Joint Programme Committee (JPC), composed of Filipino and Dutch representatives, served as the highest policy-making body of the programme. A Support Secretariat (NSS) in Luzon, a Site Coordinating Office (SCO) in Mindanao, and a Support and Liaison Office (SLO) in the Netherlands coordinated programme-level and project-level research and support activities. The PWG composed of Luzon-based natural science and social science experts served as an advisory body to the JPC, as well as provided technical back staffing to Mindanao researchers. A Local Advisory Group (LAG), composed of representatives from key stakeholder groups of Mt. Malindang, advice the JPC on how BRP could operate more effectively with strong participation and clear lines of coordination with local stakeholder groups. The LAG provided direct linkage with local governments, institutions, and stakeholders, especially in the translation of research outputs for policy advocacy. Figure 2 shows the management structure of the BRP.

The BRP had three major components: research projects, support activities, and programme management . The main thrust of the Programme was research. Research activities and projects proposed and undertaken by proponent institutions and researchers in Mindanao fall within the umbrella programme framework and research agenda developed through the series of consultations and programme formulation workshops involving both the Philippine and Dutch researchers during the PIP. These proposals were submitted to the JPC for evaluation on how well they satisfy BRP goals and objectives and how well they contribute to the overall research framework of the programme. Priority was given to researches that involved collaboration of scientists from different Mindanao partner institutions and those that included the participation of Dutch scientists to fill up an acknowledged expertise gap in the study. In general, component research activities in the BRP were envisaged to focus on methodology development, knowledge expansion/improvement, and policy-oriented research on biodiversity conservation.

The support component of the BRP was seen as necessary to boost the relevance of the programme to development problems in the research area, especially as defined by local stakeholders. This would show that the research activities of the BRP were not for the generation of knowledge alone, but did in fact have a development orientation.

Under programme management, other activities were undertaken in relation to the overall management and coordination of programme resources, including

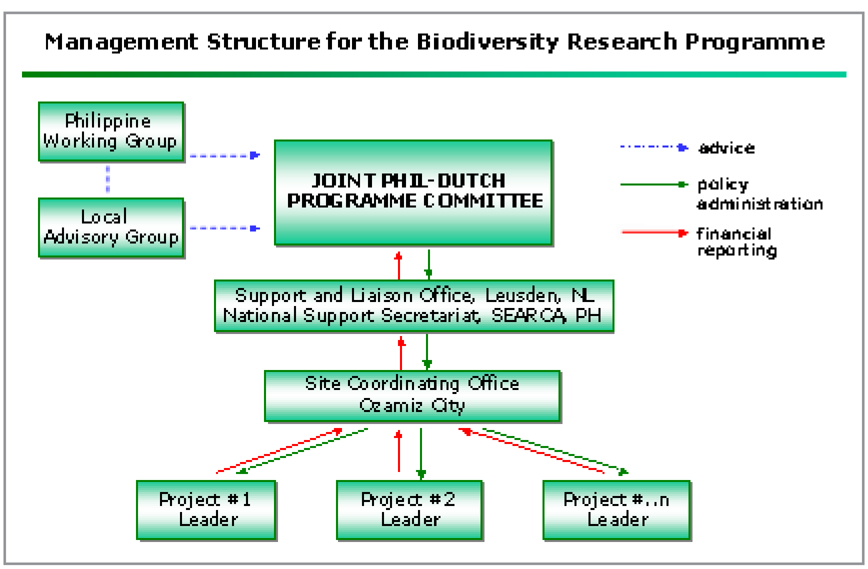

Figure 2. Programme management structure.

programme level and on-site or community support activities.

THE RESEARCH PROJECTS

The so-called First Generation Research activities, implemented during the second and third year of the Programme, gathered benchmark information on biodiversity across a representative swath of the Mt. Malindang landscape, namely: (1) biodiversity of a crater lake; (2) agrobiodiversity of a cabbage patch in the upland area; (3) botanical diversity of montane and lowland forests; (4) biodiversity of a river ecosystem; and (5) biodiversity of coastal waters. For the third and remaining years of the programme, priority was given to researches whose results could be harnessed for the development of local communities.

Emphasis was placed on the integration of research activities through the organization of three Master Projects in the terrestrial and aquatic ecosystems, and socioeconomic-cultural environment following the landscape ecology approach. These Second Generation Research projects focused on upland-lowland bio-social interactions and aimed to provide policy recommendations for biodiversity management and conservation. These included (1) floral diversity; (2) vertebrate faunal diversity; (3) invertebrate faunal diversity; (4) soil ecological diversity; (5) resource utilization patterns; (6) indigenous knowledge systems and modern technology-based approaches; (7) policy analysis; (8) assessment of two rivers; and (9) coastal biodiversity and fish stock management. Furthermore, there was a continuous call for research projects intended to fill in gaps in understanding the landscape not covered by the master projects, placing increasing emphasis on social research, policy analysis, eco-governance, and livelihood opportunities. Two action-research activities were implemented, namely: (1) Integrated Pest Management (IPM) and agrobiodiversity; and (2) utilization of economically important rare and endemic plants. Figure 3 shows the integration framework for research results following the landscape ecology approach.

THE SUPPORT ACTIVITIES

Support activities were planned in such as way that they complement the research activities to strengthen research itself and its utilization, promote participation by various stakeholders, and build sustainability.

Included as key support activities were:

- Human capability-building and institutional strengthening activities meant to build capacities of local stakeholders and institutions to adopt alternative development strategies and policies
- Information, education, and communication (IEC) for biodiversity conservation awareness using research results and other learnings with potential applications to the local community and other biodiversity hot spots in the country and the region

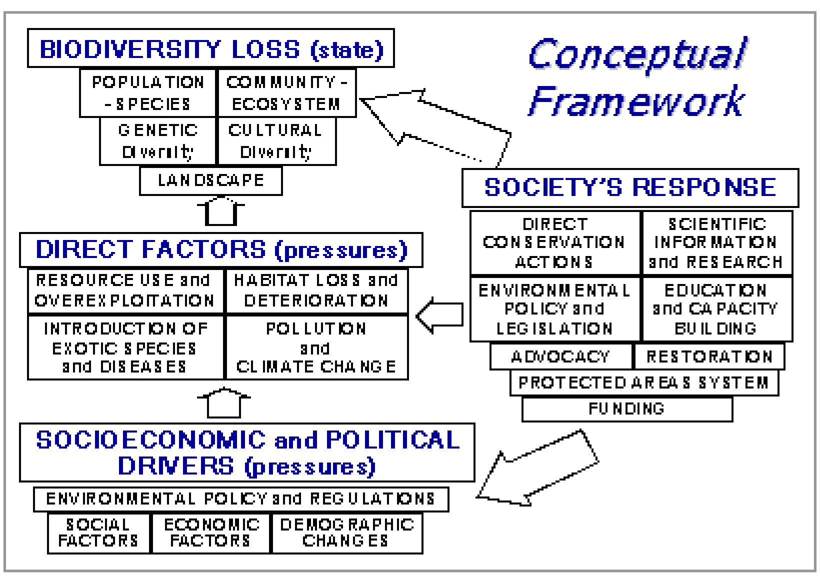

Figure 3. Integration framework of research results.

Table 1. Outline of the general programme results.

Vision: Aspiration or visionary thinking for the future; beliefs, values, new directions that are broad and forward looking but not defining the ways of achieving them.	To develop economically and culturally prosperous communities in the Mt. Malindang range and its environs, which are living harmoniously in a sustainable environment where biodiversity conservation is founded on an integrative and participatory research process.
Goal: Broad statement of what the programme hopes during its lifetime; define long-range performance targets	To develop a body of natural scientific and social scientific knowledge, which serves the sustainable interaction and use of human and natural resources.
Objectives: Operational definition of the goals; statements of what will be accomplished or changed	1. To strengthen conservation efforts in Mt. Malindang by increasing the awareness of stakeholders on the status of biodiversity in the area; 2. To enhance stakeholders' capacity to actually plan, conduct, and manage biodiversity research for development at all levels; and 3. To serve as a pilot case and/or template for similar biodiversity efforts in other parts of the Philippines.
Outputs: Short-term development results, which are expected to arise from the completion of programme activities.	1. Research results add to or enhance the body of knowledge on Mt. Malindang's biodiversity status. 2. The formulation and implementation of integrated research and support programs that will foster the implementation of biodiversity conservation efforts in other areas of the Philippines. 3. A balanced, genuine and productive partnership between Filipino and Dutch researchers and local communities is developed.
Programme activities: Processes of utilizing programme resources to achieve targeted outputs.	1. Research Programme Activities 1.1 Methodology development 1.2 Knowledge expansion and improvement 1.3 Policy-oriented research 2. Support Programme Activities 2.1 Community organizing 2.2 Capability Building/Human Resources Development 2.3 Information and Communication 2.4 Database Management 2.5 Networking
Programme resources: Human, material, capital, etc. which are accessed through programme funding.	5 million guilders over 5 years; 70% for the Philippines; 30% for the Netherlands 50% to research; 35% to support activities 15% to programme management Local counterpart support External resources through partnerships (e.g., ALTERRA, Naturalis, WURS)

- Networking with national and international linkages and alliance-building with other stakeholders to ensure future sustainability of the BRP research efforts
- Database and knowledge management network that would allow access to BRP research findings and other relevant biodiversity information to a range of users both local and international, as well as for easier translation of said research results to something more tangible and relevant to the needs of the local stakeholders.

Capacity-building activities were mostly in the form of training, wherein Dutch experts were called in to conduct short courses in areas where Filipino researchers feel they need some enhancement. Moreover, community members who were committed to assist the researchers to perform research activities in the field were also given the opportunity to attend and participate in these short training courses[iii].

LESSONS LEARNED: RESEARCH COLLABORATION ON AN EQUAL FOOTING

Equal partnership for the Philippine and Dutch partners was envisaged in all aspects of programme implementation in the BRP when it was initially designed. The partners must have an equal say in the policy-making and decision-making processes and they must play an equal role in the governance and management structure of the research programme for the sustainability of the partnership in the long term. From day one of the PIP, the challenge of the programme was to develop successful cooperation in research-for-development between the North and the South, in which the principle of ownership was integrated with partnership. This means that northern researchers became collaborators and offered their expertise in a process driven by the needs of the Philippine partners (van Veenhuizen 2004).

It was felt that the success and sustainability of any research and development undertaking is highly dependent on the involvement and participation of all relevant stakeholders, i.e., the academe, policy makers, government officials, the private sector, NGOs, and community-based organizations representing local communities, indigenous peoples, farmers, and fisherfolks in setting the research agenda and priorities. The consensus was that a research agenda grounded on the actual needs of stakeholders and target beneficiaries stands a better chance of being accepted and supported locally. The participatory nature of BRP was highlighted in its processes, wherein stakeholders and partner researchers participate in practically all aspects of the programme. This included all activities from research agenda formulation to pre-implementation planning, and finally to implementation. BRP was a test case to show that the so-called participatory approach could make a difference in setting research priorities where there may be conflicting needs and interests and power issues involved among the multiple stakeholders. The far-reaching implication was that if the BRP approach could be documented and refined as a methodology, it may be used in other sites where biodiversity is similarly threatened.

The thorough agenda-setting process and the extensive PRA of the research area, with the researchers and local stakeholders of Mt. Malindang during the PIP, did not facilitate immediate interactive and interdisciplinary partnership with the Dutch researchers for demand-driven research.

In the early years of the Programme, the need to build up programme management and to start involving the local Mindanao partners, through communication, information, and capacity building, was the predominant concern. Attention was given to human resource development of the Mindanao researchers, and not so much yet on the development of partnership with the Dutch research community. Moreover, research focus was on baseline data gathering.

Although familiarization with this new paradigm of a demand-driven collaborative research programme was a work in progress for the main actors, secretariats, and researchers, research activities had considerably improved with the development and implementation of the master projects during the fourth year of programme implementation. A lot of effort had been put in the process of integration of disciplines and activities under the landscape approach led by the Filipino researchers, with the involvement of Dutch researchers.

The challenge to develop a successful North-South research collaboration also meant keeping Northern partners interested and involved in a research programme that was driven by a Southern agenda. Partnership building required innovativeness and flexibility from both sides. The structure of the BRP facilitated collaboration between the Dutch and Filipino institutions through the availability of an infrastructure for research and assistance in finding research partners.

Initially, it was difficult to foster collaborative activities between the Philippine and Dutch researchers. Partnership development started very carefully and had started to grow only in the late years of the Programme. It appeared that a certain momentum of research, familiarity with the

Programme, and trust in the Programme management were needed before researchers could reach out and get involved. Furthermore, the researchers needed support and collaboration “on-the-job”, or when their research was actually underway. In most cases, this did not sit very well with the Dutch researchers, who needed at least 3-6 months notice for any field visits to be planned.

The original set-up of the Programme was not very attractive to the Dutch institutions because they had to be patient and invest quite some time in communication and the acquisition of the rather limited funding for a short period of time. Matching of funds by the Dutch institution was expected, and staff time (i.e., salaries and fees) was allowed only in support activities. Because of the limited funding, Dutch researchers could only allocate limited time for field activities. This followed that only a limited number of Dutch institutions could be involved for a certain time period.

The demand-driven process, together with facilitating partnership with Dutch institutions, was one of trying out and finding balances. The Dutch institutions involved were aware of and dedicated to this demand-driven approach to collaborative research. Thus, a Memorandum of Understanding (MOU) was developed for participating Dutch institutions that would like to be involved for a longer period than the one-year approved funding.

Lessons learned from the last five years of the BRP showed that genuine cooperation and equal partnership are not easy to attain. The process was slow, but steadily developing. Programmes of this sort need long-term commitment and funding to assure that the “critical mass” develops which can sustain the process. The Biodiversity Research Programme for Development in Mindanao had taken a very interesting development path, and had become a showcase for the Philippine and Dutch research community for research-for-development partnerships. Bringing its activities to an end would be a great loss and a tremendous waste of money. We’ve only just begun.

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END NOTES

[i]The reasons for selecting the Philippines, as indicated in Lammerink 1998, were the following:

1. While the country ranks as one of the most important areas in the world in terms of biodiversity, its biological and genetic resources are under severe stress as a consequence of rapid population growth, slow economic development, and overexploitation of the natural environment.
2. Biodiversity is one of the priority areas in the Philippine Agenda 21, which has recently been adopted by the Philippine society and government when it comes to the importance of conserving and managing the country's biological resources. Such a favorable policy on the environment is an important precondition for research results to be actually used in policy-making and management.
3. The country has a relatively well-developed national research system and a critical and capable NGO-community, which is important for the implementation of research results.
4. The Filipino and the Dutch research community have already established cooperative linkages and contacts, which could further be extended and enhanced in a programmatic framework.

[ii]The 14 Mindanao institutions were the following:

1. Misamis University (MU)
2. Mindanao State University (MSU) - Marawi
3. Mindanao State University (MSU) - Iligan Institute of Technology (IIT)
4. Mindanao State University (MSU) - Naawan
5. Mindanao Polytechnic State College (MPSC)
6. Research Institute for Mindanao Culture (RIMCU)
7. Central Mindanao University (CMU)
8. Bukidnon State College (BSC)
9. Northern Mindanao Institute of Science and Technology (NORMISIST)
10. University of the Philippines (UP) - Mindanao
11. University of Southeastern Philippines (UseP)
12. Southern Philippines Agribusiness, Marine, and Aquatic School of Science and Technology (SPAMAST)
13. Davao Oriental State College of Science and Technology (DOSCST)
14. Sultan Kudarat Polytechnic State College (SKPSC)

The seven Dutch partner institutions were the following:

1. ALTERRA Green World Research, Wageningen University and Research Center (WUR)
2. Department of Social Sciences, Wageningen University and Research Center (WUR)
3. Department of Soil Quality, Wageningen University and Research Center (WUR)
4. The Netherlands National Herbarium - Leiden
5. The Netherlands Museum of Natural History - Naturalis
6. International Institute for Infrastructural, Hydraulic, and Environmental Engineering (UNESCO-IHE/Delft)
7. Centre for Environmental Studies (CML) - Leiden University

[iii]The following activities had been conducted with the Dutch partners, local community members, and Mindanao researchers:

1. Training on Parataxonomy
2. GIS/Desktop Mapping
3. Preparation of Herbarium Specimens and Herbarium Upkeep
4. Training on the Use of Macroinvertebrates as Indicators of Water Quality
5. Earthworm Identification
6. Vertebrate Faunal Taxonomy and Methods for Specimen Collection and Preparation

THE BIODIVERSITY RESEARCH PROGRAMME (BRP) EXPERIMENT WITHIN THE EXPERIMENT: INNOVATIONS, STATUS, AND IMPACTS [1]

Mariliza V. Ticsay[2] and Gil C. Saguiguit, Jr.[3]

Twenty years ago, the Dutch development aid adopted a research policy strongly geared towards development-oriented and demand-driven research. Emphasis was shifted toward prioritizing the partnership and project ownership of the South partners and the shifting of knowledge production away from a dominant North. The challenge was to develop successful cooperation in research-for-development between the South and the North partners, where the decision-making power and the human and material resources from the North were made subordinate to that of the South (Lammerink 2006). This also meant that North researchers became collaborators, and offered their expertise in a process driven by the research needs of South partners-stakeholders; and the contours of a "new paradigm" in research emerged.

One aspect of this new paradigm was the need for a new approach to a joint programme that will develop innovative North-South research collaboration, where more autonomy and responsibility for programme design, organization, and implementation be given to the South partner, with activities still mainly funded by the North partner.

Furthermore, this paradigm shift involved two important components at the same time: (1) focus on the bottom-up, demand-driven research agenda formulated by the South partners; and (2) a shift from academic research to research-for-development, yet without being involved in practical development activities.

Two programmes were initiated by the Netherlands Development Assistance Research Council (RAWOO) as a response to the interest of the Dutch Minister of Development Cooperation (DGIS) in seeking advice on such as paradigm shift.

PROGRAMME OVERVIEW

The Biodiversity Research Programme (BRP) for Development in Mindanao: Focus on Mt. Malindang and Environs was one of the demand-driven, collaborative research programmes initiated by the Dutch government as part of a global development agenda aimed to develop innovative North-South research partnerships; the other one being the Health Research Programme for Development (HRP) in Ghana, Africa with a similar history and set-up as the BRP.

After three years of consultations, participatory planning, and consensus seeking between the partners in the Netherlands, the Philippines, and Mindanao, the BRP started in July 2000. It was undertaken jointly by Filipino and Dutch academic, research, and government agencies in a focus research area - a geographical wedge in the province of Misamis Occidental in the island of Mindanao, southern Philippines. This research programme on biodiversity management and conservation was supported with a five-year grant from the Netherlands until 31 December 2006.

Expectations were high on all sides. The Programme was innovative but ambitious. The BRP was envisioned to present an alternative way of doing research - a deviation from the traditional donor-led research programme characterized by an agenda defined by the donor, with research commissioned to the recipient country or research institution without maneuvering space, with the experts doing their own specialized studies, and research sites isolated from each other. Furthermore, its organizational structure involved a complex three-tiered collaboration between the North, the South, and the South-of-the-South.

[1] Paper presented during the 2nd Symposium on Long-term Ecological and Biodiversity Research in the East Asian Region. Farmers' Training Center, Central Mindanao University, Musuan Bukidnon. 25-26 October 2006

[2] Research Management Consultant and former Programme Coordinator of the Biodiversity Research Programme for Development t (BRP) in Mindanao: Focus on Mt. Malindang and its Environs. BRP National Support Secretariat (NSS), SEARCA, College, Laguna

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Table 1. The innovative features of the BRP model.

Programme activities were location-derived and development-oriented	The BRP research agenda, priorities, and methods considered the people's need in the target area, where the local people identified the problems and potential solutions significant to their own development.
The Programme promoted multi-stakeholder participation	Farmers, fisherfolks, indigenous peoples, nongovernment organizations, local government units, and research partners/institutions from Mindanao and the Netherlands worked together to come up with research results that could be valuable inputs to national policies, legislations, programs, and documentation of local best practices affecting biodiversity conservation in the target area.
The Programme promoted interdisciplinary research	Various disciplines in both the natural and social sciences were brought together by the research, including those in crosscutting or multidisciplinary studies. BRP research activities were implemented by researchers from 14[i] Mindanao research institutions and experts from seven[ii] Dutch research institutions, who have all signified their interest and commitment in pursuing research for development in Mindanao, using Mt. Malindang as their biological laboratory. The deliberate choice to have the research implemented solely by Mindanao researchers is a result of the Programme's second objective of enhancing stakeholders' capacity.
The Programme espouses the landscape approach	The research examined and aimed to understand the interactions between and among the elements of contiguous ecosystems fundamental in studying biodiversity.

The Programme believed that biodiversity research should be harnessed for the development of the local populace, for they were the ones who daily interact with the living environment; and who, through their ingrained knowledge and beliefs, capacities and practices, could have an impact on the environment.

Having decided on Mindanao as a starting point, Mt. Malindang in Misamis Occidental was chosen by Mindanao stakeholders over several potential sites for a biodiversity research project, for the following reasons (Visser *et al.* 2006):

- Other projects (development, research, etc.) were present in the area, (e.g., UP-CIDS, EU-NIPAP, and CARE-AWESOME) hence, there was a possibility for synergy;
- Mt. Malindang is a national park and protected area, which offered a microcosm of the threats and opportunities for biodiversity conservation in the Philippines;
- Local government units were ready and receptive to the idea of the Programme (i.e., Municipality of Lopez Jaena headed by its Mayor, and the Office of the Provincial Governor headed by the Governor, who then had environmental protection in his political agenda);
- The site was accessible by land transportation;
- There was a positive peace and order situation.

Mt. Malindang was a biodiversity "hotspot", which needed high priority for protection and yet received little intervention from the government and other sectors. At the time of programme implementation, there were approximately 22,300 inhabitants in the Mt. Malindang Range Natural Park (MMRNP) buffer zone, and 900 more were living in the limited portions of the park's core protected area. The inhabitants within the park and its environs were mainly the Subanen whose livelihood largely depended on the mountain's resources (Hillegers *et al.* 2006).

Given the complexity, ambitiousness, and innovativeness of the programme, the BRP was originally designed as a country-wide programme (with Malindang as the pilot site) for implementation for a period of at least ten years, divided into two phases of five years each. Unfortunately, development policies and administrative regulations shift quicker than research collaboration paradigms and their implementation. In its fourth year of implementation, when the Programme was still in full swing, it became apparent that its activities had to be finalized.

BRP RESEARCH AND SUPPORT ACTIVITIES

In the course of five years, the BRP had funded 17 research projects for implementation with the general objective of finding out what's there, how much is there, and, to a little extent, of why it's (still) there or not there. Note that support activities were implemented hand-in-hand with research activities to boost the relevance of said research projects to development problems in the research sites.

- Participatory Rapid Appraisal (PRA). Prior to the actual implementation of the BRP in 2000, a Pre-implementation Phase (PIP) paved the way for programme (concepts and framework) development. The PIP was in the form of a grant to SEARCA from RAWOO and was not part of the main grant of the Programme. For all intents and purposes it was intended as some sort of "mobilization" fund to get some important pre-implementation activities and data-gathering activities going. Such data was necessary for the formulation of the design of the Programme. This was derived from a rapid appraisal[4] of some representative sites of selected project/ research area. The PRA was conducted by researchers from several state colleges and universities and NGOs in Mindanao, who expressed interest in being part of this new project, and who underwent an orientation and PRA Training Course to level-off expectations and ensure common understanding of participatory methodologies and the landscape approach.

- First Generation Research. The research projects implemented in the first two years of the programme were defined by a set of research themes that emerged from the results of the PRA of the coastal, lowland, and upland ecosystems of the Mt. Malindang landscape during the PIP, and mostly had benchmarking characteristics (e.g., surveys and inventories). The research themes were further categorized as (1) knowledge production and expansion; (2) methodology development; and (3) policy-oriented research.

- Second Generation or Master Research Projects. The research projects during the third to the fifth year of the programme were an integrated set of studies and sub-studies that both the Filipino and the Dutch researchers considered vital in creating a critical mass of knowledge to meet the interrelated objectives of biodiversity conservation and the needs of the local stakeholders in the Mt. Malindang landscape. These were intended to fill up gaps in the geophysical landscapes (i.e., coastal, terrestrial, and riverine ecosystems) in terms of geomorphology (i.e., soils at the landscape level), biodiversity (i.e., plants, animals, and soil microorganisms), and the socioeconomic environment; looking at aspects of institutional analysis, participatory methodologies, and gender issues and concerns. These projects were meant to be integrative and focused on the complexities of ecosystem interrelatedness and interactions. Note, however, that some research projects have not totally deviated from benchmarking, especially on themes not covered in the earlier researches.

- Support Activities were implemented to be more responsive to the crosscutting needs of research activities, especially as defined by local stakeholders. Necessary support activities were envisaged to strengthen research and its utilization, promote participation by various stakeholders, and build sustainability. There were four key support activities component maintained throughout the implementation of the programme, namely, capability building and institutional strengthening; information, education, and communication (IEC) for public awareness; Data Management System; and networking and alliance building.

  Support activities provided by Philippine experts (e.g., members of the Philippine Working Group and other Luzon-based experts including those from SEARCA) and the Netherlands research institutions and researchers, both at the programme level and the project level, were planned in synchrony with the research activities to be more responsive to the needs of the researchers.

- Field methodologies adhering to scientific rigor and technical soundness, i.e., scientific method "with an attitude" was used. Research methodologies had to consider the BRP cornerstones or guiding principles: location-derived and development-oriented (i.e., demand-driven), involves multi-stakeholders (i.e., participatory), interdisciplinary (i.e., collaborative), and

[4] Participatory Rapid Appraisal (PRA) follows a specific protocol or a set of procedures and methodologies that makes it unique; several variants exist depending on the proponents and/or origins (e.g., RRA, PRSA, PALM, PLLA, etc.).

systems oriented focusing on upland-lowland interactions (i.e., landscape approach). Research results were to be translated into palatable materials (e.g., IEC materials to promote environmental awareness; policy recommendations to enable policy makers to forge policies to support biodiversity conservation) and disseminated to the target audience. Furthermore, the materials were designed to be presentable in scientific fora and publishable in scientific journals.

SOME UNINTENDED BENEFITS OF THE PROGRAMME

The results of a recent external evaluation indicated a list of unintended benefits (Lanzona and Duhaylungsod 2006) that came in the aftermath of the programme. This included often immeasurable factors, such as prestige, change in research culture, and other personal and institutional rewards arising from being a part of the BRP. The programme could be seen as an investment in human capital, particularly in the training on biodiversity research anchored on a development perspective.

While there may be some ambiguity and difficulty in making direct attribution of a number of accomplishments to BRP, in particular those achieved by the BRP researchers, it cannot be denied that they are substantial and mattered so much personally and professionally to researchers (both from local and partner institutions). Such social capital radiates institutionally. The achievements generally enhanced the status of their respective institutions. BRP researchers (and even thesis grantees) often served as resource persons; there was an increase participation of these researchers in international scientific fora; there was an increase in number of publications; there were improvements in instructional materials and science curriculum; improvement in project/proposal development; inter-institutional linkages (both local and international) were formed, and others.

Moreover, the establishment of the Mindanao Consortium for Biodiversity (MinCBio) perhaps more concretely and directly indicates BRP impact institutionally. It aims to pursue research-for-development in Mindanao, translating BRP research results into development interventions. Initiated by BRP researchers, this is composed of eight state colleges and universities who had been involved in the BRP. With the eight institutions as lead members, the consortium is open to expanding its membership across Mindanao.

SOME IMPLEMENTATION ISSUES, OPERATIONAL PROBLEMS, AND RECOMMENDATIONS

Effecting a change in the traditional way of doing things cannot be expected to be trouble-free. Some implementation and operation issues (as those stated in Table 2) could, however, be taken positively as groundwork for adjustments and refinements for similar attempts.

CONCLUSION

Trying to effect a paradigm shift in the traditional way collaborative research between the North and South countries is a long-term proposition. This only stands to reason because the development outcomes it tries to achieve in itself requires a considerable amount of time. This was aptly demonstrated by this innovative programme known as the BRP, which seemingly underestimated the ups and downs and the twist and turns of literally going into uncharted territory.

Programme operational problems, differences in perspectives and cultures, geographic distance between and among collaborators, the remoteness of the research site, differences in methodologies, among others, were factors that had weighed heavily on BRP and obstructed it from reaching its stated goals within its 5-year life. Producing research results practically consumed most of the available time and failed to make that vital link to desired development outcomes including the sustainable use of natural resources in the target area. Still, if the BRP were given the original number of years it had proposed, its noble goals would have been achieved.

In spite of its limited existence, there are a host of lessons that were learned and benefits that were reaped. For one, the sheer number of researches conducted and completed on “knowing what’s there”, as well as the complexities of the interactions between adjacent ecosystems in a landscape are quite significant and could be used as bases for future conservation efforts. Even more impressive is the type of collaborations between North and South researchers who, probably for the first time, came as close as possible to what has been described as the proverbial “equal footing” status. In this Programme, the identification of the research agenda and the considerable amount of the research activity that was South-led, made it well grounded on the actual development needs of the site. The North nicely complemented the effort by bringing into the collaboration new methodologies and technologies, relevant literature, and specialized expertise. This mode of working is already a great headway into the improvement

Table 2. Programme implementation and operation issues, and the corresponding recommendations.

Issues/Problems		Recommendations
• Difference in technical capacities	The unequal level of research capacities and skills between North and South partner researchers and institutions caused delays in implementation of projects.	Early in the programme implementation stage, there was a need to give more attention to capacity building to bring the skills of participating researchers from North and South to similar, if not complementary, levels. It may well be that the Programme should have been a capacity building programme with a research component, rather than the other way around.
• Difference in research interests and agenda	Despite efforts to orient North and South researchers to a common research framework and agenda, there were natural personal and institutional biases in topic selection.	To generate interest and support from both sides, there must be a strong IEC component from start to finish.
• Cost of operationalization	Depending on such factors as geographic distance, salary rates and standards, the participation of North researchers and scientists in programme activities based in the South required substantial financial support.	Although the cost of operationalization appeared higher at first, consideration of immeasurable benefits gained from the programme could justify some of the costs.
• Differences in culture	Culture shock is a reality in any North-South partnership. Failure to respect cultural sensitivities may get in the way of smooth implementation of joint projects.	Ways of doing and looking at things from the perspectives of two different cultures is a significant factor that must not be overlooked. This requires adjustments from both sides.
• Institutional and country context	Institutional rules and policies, schedules, and conditions affected access to and availability of quality manpower to service the research needs of the programme.	Institutional commitment and participation come with a price. On the South side, the national government must *"buy in"* from the very start, thus gaining possibilities for further support or at least complementation in action.

Table 2. Continued...

Issues/Problems		Recommendations
• Interdisciplinary research and the landscape approach	The complexity of interdisciplinary research in a landscape setting was grossly underestimated. It is still evolving and researchers are only beginning to understand its advantages and complexities.	Interdisciplinary research and the landscape approach are still something to be learned by both North and South researchers. Further exposure and refinements are in order.
• Research in the context of development	The process connection from research results to development outcomes requires time but beneficiaries' basic needs are immediate.	The long-term development goals of the programme must be complemented with quick-response type of activities that address people's livelihood needs. This will attract their attention, sustain their interest, and gain their support. More efforts should be made to focus on "research" that enhances livelihood and addresses people's immediate needs.
• Demand-driven research	The South cannot be left totally alone to do their thing. The fact that they have identified the research focus and priorities ensuring that the North's assistance is grounded on actual development needs was already a big step.	However, in actual implementation, the temptation to stray must be minimized by the North country's directional guidance and rules in the implementation process.

of how North and South research collaboration is traditionally done.

While the impacts of the BRP cannot as of yet be conclusively gauged and measured, particularly on how research results will be of use to conserving natural resources in the area and ultimately improving the lives of the poor people who reside on Mt Malindang, it is nevertheless a big step forward.

What needs to be done is to further distill lessons learned, follow through with the research results by connecting it to local legislation to conserve natural resources, and finally use it for identifying sustainable livelihood initiatives to alleviate poverty in the area. Although, clearly, the approach has kinks and must be refined, it represents a viable alternative to the traditional way collaborative research is done. This "experiment" must be allowed to continue to prove its true worth.

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END NOTES

[i]The 14 Mindanao institutions were the following:

1. Misamis University (MU)
2. Mindanao State University (MSU) - Marawi
3. Mindanao State University (MSU) - Iligan Institute of Technology (IIT)
4. Mindanao State University (MSU) - Naawan
5. Mindanao Polytechnic State College (MPSC)
6. Research Institute for Mindanao Culture (RIMCU)
7. Central Mindanao University (CMU)
8. Bukidnon State College (BSC)
9. Northern Mindanao Institute of Science and Technology (NORMISIST)
10. University of the Philippines (UP) - Mindanao
11. University of Southeastern Philippines (UseP)
12. Southern Philippines Agribusiness, Marine, and Aquatic School of Science and Technology (SPAMAST)
13. Davao Oriental State College of Science and Technology (DOSCST)
14. Sultan Kudarat Polytechnic State College (SKPSC)

[ii]The seven Dutch partner institutions were the following:

1. ALTERRA Green World Research, Wageningen University and Research Center (WUR)
2. Department of Social Sciences, Wageningen University and Research Center (WUR)
3. Department of Soil Quality, Wageningen University and Research Center (WUR)
4. The Netherlands National Herbarium - Leiden Branch
5. The Netherlands National Natural History Museum - Naturalis
6. International Institute for Infrastructural, Hydraulic, and Environmental Engineering (UNESCO-IHE/Delft)
7. Centre for Environmental Studies (CML) - Leiden University

[iii]List of researches successfully conducted:

Title	Institutions Involved
Pre-Implementation Phase (1999-2000)	
• Participatory Rapid Appraisal in the Upland Ecosystems of Mt. Malindang	Mindanao State University (MSU) – Marawi; MSU-Iligan Institute of Technology (IIT); University of the Philippines Los Baños (UPLB); Central Mindanao University (CMU); DENR Region 10
• Participatory Rapid Appraisal in the Lowland Ecosystems of Mt. Malindang	CMU; MSU-IIT; MSU-Marawi; Mindanao Polytechnic State College (MPSC); Sultan Kudarat Polytechnic State College (SKPSC)
• Participatory Rapid Appraisal in the Coastal Ecosystems of Mt. Malindang	MSU-IIT; MSU-Marawi; CMU; Davao Oriental State College of Science and Technology (DOSCT); Southern Philippines Agribusiness, Marine, and Aquatic School of Science and Technology (SPAMAST) (SPAMAST)
• Stakeholders' Involvement and Analysis	SPAMAST; Technical Assistance Center for the Development of Rural and Urban Poor (TACDRUP)

Titles	Institutions Involved
First Generation Researches (2001-2003)	
• Development of a Participatory Methodology for Inventory and Assessment of Floral Resources and their Characterization in the Montane Forests of Mt. Malindang (Methodology Development)	CMU; Netherlands National Herbarium; Wageningen University Research Centre (WUR); National University of Singapore (NUS); UPLB; Subanen researchers
• Participatory Biodiversity Assessment in the Coastal Areas of Northern Mt. Malindang (Knowledge Expansion and Improvement)	SPAMAST; International Institute for Infrastructural, Hydraulic, and Environmental Engineering (UNESCO-IHE/Delft); DOSCST; MSU-IIT
• Biodiversity Assessment of Arthropods in Upland Vegetable-Growing Areas in Mt. Malindang (Knowledge Expansion and Improvement)	MSU-Marawi; UPLB; WUR
• Community-based Inventory and Assessment of Riverine and Riparian Ecosystems in the Northeastern Part of Mt. Malindang (Knowledge Expansion and Improvement)	MSU-Naawan; MSU-Marawi; Research Institute for Mindanao Culture (RIMCU)
• Participatory Biodiversity Inventory and Assessment of Lake Duminagat, Mt. Malindang National Park (Knowledge Expansion and Improvement)	MSU-Marawi; CMU
Second Generation Researches or Master Projects (2003-2005)	
• Terrestrial Ecosystem Master Project (TEMP): Floral Diversity and Status in the Northern Landscape of Malindang Range and Environs, Misamis Occidental, Philippines (Methodology Development; Knowledge Expansion and Improvement – Participatory Inventory)	CMU; Northern Mindanao Institute of Science and Technology (NORMISIST); University of Southeastern Philippines (USeP); MSU-IIT; Bukidnon State University (BSU); UPLB; UP-Diliman; Netherlands National Herbarium; WUR; ALTERRA
• TEMP: Vertebrate Faunal Diversity and Relevant Interrelationships of Critical Resources on Mt. Malindang (Knowledge Expansion and Improvement-Inventory)	MSU-IIT; MSU-Marawi; Misamis University (MU); UP-Mindanao; USeP; CMU; Centre for Environmental Studies (CML) - Leiden; Naturalis; Haribon Foundation
• TEMP: Invertebrate Faunal Diversity and Relevant Interrelationships of Critical Resources on Mt. Malindang (Knowledge Expansion and Improvement-Inventory)	CMU; UPLB; Naturalis
• TEMP: Soil Ecological Diversity and Relevant Interrelationships of Critical Resources on Mt. Malindang (Knowledge Expansion and Improvement - Profiling)	MSU-Naawan; MSU-Marawi; MSU-IIT; USeP; WUR; Maharishi University-USA
• Aquatic Ecosystem Master Project (AMP): A Comparative Assessment of Langaran and Layawan Rivers (Knowledge Expansion and Improvement-Inventory)	MSU-Marawi; MSU-Naawan; MSU-IIT; NORMISIST; USeP; ALTERRA; Naturalis; (UNESCO-IHE/Delft)

Title	Institutions Involved
• AMP: A Comprehensive Analysis of the Ecological Factors for the Development of Strategies to Sustain Coastal Biodiversity and to Improve Fish Stock Management (Knowledge Expansion and Improvement-Inventory)	MSU-Naawan; SPAMAST; MSU-Naawan; MSU-IIT; USeP; ALTERRA; Naturalis; UNESCO-IHE-Delft; UP-Diliman
• AMP: Assessment of the Headwaters of Layawan River: Linkage Between the Terrestrial and Aquatic Ecosystems in the Oroquieta Watershed of Mt. Malindang (Knowledge Expansion and Improvement-Inventory)	MSU-Marawi; NORMISIST; CMU; MSU-Naawan; USeP; MSU-IIT; ALTERRA; Netherlands National Herbarium; UNESCO-IHE-Delft
• Socioeconomic Cultural Studies (SEC): Resource Utilization Patterns in the Aquatic and Terrestrial Ecosystems of Mt. Malindang and its Environs (Knowledge Expansion and Improvement- Policy-Oriented)	MSU-Marawi; MSU-Naawan; UP-Baguio; USeP; MSU-IIT; ALTERRA; WUR; Forestry, Manpower, Development (FMD) Consultants
• SEC: IKS and Modern Technology-Based Approaches: Opportunities for Biodiversity Management and Conservation in Mt. Malindang and its Immediate Environs (Knowledge Expansion and Improvement)	MSU-IIT; UP-Baguio; WUR; FMD Consultants
• SEC: Policy Analysis for Biodiversity Management and Conservation in Mt. Malindang and its Environs (Policy-Oriented)	UP-Min; MU; MSU-IIT; WUR; ALTERRA; Department of Science and Technology (DOST); UPLB
Open (Action) Researches (2003-2005)	
• Biodiversity Conservation of Arthropods in an Upland Cabbage-Growing Area of Mt. Malindang through Integrated Pest Management (IPM)	MSU-Marawi; Municipal Agriculture Office (MAO) - Don Victoriano; UPLB
• Conservation and Utilization of Endemic, Rare, and Economically Important Plants in Three *Barangays* of Don Victoriano, Misamis Occidental	CMU; WUR; local (Subanen) community members

Student Thesis Researches

- Diversity Studies of Lichens in Barangay Lake Duminagat, Malindang Range, Don Victoriano, Misamis Occidental (BS Biology, CMU)
- Inventory and Assessment of Pteridophytes in Barangay Lake Duminagat, Malindang Range, Don Victoriano, Misamis Occidental (BS Biology, CMU)
- Diversity of Bryophytes in Barangay Lake Duminagat, Malindang Range, Don Victoriano, Misamis Occidental (BS Biology, CMU)
- Diversity of Trees along the Altitudinal Gradient: Layawan River to North Peak of Mt. Malindang Range, Don Victoriano, Misamis Occidental (BS Biology, MSU-Marawi)
- Taxonomy and Distribution of Earthworms in Mt. Malindang (MS Biology, MSU-IIT)
- Subanen Indigenous Knowledge and Biodiversity Conservation and Management in Mt. Malindang Natural Park (MS Environmental Science, UPLB)
- The Volant Mammals of Mt. Malindang Range, Misamis Occidental (MS Biology, MSU-IIT)
- Species Diversity and Abundance of Land Snails on Mt. Malindang, Misamis Occidental (MS Biology, MSU-IIT)
- Composition and Abundance of Zooplankton in the Coastal Waters of Misamis Occidental (MS Biology, MSU-IIT)
- Phytoplankton Diversity in the Coastal Waters of Mt. Malindang (MS Biology, MSU-IIT)
- Adaptation and Vulnerability of Subanen Community to the Environmental Conditions in Mt. Malindang National Park, Misamis Occidental, Philippines (PhD Environmental Science, UPLB)
- Bryophyte Flora of Mt. Malindang (PhD Biology, CMU)
- The Lichen Flora of Mt. Kalatungan, Bukidnon and Mt. Malindang, Misamis Occidental (PhD Biology, CMU)

Land

PARTICIPATORY BIODIVERSITY ASSESSMENT IN MALINDANG RANGE, PHILIPPINES[1]

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The Terrestrial Ecosystem Master Project (TEMP), as part of the Philippines-Netherlands Biodiversity Research Programme (BRP), aimed to generate a more comprehensive information and knowledge of the diversity of flora, fauna, and soil ecology across the landscape of the Malindang Range. With the participation of Subanens as local researchers, the assessment revealed 666 species of plants with 22 percent of the 85 tree species endemic. A complete inventory of trees showed high species richness (63-67% species/hectare) and high tree density (961-1000 trees/hectare). Of these, 11 were endangered, 98 endemic, 52 rare, and 258 were of economic importance. Sixty varieties of agricultural crops were also recorded. Moreover, vertebrate fauna survey recorded a total of 138 species including 16 anurans, four skinks, five snakes, 88 birds, 12 volant, and 13 non-volant mammals. A 53 percent endemism was recorded, with 16 species as rare and endangered. On the other hand, invertebrate survey showed 183 insects, five spiders, and one crustacean species. Of these, nine species of butterflies were endangered and endemic, and five were rare. High species richness of earthworms was recorded in the forest ecosystem with 27 species, while only one in the agroecosystem. As a result of participatory assessment and community validation, the local researchers had identified the establishment of a nursery and community economic garden as potential livelihood projects for biodiversity conservation. The active participation of local researchers had enriched scientific results on inventory and assessment of biological resources.

INTRODUCTION

The Philippines is rich in biodiversity. In fact, it is recognized as one of the world's top 17 "megadiverse" countries. The rapid destruction of tropical rain forest that happened in the 20th century drastically altered the environmental conditions to which many forms of life had adapted in the past. Mindanao, one of the largest islands in the Philippine Archipelago, supports a wide variety of flora and fauna. However, the pressures that threaten the existence of these floral and faunal resources in the other parts of the country are also present in this island. Deforestation, which is a major factor to declining wildlife population, has reduced the country's forest cover from 17 million hectares (ha) in 1934 to 5.7 million ha (19%) in 1993 (Heaney and Regalado 1998). Like the rest of the archipelago, only a very small amount of forest (29%) remains covering the areas of Mindanao. Most of these are located in upland ranges.

Located in the province of Misamis Occidental, Mindanao, Mt. Malindang is the only representative natural forest in the Zamboanga Peninsula Biogeographic Zone (Myers 1988). It is one of the upland ranges whose biodiversity has been severely threatened due to forest loss and therefore considered as the "hottest among the hotspots" in the Philippines. The results of the Participatory Rapid Appraisal (PRA) manifested high species richness, many endemic and economically and socio-culturally important floral resources. But these data were only indicative in nature. The kind and realistic levels of biodiversity resources need to be inventoried and assessed so that strategies for their sustainable development could be effectively designed and implemented. Biodiversity conservation becomes more imperative as more pressure is made through the constant use of biodiversity resources, causing the loss of habitat and reduction in species richness.

This project was conducted to provide guidelines for researchers, communities, and institutions on the project sites in designing protection and conservation strategies of biological resources. These were the bases in identifying livelihood opportunities for developing socioeconomic interventions and sustained biodiversity conservation measures in the forests of Mt. Malindang.

[1] Paper presented at the 7th International Conference on Philippine Studies, 16-19 June 2004, Leiden, The Netherlands
[2] Central Mindanao University, Musuan, Bukidnon
[3] Mindanao State University - Iligan Institute of Technology, Iligan City
[4] Netherlands National Herbarium

This project was undertaken to conduct an assessment of floral and faunal resources to generate an understanding of those present in the Mt. Malindang forests. Specifically, the project aimed to: determine the species richness and diversity of the biological resources; build up a database of Subanen indigenous knowledge on plant and animal names and uses; assess the conservation status of the species, e.g., determine if they are endangered, endemic, rare, economically and socio-culturally important flora and fauna; characterize the vegetation profile of Mt. Malindang forests and agroecosystems; identify species, sites, and habitats of plants and animals for *in situ* conservation; identify the ethnobiological uses; and recommend livelihood projects for biodiversity conservation.

METHODOLOGY

Re-entry Protocol and Prior Arrangements

Although a permit was issued for the conduct of this project during the community validation and workshop, a re-entry protocol was conducted. Preparatory activities, such as team organization among local participants and researchers, action planning, and training-workshop, were done. Nomination and selection of participants and local researchers (Subanen) for the project from the three *barangays* bordering the three study sites were made with the stakeholders in the communities. Participants were those with sufficient to excellent indigenous knowledge of the floral and faunal resources of the study sites. Being co-researchers, the participants/major informants were compensated for their services and were involved throughout the duration of the research activities.

Location and Description of Study Sites

The study sites were located in Don Victoriano, Misamis Occidental in primary and secondary forests, as well as agroecosystems. The first site was situated within Barangay Lake Duminagat at Mt. Ginanlajan in the North Peak Range, with an altitude of about 1,600 meters above sea level (masl), representing primary forest. The second and third sites were located within Barangays Mansawan and Lake Duminagat, representing secondary forest. Sampling sites for the agroecosystems were likewise established in Barangays Mansawan and Lake Duminagat.

The two 1-ha plots established in Barangays Lake Duminagat and Mansawan were more or less permanent for future re-assessment and monitoring even beyond the project duration. The semi-permanent plots served as demonstration center or laboratory for developing a methodology and training of local researchers for participatory inventory, assessment, monitoring, and *in situ* conservation of flora and fauna. In addition, nested plots of 20 x 20 m, 5 x 5 m and 1 x 1 m were established in the forest and agroecosystem to determine species richness of flora and invertebrate fauna. Line transects, mist netting, and trapping areas were established for vertebrate fauna in the identified sampling sites.

Based on the community validation of the project proposal, the decision of both the stakeholders and the researchers was to locate the sampling plot along the primary forest approaching Barangay Lake Duminagat at the southwest side of the *barangay* proper at an altitude of about 1,600 masl. In addition, another plot in Palo 6 at about 1,650 masl, which is located at the southeastern side of Barangay Mansawan, was selected by the stakeholders for comparison purposes on the dynamics of the floral resources between primary and secondary forests. The stakeholders also expressed their desire to preserve the floral species inside the secondary forests that are threatened due to round timber harvesting.

Barangay Lake Duminagat is a crater valley with residential houses and a primary school. With farms and gardens located at the base of the mountain around the North Peak Mountain Range, it has an elevation of 2,199 masl. The lake itself is located across the ridge, about 1 km away at the western part of the *barangay*. With an elevation of 1,400 masl, the Lake is about 10 ha large. A shallow stream at the eastern side drains the surface water towards Kalilangan River and ultimately joins the Dapitan River.

Establishment of Biodiversity Plots and Transects

With the involvement of the local researchers, two 1-ha plots with an area of 20 x 500 m were established along the contour lines at the southwest portion of Barangay Lake Duminagat. The first plot at the southwest site represented the primary forest and the second plot at Mansawan represented the secondary forest. Within the 1-ha plot, six 5 x 50 m subplots were established for tree profiling, 40 5 x 5 m for the inventory of trees and shrubs, and 40 1 x 1 m within each 5 x 5 m subplots were added for the inventory of life forms (herbs, vines, pteridophytes, bryophytes, lichens, and even fungi). All corners of the 20 x 500 m plot, 5 x 50 m subplots, 5 x 5 m subplots, and 1 x 1 m subplots were staked and tied with strings in different colors for identification.

Visual and opportunistic sampling for invertebrate fauna was conducted in the 1 x 1 m squares. Sweep net sampling was performed in two intersecting diagonal strips extending from end to end of the 20 x 20 m plot. Vertical 250 x 10 m transects between center plots were also utilized for opportunistic sampling. Moreover, ten holes measuring 0.5 x 0.5 x 0.3 m^3 were established within the 20 x 20 m plots and searched for earthworms.

Five sampling sites were established for the vertebrate fauna study, where Site 1 was a disturbed forest, Sites 2, 3, and 4 were agroecosystems, and Site 5 was a primary forest. Considering that vertebrate fauna is highly mobile, a plotless method was followed to sample the major vertebrate groups. Two-kilometer long line transects, however, were also established to record birds diversity in the area.

Training of Local Researchers

Training Subanens as local researchers was done by experts/taxonomists. Subanen researchers were trained on the inventory techniques, identification and nomenclature, field collection, preparation of voucher specimens, assessment of conservation status (endemic, endangered, rare, common, economically and culturally important species), ethnobiological survey, diversity measurements, use of equipment, tree profiling, data collection and analysis.

Subanen researchers participated in the establishment of sampling plots. After the training and subsequent involvement in the conduct of the research inventory, the Subanen researchers were able to learn the inventory techniques, and classify flora and fauna to a certain extent. Furthermore, they had developed skills in proper documentation, collection, and preparation of specimens as vouchers during the training courses.

Data Collection and Community Participation

Participatory Inventory, Collection, and Identification of Flora and Fauna

A combination of different sampling techniques was employed for vertebrate fauna sampling. Collection of amphibians and reptiles followed the visual encounter or opportunistic method. Line transect and mist netting methods were used to sample birds in the area. Systematic trapping and mist netting were used to sample small non-volant and volant mammals, respectively.

Identification of plants and animals was done by the experts and the Subanen researchers. The local names of plants and animals given by the local researchers were verified/ confirmed by the local people through community validation.

All plant and animal groups were identified as to their scientific and official Philippine common names by the researchers from the academe and the Subanen researchers using books, monographs, and taxonomic keys (Rojo 1999, Tan *et al.* 1986, Kalkman and Noteboom 1998, de Guzman *et al.* 1986, Inger 1954, Brown and Alcala 1978, Brown and Alcala 1980, Alcala 1986, Kennedy *et al.* 2000, Ingle and Heaney 1992). Indigenous knowledge on how to identify the species was recorded.

For unidentified specimens, representative samples were collected and preserved as voucher specimens for laboratory examination. The preliminary field identification was confirmed by Dutch and Filipino taxonomists using the voucher specimens prepared by the Subanen researchers.

Interactive Ethnobiological Survey and Assessment by Subanen Researchers and the Community

An ethnobotanical survey inside the sample plots was conducted, with the Subanen researchers as informants and research assistants. They collected and evaluated all medicinal plants, and gave information about their local names, diagnostic characters, habitat, altitude, and use. Fertile specimens were collected for permanent herbarium retention, while sterile plants were simply tagged for later identification by Subanen researchers who were the main informants on local names and uses of plants.

A questionnaire was prepared, and a survey with 10 percent sampling intensity of the households in the communities was conducted. This involved quantitative evaluation of plants used as food, timber forest products (construction, poles, piles, etc.), and non-timber forest products (ornamentals, medicinal, basketry, etc.). A list of species, uses, means of preparation, parts of plants used, and dosages was also prepared. Specimens of plants not found in the sample plots were gathered for scientific identification. A similar survey was conducted for vertebrates (amphibians, reptiles, birds, volant and non-volant mammals), as well as invertebrates (insects, coleopterans, and earthworms) to get information on the resource utilization of the different animal groups by the local community.

During the participatory inventory of flora and fauna, a list of endangered, endemic, depleted, and rare species was made based on the criteria of International Union for Conservation of Nature (IUCN), Mace and Stuart (1994), Rojo (1999), Merrill (1926), Zamora and Co (1986), and Statistics On Philippine Protected Areas and Wildlife Resources (2000). Information on economically and socio-culturally important species was provided by key Subanen informants.

The researchers and the local researchers (Subanen) presented the results for validation. Through the community validation, the local names and uses of flora and fauna were confirmed. One or two local names for a particular species were adopted. Several additions in the use, mode of preparation and use, and ailments that can be cured herbally were made.

RESULTS AND DISCUSSION

Species Richness and Density in the Forest and Agroecosystems

Survey of the flora in the two 1-ha plots and 113 nested plots in the forest and agroecosystem, quadrats in grassland and transect belt between center plots in Malindang showed 666 species. The two 1-ha plot alone revealed a total of 301 species, 177 genera, and 109 families. Of these, 167 species were angiosperms, five were gymnosperms, 57 were pteridophytes, 61 were bryophytes, and 11 were lichens (Table 1).

Of the two 1-ha plots, plot 2 in Barangay Mansawan showed higher species richness (216 species) than plot 1 in Barangay Lake Duminagat, which had only 202 species. The high species richness in the secondary forest of Barangay Mansawan was due to the presence of more species of pteridophytes and bryophytes. The presence of more trees, abundance of tree ferns, and varied habitat types could explain the abundance of pteridophytes and bryophytes in plot 2.

Complete inventory of trees in the two 1-ha plots showed a total of 86 species, with 67 species found in plot 2 and 63 species in plot 1. This number of tree species per hectare basis was extremely high as compared to Mt. Kitanglad in Bukidnon which had only 43 species of trees per hectare (Pipoly and Madulid 1996). Not only that high tree species richness was observed in Mt. Malindang, but also a spectacular high tree density per hectare was noted, ranging from 961 to 1,000 individuals. This figure was nearly 25 percent higher than that reported for lowland forests in Neotropics (Balslev *et al.* 1987, Valencia and Paz 1993) and 15 to 20 percent greater than Neotropical montane forest (Grubb *et al.* 1993).

Initial inventory of Pteridophytes in Malindang Range showed 207 species, which was 33 percent of the 632 species found in the Mindanao island.

Evaluation of agricultural crop diversity in Barangays Mansawan, Gandawan, and Lake Duminagat showed a total of 60 varieties/cultivars of different crops. Of these, five locally-known green onion (*Alium fistulosum)* varieties/cultivars were noted. The varieties *Cebuano, Berling,* and Native yellow outer skin were commonly planted as cash crops in the three *barangays*. *Cebuging* was only observed in Barangay Mansawan together with *Ganda,* a well-known herbal medicine and spice.

Sweet potato (*Ipomoea batatas*), with 19 locally-known cultivars, were documented as cash crops, but mostly for daily subsistence of the farmers. *Dublesa* and *kaulbo* were commonly planted in all *barangays*. A total of 18 locally-known varieties/cultivars of *gabi/taro* (*Colocasia esculenta*) and *kabilids, karayo, palawanon,* and *sarubia* were common in the three *barangays*.

Furthermore, the corn varieties cultivated in small scale were hybrid white corn, hybrid yellow corn, and native white corn only since physiological maturity takes seven to eight months.

Other species of horticultural and agronomic crops that were cultivated in the three *barangays* of Don Victoriano, Misamis Occidental included four local varieties/cultivars of chayote (*Sechium edule*), *alugbati* (*Basella alba)*, cabbage (*Brassica oleracea* var. *capitata)*, chinese cabbage (*Brassica rapa* ssp. *pekinensis*), *patola* (*Luffa cylindrica*), squash (*Cucurbita maxima*), cassava (*Manihot esculenta*), chewing type of sugarcane (*Saccharum officinarum*), and banana (*Musa sapientium*). Abaca (*Musa textiles*) plants, introduced by CARE Philippines, were planted in fallowed areas, with the provision of PHP 10 per hill planted to a minimum of 500 hills per farmer. Stripping machine was available at Barangay Mansawan.

Survey results on vertebrate fauna in the five sampling sites showed a total of 16 species of amphibians, four species of skinks, five species of snakes, 90 species of birds, 12 species of volant mammals, and 16 species of non-volant mammals (Table 2).

Higher amphibian species richness was consistently observed in the forested areas as compared to the agroecosystems. This may be due to the greater heterogeneity of vegetation present in forested habitats than in agricultural areas that may provide amphibians the needed microenvironmental requirements for their survival. The result represented about 56.25 percent of the approximately 80 amphibian species known to occur in the Philippines and about 66.67 percent of those recorded for Mindanao Island.

Table 1. Species richness and endemism in Malindang Range.

Plant Groups	Total Number of Species		
	Two 1-ha Plots	All Plots	Endemic (%)**
Angiosperms	167	365 (140*)	69 (49.29%)
Gymnosperms	5	8 (6*)	3 (50.00%)
Pteridophytes	57	207 (179*)	26 (14.53%)
Bryophytes	61	70	
Lichens	11	16	
Total	**301**	**666**	**98**

*number of identified species
**based only on the identified species

Table 2. Vertebrate faunal species found in five sampling sites of Mt. Malindang.

	Mt. Malindang (on-going study)	**Mt. Malindang (Don Victoriano)** (Tabaranza *et al.* 2001)	**Mindanao**	**Philippines** (Alcala 2001)
Frogs and toads	16	16	35 (Crombie 1994)	80
Skinks	4	3	92 (Crombie 1994), reptiles	240 (reptiles)
Snakes	5	6		
Birds	90	147	325 (Kennedy *et al.* 2000)	576
Volant mammals	12	11	84 (PAWB 2002)	174 Mammals
Non-volant mammals	16	23	(Mammals)	
Total Number of Species	**143**	**206**	**506**	**1,070**

All skinks and most snakes, however, were captured from agroecosystem sites than in forested sites, which could be attributed to the sparse vegetation and high exposure to sunlight in agroecosystem that are favorable as foraging place of reptiles. The reptiles recorded constitute only 3.75 percent of the 240 reptilian species known to occur in the Philippines and about 9.78 percent of the 92 species known to occur within the Mindanao faunal region. The high elevation of the sampling sites (1,269-2,175 masl) could be the reason for this low species richness since Alcala (1976) reported that majority of the reptiles occur at lowlands up to 1,200 masl or less and only a few occur at high elevations.

Results indicated that of the 90 species of birds recorded, more were found in the agroecosystem sites than in the forested sites. This was perhaps due to the greater number of food plants available in the agroecosystem areas. Most of the birds comprising this site, however, were widespread species, while the endemic species were confined to the primary forest of high elevation. Mallari and Jensen (1993) also observed in their study in Sierra Madre that endemic forest specialists characterized the avian communities at the higher elevations.

Species richness of volant mammals was higher in the agroecosystem sites. Abundance of fruit-bearing plants in these sites could be the reason for the greater number of species. This record was higher compared to that of Tabaranza *et al.* (2001) in the other side of Mt. Malindang, however, the number of non-volant mammals in this study was lower.

A partial inventory of the species richness of invertebrates in the secondary forest of Barangay Lake Duminagat is shown in Table 3.

More species of insects (60) were recorded in the multicropped agroecosystem of Barangay Lake Duminagat, composed of 28 families in nine insect orders. The disturbed forests had lower species richness of 53 in 31 families and 10 orders in Lake Duminagat, while 42 species in 26 families and nine insect orders were recorded in Sitio Pungol. Of all the families, Family Curculionidae of weevils had the most number, where there were eight species. Family Curculionidae had only two species, while the highest number of species was observed under the category of undetermined Diptera. As an initial result of the inventory of the species richness of this site, Family Phasmatidae of walking sticks ranked first with six species. The leaf beetles of the Family Chrysomelidae ranked first in terms of pest species richness in the multicropped agroecosystem.

Earthworms collected in the 400 m^2 plots in the sampling sites in Mt. Malindang showed higher species richness (26) in the disturbed forest than the primary forest (20). The agroecosystem sites consistently showed a dominance of only one species, *Pontoscolex corethrurus,* which is a native species of South America. This species was also found in all sampling sites. It is interesting to mention that the distured forest of Toliyok had the most abundant *P. corethrurus.* The habitat type and vegetation of Toliyok may have caused the greater population of this widespread species in the area.

Assessment of Floral and Faunal Resources

As basis for the protection and conservation of the flora and fauna, assessment of its status is necessary. Assessment of the status of each species using IUCN categories (1994) of plants revealed 11 endangered, 98 endemic, 52 rare, and 258 economically important species. The two 1-ha plots alone revealed two endangered, 71 endemic, 11 rare, 171 economically important species, and 10 species of socio-cultural importance (Table 4).

An endangered plant seen in the two 1-ha plots was *Tmesipteris lanceolata* Dang (Psilotaceae). This primitive plant grows only as an epiphyte on the trunk of *Cyathea* spp. and nowhere else. However, unabashed collection of trunks of *Cyathea* as medium to grow orchids, anthurium, and other epiphytic plants had endangered the life of *Tmesipteris.* Although not observed within the sampling plots, *Bryum russulum* (Bryaceae) was another endangered plant seen only in the 1-ha plot of Mt. Guinlajan.

Complete inventory of trees in the two 1-ha plots showed 85 species, of which 48 species (57%) were endemic. This percentage becomes higher when considered by hectare basis since species endemism reach up to 60 percent. This figure was comparatively higher than in Mt. Kitanglad, which has only 47 percent of species endemism (Pipoly and Madulid 1996). However, when results of the inventory from nested plots and transect belt were added, endemism was reduced to 33 percent. It is noteworthy that some species were site endemic, such as *Medinilla malindangensis*, or island Mindanao endemics, such as *Saurauia involucrata, Saurauia fasciculiflora, Saurauia glabrifolia,* and *Cinnamomum mindanaense,* and others were widespread Philippine endemics. In some cases, reported Luzon endemics were now reported in Mindanao, like *Begonia cumingii, Vaccinium jagori,* and *Saurauia fasciculiflora.* As to the endemicity of plant groups, the trees and shrubs obtained a high percentage of endemism, ranging from 33 to 49 percent, while the herbs and vines had 11 to 44 percent endemism.

Table 3. Species richness of invertebrates and earthworms recorded in Mt. Malindang.

Sampling Sites	Number of Species
Insects	
Secondary forest (Lake Duminagat)	53 (22*)
Secondary forest (Sitio Pungol)	42 (8*)
Multicropped agroecosystem (Barangay Lake Duminagat)	60 (17*)
Earthworms	
Secondary forest	26
Primary forest	20
Agroecosystem	1

*undetermined species

Table 4. Conservation status of floral species in Malindang Range.

Conservation Status	Total Number of Species	
	Two 1-ha Plots	All Plots
Endangered	2	11
Endemic	71	98
Rare	19	52
Economically important species	171	258
Socio-culturally important species	10	10

Many of the floral species have economic importance. As assessed by the local researchers and validated by the community, 181 species of plants were utilized as food, medicine, ornamental, building materials, handicraft, and/or forage and with socio-cultural importance.

Table 5 shows the endemism of the vertebrate faunal groups in Mt. Malindang. Nine of the amphibian species were endemic to the Philippines, with six having ranges restricted to Mindanao. Most of the endemics were captured in the forested sites of higher elevation. All of the amphibians recorded were of stable conservation status. Considering that the top four abundant amphibian species were all endemics, namely, *Philautus* sp., *Ansonia muelleri, Ansonia mcgregor,* and *Philautus surdus*, suggested that the habitat in Mt. Malindang is still favorable for amphibian growth and development. Reptilian endemism was also very high at 89 percent, with three of the skinks and all of the snakes being endemic.

The high endemism in Mt. Malindang is very encouraging considering that the forest was already disturbed, especially sampling site 2 which was already converted to agriculture. Continued habitat disturbance and destruction, however, may severely threaten survival of the endemic species and may push these endemic species higher up the forest where the habitat conditions are usually more unfavorable for species adapted to lowland conditions. Results showed that only endemic species were found in the higher elevation of the forest, while the lower elevation and the agroecosystem sites supported widespread as well as endemic species.

Of the 576 bird species known to occur in the Philippines, 253 are endemic, 39 of which were recorded in this survey, including 25 Mindanao endemics. The endemic species found were confined to the disturbed and pristine forests of higher elevations. This suggested that endemic birds prefer to occupy the less disturbed forested areas, having

Table 5. Endemism and threatened species recorded in Mt. Malindang.

	Mt. Malindang (on-going study)	**Mt. Malindang (Don Victoriano)** (Tabaranza *et al.* 2001)	**Mindanao**	**Philippines** (Alcala 2001)
Endemism				
Frogs and toads	9 (56.25%) 6 (66.67%*)	5 (31.25%)	8 (22.86%) (Crombie 1994)	 60 (75%)
Skinks	3 (75%)	1 (33.33%)	21 (22.82%) (Crombie 1994)	168 (70%)
Snakes	5 (100%) } 89%	1 (16.66%)	(Reptiles)	(Reptiles)
Birds	39 (43.33%) 25 (64.10%*)	64 (43.54%)	34 (10.46%) (Kennedy *et al.* 2000)	253 (44%)
Volant mammals	8 (66.67%) 2 (25%*)	9 (78.26%)	22 (26.19%) (PAWB 2002)	111 (64%)
Non-volant mammals	10 (62.5%) 6 (62.5%*)	11 (47.82%)	(Mammals)	(Mammals)
Total	**74 (51.75%)**	**91 (44.17%)**	**85 (16.80%)**	**592 (55.62%)**
Threatened Species				
Frogs and toads	0	2		2
Skinks	0	0		0
Snakes	0	0		0
Birds	9	14		86
Volant mammals	3	1		14
Non-volant mammals	1	3		37
Total	**13**	**20**		**139**

*Mindanao Endemic

a more complex vegetation structure, as these could provide them more protection and cover. Of the Mindanao endemics, two were endangered, namely, the Giant scops owl (*Mimizuku gurneyi*), and the Silvery kingfisher (*Alcedo argentata*). Three species were vulnerable: the Mindanao scops owl (*Otus mirus*), the Blue-capped kingfisher (*Actenoides hombroni*), and the Mcgregor's cuckoo-shrike (*Coracina mcgregori*). Another four species were of the near- threatened category.

Endemism of volant mammals was high at 66.67 percent, of which 25 percent were Mindanao endemics. Of the endemic species captured, three were listed in IUCN (2000) as vulnerable: Small rufous horseshoe bat (*Rhinolophus subrufus*), Philippine pygmy fruit bat (*Haplonycteris fischeri*), and Harpy fruit bat (*Harpionycteris whiteheadi*). *H. fischeri,* although reported vulnerable, appeared to be abundant in the sampling sites. For non-volant mammals, endemism was also high at 62.5 percent, with 62.5 percent Mindanao endemics. Two of the Mindanao endemics, *Urogale everetti* and *Crocidura beatus,* were of vulnerable status, while the rest had stable status. *U. everetti* is an indicator species. It is common in primary forest and dependent on lowland forest. Lowland forest is rarely found in Mt. Malindang. In the absence of such forests, it is believed that this mammal may adapt to lowland montane forest and secondary growth forest situation.

Ethnobiological Survey

Survey of Subanen Researchers within the Plots

An ethnobotanical survey was conducted by recording the indigenous knowledge of the Subanen researchers regarding the ethnobotanical uses of plants found within the two 1-ha plots. It revealed 10 socio-culturally important species and 171 economically important species. The economically important species included 39 medicinal species, 14 species of food plants, 18 ornamental plants, and 100 species either for lumber, firewood, or handicraft. Preparations of plants for specific uses were annotated as described by local researchers.

Most of the medicinal species are common or cosmopolitan plants. However, prescriptions on the way the Subanens used these plants are often unique to their community based on transferred knowledge through generations. The identification and uses of these ethnobotanical plants were validated by the community. As a result of the validation with the community, the uses and procedure on how to use these plants were refined based on the articulations of women who used them. It was also found that some members of the community had already forgotten the uses of these plants due to the easy and cheap access to western medicine. As such, the local people were happy and fascinated that these information/results of the survey were shared to them.

The Subanen researchers considered *bakbak* or frogs in general as edible, however, not a single respondent in the interview conducted utilized frogs as food. Some birds, like the different species of doves and the jungle fowl, were hunted for food and as pets. It is interesting to note that none of the birds in the threatened category was hunted. Large mammals, which included the deer, monkey, civet cat, and wild pig, were commonly hunted for food consumption. Animal species considered as pests, like the rats and tree squirrels, were hunted to control their population.

Community Ethnobotanical Survey

Using ethnobotanical knowledge, the local people could design, test, and develop resource use patterns, establish microenterprise and markets, and develop mechanisms for transferring knowledge from one generation to the next. Of the 247 medicinal plant species mentioned by the residents of the three *barangays*, it was the *Elephantopus scaber* that was the most versatile. It could allegedly cure 16 ailments out of 87 illnesses recorded. *Blumea balsamifera* (14 ailments) followed, then *Psidium guajava* (12 illnesses). *Zingiber officinale, Persea americana,* and *Eleusine indica* could cure 11 ailments each. Many of these plant species were found outside the plots and at lower elevations. These included exotic or introduced species, like *Persea american*a and *Sweitenia macrophylla*.

Of the 87 illnesses recorded by the local people of Mt. Malindang, fever could be cured using 59 species of herbal plants, while *pasmo*, wounds, stomachache, relapses, and cough could be cured using as many as 30 species of herbal plants. These ailments were the most common illnesses that the local people usually experience.

Seventy-nine plant species were recorded as food plants. Fifty-seven (72%) of these were fruits, 25 (32%) were vegetables, five (6%) were used as spices, and six (8%) could be eaten raw. Results of interview revealed that the local people never depend much on wild plants for their food, but their knowledge on the availability of wild fruits was quite high.

The local people used 134 species of plants with economic importance. Fifty-one species (38%) were used for housing construction, 39 (29 %) were ornamentals, 16 (12%) were raw materials for handicraft, and 25 species (19%) were used for mat weaving and as ties. Plants for housing construction was the priority for the local people, hence these were more commonly known and were considered of great importance.

Some Socio-culturally Important Species

Of the flora species within the sampling plots, 10 species were reported by Subanen researchers to have higher sociocultural importance. These were being used in social occasion (burial rites), courtship, giving birth or conception, hunting, fishing, farming, and even as personal possession, such as *anting-anting*. Below are the ten species of socio-cultural importance:

a. *Solanum* sp. (*gabol*) and *Scleria scrobiculata* (*limbas-limbas*) - These plants are burned after burial rites as *pamalina*. The Subanens believe that these species can cast away the bad spirits so as not to harm the living.
b. *Habenaria* sp. (*dalamdam*) - During courtship, *dalamdam* is sometimes used by a desperate man dying to capture the heart of his beloved. This species is considered as *panglumay*. It is mixed with perfume to be used during courtship for the girl to accept the suitor's pleas. This can be placed in a small bottle filled with coconut oil and put on the windowpane with the early morning rays of the sun striking it. By chanting the name of the girl being prayed for, she would be summoned by the man holding this mysterious plant.
c. *Macaranga bicolor* (*labulag*). This plant is used to rekindle lost love by placing a leaf under the pillow while sleeping. It is also believed to cast away bad spirits that cause illnesses to newborn babies if its leaves are placed as poultices on the abdomen of the pregnant woman.
d. *Xylaria hypoxylon* (*oten-oten sa unggoy*). For couples who want a baby boy, this fungus species is believed to answer their prayers by making it part of the wife's belt or *habak* before pregnancy.
e. *Impatiens montalbanica* (*silangka*). This species is of great help to pregnant women who are about to give birth. The ripe capsule of this plant is believed to assure women of delivering the baby quickly and easily by placing the capsule near the feet of the woman about to give birth and letting the capsule dehisce by touching it.

f. *Gardenia longiflora* (*tamilok*). This plant is of great importance to Subanen hunters who use it for attracting civet cats (*milo*). If placed near the bait, it would surely capture one.
g. *Rubus* sp. (*sampinit*). Fishermen place the *sampinit's* thorny twigs on the fishing pole to attract more fish to the bait, allowing them to catch baskets full of fish.
h. *Ficus* sp. (*busyong*). For farmers who wished to harvest abundant and bigger sweet potatoes, they include fruits of the *busyong* in the stems of camote during planting. The Subanens believe that if the fruit is included in the first seven seedlings, this would give them a bountiful harvest.
i. *Glochidion canescens* (*tulog-tulog*). This plant, sometimes called *tulog-tulog*, is used by some people who wish to be invisible. *Tulog-tulog,* mixed with *Mimosa pudica*, would make a person who wants to visit a loved one's house, or who needs protection, invisible, if placed in a bottle of oil accompanied by a prayer.

Livelihood Development for Biodiversity Conservation

During the community validation, the community had identified two projects with potential for livelihood. These are briefly described below:

Establishment of Nursery

As a result of the inventory of trees in the two 1-ha plots in Malindang Range, 15 species of indigenous fast-growing trees were identified and recommended by the Subanens as reforestation species.

These fast-growing trees would be used in the three *barangays* of Don Victoriano to reforest denuded areas. Not only that these trees are fast growing, they have other economic uses to the community as well - for lumber, medicine, food, and others. The Subanen researchers would collect seeds of the fast-growing trees and grow them in the nursery. The seedlings produced would be used by the community to reforest denuded mountains, and also for planting along the road and trail to provide shade. As an income-generating project of the community, all visitors, e.g., mountain climbers, of Mt. Malindang would be asked to buy a seedling from the nursery and plant it as part of the reforestation project. The *barangay* officials would make a resolution and prepare a project proposal for submission to SEARCA-BRP for possible funding. If approved, this could generate income to the community, and at the same time promote biodiversity conservation.

Establishment of a Community Economic Garden

The Subanen researchers had identified many economically important plants within the two established semi-permanent plots and along the trail from Barangays Mansawan, Gandawan, and Lake Duminagat. These economic plants could be tapped as sources of (a) vegetables for human food; (b) medicine; (c) ornamentals; and (d) raw materials for handicraft making. With information on their uses and financial support from the SEARCA-BRP and local government units, these economic plants could be mass propagated and could benefit the socioeconomic condition of the three *barangays* through the establishment of a community economic garden. This could be made possible by developing a: community farm for edible plants as cash crops, such as chayote (*Sechium edule*), and *pako* (*Diplazium esculentum*); plantations for medicinal plants; commercial gardens for plants with ornamental values; and cottage industry for plants with handicraft potential, like *Lygodium* spp., *Dicranopteris* spp., *Musa textiles*, *Pandanus* spp., and *Calamus* spp.

Establishing a community economic garden proposed by officials and local members of the community is not only a livelihood project, but also a strategy in conserving the remaining biodiversity in the forest. This *ex situ* conservation technique would allow the use of plant resources without depleting their natural population in the wild.

SUMMARY AND CONCLUSION

Participatory inventory of the flora and fauna in the forests and agroecosystem of Malindang Range revealed a total of 666 plant species in 305 genera and 147 families; 160 species of above-ground invertebrates, 27 species of earthworms, and 143 species of vertebrate fauna. Complete inventory of trees in the two 1-ha plots showed high species richness (63-67 species), high density (961-1,000 individuals), and high endemism (60%). The trees with high species importance values included *babasa* (*Polyosma philippinensis*), *sakam* (*Clethra lancifolia*), *gantaw* (*Cyathea brevipes*), and *gulayan* (*Lithocarpus philippinensis*). These species have various uses to the community. Higher species richness and endemism of amphibians was recorded in forested areas than in agroecosystem sites. Unlike the amphibian population, more reptiles were captured in the agroecosystem.

Assessing floral and faunal resources revealed 11 endangered plant species and 13 threatened vertebrate faunal species. A total of 98 species of plants and 74 species (51.75%) of vertebrate fauna were endemic. One hundred percent endemism was recorded for snakes, 75 percent for skinks, 56.25 percent for frogs and toads, 43.33 percent for birds, 66.67 percent for volant mammals, and 62.5 percent for non-volant mammals. Of the Mindanao endemic birds, two were andangered, three vulnerable, and four near-threatened. Of the Philippine endemic bats, three were of vulnerable status, while two of the Mindanao endemic non-volant mammals were also of vulnerable status.

The survey on species of socioeconomic and cultural importance revealed 10 plant species (within the plots) and 79 species (outside the plots) that were used in burial rites, courtship, wedding, conception, hunting, farming practices and personal “charm”. Of the faunal species identified, the local people used 13 species composed of eight birds and five mammals. These resources were utilized either as pets or consumed as food.

Active participation of the Subanen researchers contributed significantly to the scientific results on ethnobiological and scientific identification of flora and fauna. Two immediate potential livelihood projects for biodiversity conservation were identified - establishment of a nursery and a community economic garden.

The upper montane forest of Mt. Malindang is still very rich rich in floral and faunal resources, an important resource for both *in situ* and *ex situ* conservation in Mindanao.

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VERTEBRATE FAUNAL DIVERSITY AND RELEVANT INTERRELATIONSHIPS OF CRITICAL RESOURCES IN MT. MALINDANG[1]

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The study on the diversity of four vertebrate faunal groups – amphibians, reptiles, avifauna, and mammals – aimed to assess the faunal diversity in Mt. Malindang to come up with conservation strategies for community biodiversity management. Line transect, mist netting, trapping, and opportunistic methods were used in collecting primary data from the selected sampling sites representing the mossy, montane, almaciga, dipterocarp, mixed dipterocarp and agroecosystem vegetational types.

A total of 278 species of vertebrate fauna were found, represented by 26 species of amphibians, 51 reptiles, 161 birds and 40 mammals. Mindanao has, reportedly, 506 vertebrate faunal species out of the 1,070 species found in the Philippines. The higher species richness on Mt. Malindang was matched with a higher level of endemism, wherein 117 (42.09%) species and 41(35.04%) species were Philippine and Mindanao endemics, respectively. Avifauna endemicity was relatively higher compared to other faunal groups. Of the total Philippine endemics, 56.41 percent belong to avifauna, 19.26 percent belong to mammal, 12.82 percent belong to amphibian, and 11.11 percent belong to reptile group. The number of Mindanao endemics was consistently higher among avifauna (56.09%), followed by reptile (48%), amphibians (19.51%), and mammals (19.51%).

The data showed that Mt. Malindang presents a biologically unique landscape supporting a number of endemic animals. Faunal exploitation of the communities was found to be maintained at a subsistence level, but the biggest threat to the vertebrate fauna is habitat loss. With the dissemination of the research findings to communities, people realized the status of the fauna as basis for conservation actions. The widest dissemination of the output of the study, as well as its recommendations, could hopefully create a network of concerned groups (communities, local government units [LGUs], institutions, and agencies) working for the protection and conservation of endemic and threatened fauna on Mt. Malindang.

RATIONALE

Clearing of the lower slopes of the forest for farming purposes, *kaingin*, and human encroachment are some of the threats to biodiversity in Mt. Malindang. Given these problems, it is important to study the quality of the remaining habitats and the current status of the faunal species in the area especially the threatened and restricted-range vertebrate species. The knowledge of what is left of or what is found in the forest is essential in recommending effective measures for conservation.

Vertebrates are very good indicators of the health of the ecosystem, aside from their socioeconomic significance to the life of the indigenous people in Mt. Malindang. Hence, there is a need to assess the major vertebrate faunal groups in Mt. Malindang. The collaborative-integrative approach, where findings are integrated and discussions among different study groups are done, ensures that possible interrelationships among faunal diversity, floral diversity, soil ecology, other environmental parameters, and socioeconomic factors are drawn or established. Integrated results towards an integrated conservation and management plan are viewed to have more impact and to be more effective. Through the participatory approach, where local researchers, the community, and other

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stakeholders are involved, it is hoped that better strategies for conservation and production of information, education, and communication (IEC) materials could be developed, which could contribute towards development in Mt. Malindang.

OBJECTIVES

The general objectives of the study were: (1) to assess faunal resource diversity in selected sites in Mt. Malindang for better understanding and management of critical resources, and (2) to analyze significant interrelationships of the faunal resources. The specific objectives were to: (a) identify the vertebrate faunal communities/species in the forest and agroecosystems in Mt. Malindang; (b) determine the vertebrate faunal species being threatened by various resource utilization practices; (c) determine the biodiversity indices for designing appropriate conservation and management schemes of the critical resources; (d) relate socioeconomic and cultural activities with the biophysical properties of the terrestrial ecosystems; (e) to assess and build on the existing indigenous knowledge system (IKS) or community-based biodiversity monitoring and conservation practices; (f) formulate recommendations for increasing awareness on biological diversity and conservation; and (g) develop integrated development and conservation strategies that can be used in local biodiversity conservation and management.

METHODOLOGY

Sampling Sites

A total of 14 sites were assessed for vertebrate faunal diversity in Mt. Malindang (Figure 1). One sampling site each was assessed in the mossy, almaciga, montane, plantation, and dipterocarp forests, four in mixed dipterocarp forest, and five in agroecosystem areas. Some of the samplings sites established were further subdivided into two subsites to determine whether there are apparent significant differences on species composition between north (subsite 1) and south (subsite 2) exposures.

Sampling Methods, Measurements, and Identification

Primary data were collected through appropriate participatory and multidisciplinary approaches. Standard sampling techniques of Haribon (2001) were followed for vertebrate fauna. Species effort curve was the basis for determining the sufficiency of sampling efforts. The study followed the capture-mark-release technique, where identified specimens were marked and released. For large species, however, like wild pigs and other large mammals and birds, no capture was done but their presence was noted through direct observation and information gathered through key informant interviews. Two to three voucher specimens were prepared for captured species, especially new and unidentified species.

Herpetofauna

Collection of amphibians and reptiles was done by visual encounter or opportunistic method. Sampling for amphibians was conducted during daylight and nighttime hours. Aquatic, subterranean, surface, and arboreal strata were searched for amphibians.

Late in the morning to early afternoon is the best time to sample reptiles, considering the peak activity of these species. Reptiles were collected by digging and trenching using *bolos* and sticks, climbing and searching through the forest, checking isolated pools, seepage areas, tree holes, burrows, rotten logs and rocks, vines, ant mounds, leaf litter, tree foliage, and other microhabitats. A total of 203 field days were spent on collecting herpetofaunal species in Mt. Malindang. Body weight and morphometrics were taken. These are important data for identification. Different

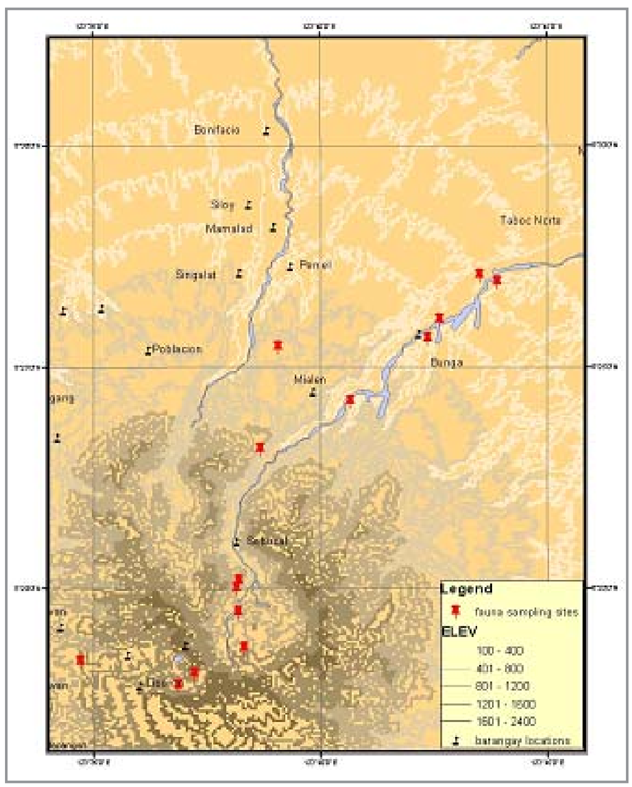

Figure 1. Map showing the 14 established sampling sites in different Barangays on Mt. Malindang.

animal groups have different morphometrics. Each group has specific standard measurements, which are important in giving the appropriate body configuration for each species. The following morphometrics were taken for amphibians and reptiles: total length (TL), snout to vent length (SVL), tibia length (TBL) for adult anurans only, head length (HdL), tail length (TV) except adult anurans, forelimb length (FL), and hindlimb length (HbL). Inger (1954), Brown and Alcala (1978), Brown and Alcala (1980), and Alcala (1986) were used as references in the identification.

Avifauna

Mist netting was used to sample birds in the area. Mist nets were set up at least 0.5 meter above the ground to sample ground and understory dwellers. Sky nets as high as 15 m above the ground were set up in appropriate sites to catch canopy species. Nets were set along and across waterways, forest edges and clearings, flyways, and vicinities of feeding trees. Nets were checked every hour during the day so as not to unduly subject the captured birds to stress. A total of 7,506 net days were spent to sample birds in all the sampling sites. Body weight and morphometrics were taken for each bird captured. The following morphometrics were taken: wing length (WL), tail length (TV), total length (TL), tarsus length, culmen, and bill length. Taxonomic keys, Dickinson *et al.* (1991), Kennedy *et al.* (2000), and DuPont (1971) were used as references in the identification.

To supplement capture results, the line transect method was also done, where a standard 2-km transect line was first established in the chosen sampling area. Using colored plastic markers, the line was divided into 80 transect points with an interval of 25 m per point and eight reference points. Data, such as the locality, elevation, location, date, weather, habitat type, species, number of times the bird was observed during the walk, stratum or the location of the bird during observation, the method of observation used, the transect point where it was observed, and remarks, were all written in the transect forms provided for each observer. A standard 2-hr walk per observer was done along the transect line.

Mammalian fauna

Systematic trapping and mist netting were used to sample small non-volant and volant mammals, respectively. Direct observation and interviews with the local residents were done to record large mammalian species.

Mist nets were used to sample volant mammals. The same mist nets used to sample birds were used for volant mammals. The nets were left open at night to capture bats and other nocturnal species. Checking of nets was done in the early evening since insect-eating bats are active at this time, and every hour thereafter so as to prevent the bats from tearing the nets and being stressed when left too long in the nets. A total of 7,506 net nights were spent to sample volant mammals in all the sampling sites. Trapping (live traps and snap traps) was carried out to sample small non-volant mammals. Traps were set with earthworms, bananas, and roasted coconut coated with peanut butter as bait. Traps were placed at 5-m intervals on the ground, along suspected runways, near holes, among root tangles, and on fallen logs. Checking of traps and rebaiting were done twice a day, early in the morning and late in the afternoon. A total of 14,973 trap nights were spent in all sampling sites. On the other hand, locally-made traps, made of wood with a string attached, were set up to compare their efficiency with the standard traps in capturing non-volant mammals. Twenty-one traps were set up in Site 1 and 11 in Site 5. Results showed that standard traps were more efficient in capturing non-volant mammals than locally-made traps. Only one locally-made trap was able to capture one *Paradoxurus hermaphroditus* out of the 32 traps set up. The low capture may be due to the kind of materials used in locally-made traps that made it not durable enough to prevent the escape of non-volant mammals captured. Body weight and morphometrics were taken, which included total length (TL), tail to vent length (TV), hindfoot length (HF), external ear length (EAR), and forearm length (FA). Identification key of Ingle and Heaney (1992) was used in the identification.

Threatened Faunal Species

A list of threatened species, as per IUCN criteria, as well as endemic, and economically and culturally important species based on published literature and information obtained from the community was generated after the conduct of field sampling. Information on species occurrence, socioeconomic importance of the vertebrate fauna to the community, and resource utilization was obtained through key informant interviews and through discussions and integration meetings with the resource utilization study group of the Socioeconomic and Cultural Studies (SECS) Master Project of the Biodiversity Research Programme (BRP) for Development in Mindanao: Focus on Mt. Malindang and Environs.

Community Validation

The results of this study were presented to the local residents of the *barangays* in Mt. Malindang where the sampling sites were located. Simultaneous validation meetings were held on 26 February 2005, attended by the different representatives of the different studies of the BRP and the local community from Mansawan-Gandawan cluster and Peniel. Another validation meeting was held on 5 March 2005 for Toliyok-Mialen-Bunga cluster, Lake Duminagat-Sebucal cluster, and Mamalad. The participants from the communities, which included *barangay* captains, *barangay* councilmen, local researchers, key informants, and the general community, validated the data gathered and verified species that might not have been encountered in the actual sampling activities. Insights and recommendations were drawn from the participants, and the information obtained was used in the formulation of recommendations for biodiversity conservation and management.

Analysis of Data

Turboveg 2.0 for Windows was used for data input. This is a program originally designed for the storage, selection, and export of vegetation survey data (relevées). It can also be used for faunal data. Data can be imported manually (separate relevées or tables) and automatically (import of data files). Selections of relevées can be made by choosing one or several of the header data or by choosing a species or a combination of species. Several (export) formats are available to export the selected relevées (selections) and to enable a further analysis with various programs (e.g., TWINSPAN, CANOCO, Mulva, Syntax-5, Excel, Lotus 123, and Megatab).

Biodiversity Indices

For each sampling site, the following biodiversity indices were considered: species richness, species diversity, and evenness. These indices were computed using BIODIV PRO and SPSS. Species diversity refers to the number (species richness) and relative abundance of species in a biological community.

Socioeconomic and Cultural Activities and the Biophysical Properties of the Ecosystem

Discussions and sharing of data with the SECS group were conducted to integrate findings and relate the socioeconomic and cultural data to the findings derived from the faunal survey. Validation meetings with the local community had also verified data from the field. The meetings were done to present to the community the result of the recently conducted biodiversity research of the terrestrial vertebrate fauna and the whole BRP; to show to the community the different species of vertebrate fauna collected and to know from them whether the local names taken by the researchers are correct; and to know the issues and concerns of the community regarding the biodiversity research.

Assessment and Building on the Existing Indigenous Knowledge System (IKS) or Community-based Biodiversity Monitoring and Conservation Practices

This aspect of the study was done by the SECS group of BRP. Existing IKS was assessed by this group through interviews and focus group discussions. Nevertheless, the vertebrate fauna study also obtained some information on biodiversity monitoring and conservation practices through interviews with local researchers and other key informants in the communities where sampling was done.

Formulation of Recommendations for Increasing Awareness on Biological Diversity and Conservation

Recommendations were prepared based on field sampling results, information obtained through interviews with local people, integration meetings within the BRP group, and the biodiversity map translated from the cluster data obtained using the TWINSPAN analysis. Some of the IEC materials that were recommended in this study would actually be produced before the end of the project period.

Development of Integrated Development and Conservation Strategies that can be Used in Local Biodiversity Conservation and Management

A set of strategies or schemes for conservation and management of critical resources was prepared at the study level based on the findings of the study. These recommendations and suggested strategies for conservation would be further enhanced at the project and program level during the BRP integration meetings and exit conference with the local stakeholders, concerned government officials, heads of agencies, and policy/ decision makers in attendance.

RESULTS AND DISCUSSION

Vertebrate Fauna and Interrelationships with Other Resources in the Ecosystem

Table 1 shows a total of 278 terrestrial vertebrate species (26 amphibians, 51 reptiles, 161 birds, and 40 mammals) recorded from the 14 sites explored within the Mt. Malindang Range. Of these, 117 (42.09%) were endemic to the Philippines, with 41 species having ranges restricted to Mindanao. Thirty of the species recorded were considered threatened and further categorized as critically endangered (2 species), endangered (4 species), and vulnerable (24 species).

Table 1. Vertebrate faunal species found in Mt. Malindang.

	Mt. Malindang	**Mt. Malindang (Don Victoriano)** (Tabaranza *et al.* 2000)	**Mindanao**	**Philippines** (Alcala 2001)
Frogs and toads	26 (32.5%); (74.28%)*	16	35 (Crombie 1994)	80
Skinks		3	Reptiles, 92 (Crombie 1994)	Reptiles, 240
Snakes	51 (21.2%); (55.4%)*			
Birds	161 (27.9%); (49.5%)*	147	325 (Kennedy *et al.* 2000)	576
Volant mammals		11		
Non-volant mammals	40 (22.9%); (47.6%)*	23	Mammals, 84 (PAWB 2002)	Mammals, 174
Total Number of Species	**278 (25.9%); (54.9%)***	**206**	**506**	**1,070**
Endemism				
Frogs and toads	15 (59.69%); 8 (53.33%)*	5 (31.25%)	8 (22.86%) (Crombie 1994)	60 (75%)
Skinks	7 (58.33%); 1 (14.28%)*	1 (33.33%)	21 (22.82%) (Crombie 1994)	168 (70%)
Snakes	6 (37.5%); 1 (16.67%)*	1 (16.66%)	(Reptiles)	(Reptiles)
Birds	66 (40.99%); 23 (34.85%)*	64 (43.54%)	34 (10.46%) (Kennedy *et al.* 2000)	253 (44%)
Volant mammals	9 (47.37%); 2 (22.22%)*	9 (78.26%)	22 (26.19%) (PAWB 2002)	111 (64%)
Non-volant mammals	14 (66.67%); 6 (42.86%)*	11 (47.82%)	(Mammals)	(Mammals)
Total	**117 (42.09 %); 41 (35.04%)***	**91 (44.17%)**	**85 (16.80%)**	**592 (55.62%)**
Threatened Species				
Frogs and toads	12 (1 E, 11 V)	2		22 (7 CE, 6 E, 9 V)
Skinks	0	0		0
Snakes	0	0		0
Birds	9 (2 CE, 2 E, 5 V)	14		86
Volant mammals	4 (1 E, 3 V)	1		14
Non-volant mammals	5 V	3		37
Total	**30 (2 CE, 4 E, 24 V)**	**20**		**159**

*Mindanao Endemic
CE - Critically Endangered
E - Endemic
V - Vulnerable

The results revealed that the total number of species recorded (278) was 54.9 percent of the total species recorded in Mindanao (506), and 25.9 percent of the record in the Philippines (1,070). Likewise, 41 (35.04%) of the Mindanao endemic species and 117 (42%) of the Philippine endemic species were recorded in Mt. Malindang. Highest endemism was observed in amphibians (74.28%), followed by reptiles (55.4%), and avifauna (49.5%). The mammalian group showed a lower endemism of 47.6 percent. The data also showed that there were more amphibians that are Mindanao endemic (53.33%), lesser in birds (34.85%) and mammals (34.78%), and very low in reptiles (30.95%). The findings in this study indicated that Mt. Malindang is a rich biodiversity area and a key conservation site owing to its high number of endemic and threatened species.

Table 2 shows that among the 14 sites surveyed, four (three forested sites and one agroecosystem site) had comparably high species richness. These were: sampling site 5, subsite 1 (dipterocarp forest, 700-1,400 masl) with 98 species; sampling site 5, subsite 2 (dipterocarp forest, 700-1,400 masl) with 100 species; sampling site 9 (almaciga forest, 800-1,200 masl) with 95 species; and sampling site 10 (agroecosystem, 600-985 masl) with 104 species. Three sites were moderately species-rich, which included sampling site 3, subsite 2 (montane forest, 1,450-1,790 masl) with 78 species; sampling site 1 (mossy forest, 1,600-2,175 masl) with 70 species; and sampling site 13, subsite 1 (mixed dipterocarp forest, 300-475 masl) with 71 species. Low species richness was observed in the five agroecosystem sites, namely, sampling site 6 (agroecosystem, 1,400-1,550 masl) with 66 species; sampling site 8 (agroecosystem, 1,235-1,290 masl) subsite 1 with 30 species, and subsite 2 with 42 species; sampling site 12 (agroecosystem, 600-610 masl) with 51 species, and sampling site 17 (agroecosystem; 165-465 masl) with 52 species. Also low in species richness were sampling site 15 (mixed dipterocarp, 195-445 masl) subsite 1 with 60 species, and subsite 2 with 53 species; sampling site 19 (mixed dipterocarp forest, 100-250 masl) with 52 species; sampling site 1, subsite 2 (mossy forest, 1,600-2,175 masl) with 59 species; and sampling site 11 (plantation forest, 600-885 masl) with 64 species.

The remarkably high species richness recorded for the three forested sites (subsites 1 and 2 of sampling site 5, dipterocarp forest, 700-1,400 masl, and sampling site 9, almaciga forest, 800-1,200 masl), which were part of an old-growth forest, demonstrated the importance of older forests to terrestrial vertebrates. A forest habitat with its complex arrangement of vegetation offers terrestrial vertebrates a wide range of suitable microhabitats in which to settle. Sexton *et al.* (1964) noted that the arrangement of vegetation in space is important in determining the local distribution of species as it affects the microenvironment. By incidentally providing the proper environmental conditions, the arrangement of vegetation could influence an animal's distribution. Thus, it may be suggested that the structural complexity of the aforementioned forest sites may have influenced the establishment of suitable micro environmental conditions for the different land vertebrates, thereby encouraging the settling of most species. This suitable microenvironment provided by forest habitat included the creation of various breeding sites, a humid environment, sufficient cover, and an abundant supply of food. Also, Alcala (1976) noted that the land vertebrates of the Philippines are generally distributed in areas covered by natural vegetation, with forests harboring a majority of them. Similarly, the findings of this study clearly showed that the forest harbors a big proportion of terrestrial vertebrates, as the species richness of the four vertebrate groups have been observed to consistently occur in higher proportions in these three forested sites mentioned relative to the other sites, in particular subsite 2 of sampling site 5 (dipterocarp forest; 700-1,400 masl) with (N=100) 14 amphibians, 17 reptiles, 59 birds, 10 mammals.

In the case of amphibians, their reliance to cutaneous respiration and their subsequent sensitivity to dehydration, necessitate the settling of most of the species in areas where there is continuous moisture. Alcala (1976) reported that most Philippine anurans live in tropical rainforests, where the relative humidity is always at or near saturation. For reptiles, although their skins are impermeable to water, they are still affected by humidity. In fact previous studies by Alcala (1976) have shown that these animals are restricted to the moist or humid microhabitats in the tropical rain forests. Also, reptilian eggs/embryo requires the availability of moisture for proper growth and differentiation (Zug 1993). For birds, they naturally opt to settle in areas where breeding sites and food are abundant and cover is sufficient. Similarly, Philippine mammals also occupy habitats that assure them of sufficient cover, food, and breeding sites. Thus, it can be said that the aforementioned forested sites, with its tall trees and high canopy cover of 75-90 percent, have ensured the establishment of environmental conditions that are required for the flourishing of the population of the different land vertebrates, hence, the high species richness.

It is interesting to note that although subsite 1 of sampling site 5 (dipterocarp forest, 700-1,400 masl) was among the highly species-rich sites, the high count, however, was largely due to the high count of birds and volant mammals recorded for this site. Highest species richness for birds (75 species) and volant mammals (12 species) was recorded on this site, thereby compensating for the low species count in the other vertebrate groups, where only

Table 2. Species richness, threatened species, and endemic species of the vertebrate fauna in Mt. Malindang.

Elevation (masl)	Sampling Site	Subsite	Location	Vegetation Type	All Faunal Groups			Amphibians		
					SR	TS	ES	SR	TS	ES
1,600-2,175	1	1	North Peak	Mossy forest	70	13 (3 E, 10 V)	42 (21*)	5	5 (1 E, 4 V)	5 (3*)
		2	North Peak	Mossy forest	59	14 (3 E, 11 V)	41 (21*)	7	6 (1 E, 5 V)	7 (6*)
1,500-1,900	2 not sampled	0	Mt. Guinlajan	Mossy forest		NA			NA	
1,450-1,790	3	1 not sampled	Ulohan sa Dapitan	Montane forest		NA			NA	
		2	Ulohan sa Dapitan	Montane forest	78	16 (3 E, 13 V)	46 (23*)	11	7 (1 E, 6 V)	8 (6*)
1,450-1,600	4	0	Sitio Pungol	Montane forest	50	3 (1 CE, 2 V)		25 (11*)	NA	
						Transect Data Only				
700-1,400	5	1	Mt. Capole/ Sebucal	Dipterocarp	98	8 (2 E, 6 V)	49 (16*)	3	2 V	2 (2*)
		2	Mt. Capole/ Sebucal	Dipterocarp	100	14 (1 E, 13 V)	53 (19*)	14	8 (1 E, 7 V)	10 (5*)
1,400-1,550	6	0	Lake Duminagat	Agroecosystem	66	6 V	34 (15*)	4	2 V	3 (2*)
1,000-1,400	7	0	Gandawan	Agroecosystem	58		0	16 (5*)		
						Transect Data Only				
1,235-1,290	8	1+	Mansawan	Agroecosystem	30	7 V	16 (7*)	9	6 V	8 (5*)
		2+	Mansawan	Agroecosystem	42	4 (1 E, 3 V)	47 (21*)	7	3 (91 E, 2 V)	3 (3*)
		##	Mansawan	Agroecosystem	41		0	11 (2*)		
800-1,200	9	0	Sebucal	Almaciga forest	95	10 (1 CE, 2 E, 7 V)	47 (21*)	9	5 (1 E, 4 V)	7 (5*)
600-985	10	0	Sebucal	Agroecosystem	104	3 V	36 (9*)	6	2 V	3 (2*)
600-885	11	0	Peniel	Plantation forest	64	5 V	28 (8*)	9	3 V	4 (2*)

SR - species richness; TS - threatened species; ES - endemic species; CE - Critically endangered; E - endangered; V - vulnerable; NA - not applicable; ## - bird data only; 1+ and 2+ - data excluding birds
*Mindanao endemic

Table 2. Continued…

Elevation (masl)	Sampling Site	Subsite	Location	Vegetation Type	Reptiles			Birds		
					SR	TS	ES	SR	TS	ES
600-610	12	0	Peniel	Agroecosystem	51	0	16 (4*)	5	0	0
300-475	13	1	Mialen	Mixed dipterocarp	71	5 (1 E, 4)	35 (14*)	6	3 (1 E, 2 V)	5 (3*)
		2	Mialen	Mixed dipterocarp	63	3 (1 E, 2 V)	27 (28*)	5	2 V	2 (1*)
300-475	14 not sampled	0	Mialen	Agroecosystem		NA			NA	
195-445	15	1	Toliyok	Mixed dipterocarp	60	2 (1 E, 1 V)	17 (3*)	3	0	1
		2	Toliyok	Mixed dipterocarp	53	4 (1 CE, 3 V)	31 (11*)	3	1 V	1 (1*)
175-465	16	0	Mamalad	Mixed dipterocarp	66	1 E	20 (8*)	7	0	2
165-465	17	0	Mamalad	Agroecosystem	52	1 V	10 (4*)	5	1 V	2 (1*)
165-420	18 not sampled	0	Toliyok	Agroecosystem		NA			NA	
100-250	19	1	Bunga	Mixed dipterocarp	52	1 V	16 (4*)	3	1 V	1 (1*)
		2	Bunga	Mixed dipterocarp	42	2 V	12 (3*)	2	1 V	2 (1*)
95-165	20 not sampled	0	Bunga	Agroecosystem		NA				
1,600-2,175	1	1	North Peak	Mossy forest	No Species Captured		53		3 (1 E, 2 V)	27 (11*)
		2	North Peak	Mossy forest	No Species Captured		33		3 (1 E, 2 V)	20 (9*)
1,500-1,900	2 not sampled	0	Mt. Guinlajan	Mossy forest		NA			NA	
1,450-1,790	3	1 not sampled	Ulohan sa Dapitan	Montane forest		NA			NA	
		2	Ulohan sa Dapitan	Montane forest	No Species Captured		51		3 (1 E, 2 V)	28 (13*)
1,450-1,600	4	0	Sitio Pungol	Montane forest	NA		50		3 (1 CE, 2 V)	25 (11*)

SR - species richness; TS - threatened species; ES - endemic species; CE - Critically endangered; E - endangered; V - vulnerable; NA - not applicable; ## - bird data only; 1+ and 2+ - data excluding birds
*Mindanao endemic

Table 2. Continued...

Elevation (masl)	Sampling Site	Subsite	Location	Vegetation Type	Reptiles SR	Reptiles TS	Reptiles ES	Birds SR	Birds TS	Birds ES
700-1,400	5	1	Mt. Capole/ Sebucal	Dipterocarp	7	0	2	75	4 (1 E, 3 V)	39 (13*)
		2	Mt. Capole/ Sebucal	Dipterocarp	17	0	6	59	3 V	32 (11*)
1,400-1,550	6	0	Lake Duminagat	Agroecosystem	2	0	1	48	1 V	24 (11*)
1,000-1,400	7	0	Gandawan	Agroecosystem				58	0	16 (5*)
									Transect Data Only	
1,235-1,290	8	1+	Mansawan	Agroecosystem	10	0	4		Two Subsites Combined	
		2+	Mansawan	Agroecosystem	23	0	3			
		##	Mansawan	Agroecosystem				41	0	11 (2*)
800-1,200	9	0	Sebucal	Almaciga forest	10	0	1	59	3 (1 CE, 1 E, 1 V)	30 (13*)
600-985	10	0	Sebucal	Agroecosystem	26	0	4	60	1 V	25 (6*)
600-885	11	0	Peniel	Plantation forest	11	0	2	41	1 V	20 (5*)
600-610	12	0	Peniel	Agroecosystem		0	1	38	0	13 (3*)
300-475	13	1	Mialen	Mixed dipterocarp	13	0	6 (1*)	43	1 V	18 (8*)
		2	Mialen	Mixed dipterocarp	3			48	1 E	18 (6*)
300-475	14 not sampled	0	Mialen	Agroecosystem		NA			NA	
195-445	15	1	Toliyok	Mixed dipterocarp	7	0	2	37	2 (1 E, 1 V)	8 (3*)
		2	Toliyok	Mixed dipterocarp	2	0	3 (1*)	40	2 (1 CE, 1 V)	22 (8*)
175-465	16	0	Mamalad	Mixed dipterocarp	3	0	1 (1*)	45	1 E	13 (6*)
165-465	17	0	Mamalad	Agroecosystem	6	0	2 (1*)	37	0	5 (2*)

SR - species richness; TS - threatened species; ES - endemic species; CE - Critically endangered; E - endangered; V - vulnerable; NA - not applicable; ## - bird data only; 1+ and 2+ - data excluding birds
*Mindanao endemic

Table 2. Continued...

Elevation (masl)	Sampling Site	Subsite	Location	Vegetation Type	Reptiles			Birds		
					SR	TS	ES	SR	TS	ES
165-420	18 not sampled	0	Toliyok	Agroecosystem		NA			NA	
100-250	19	1	Bunga	Mixed dipterocarp	3	0	0	37	0	11 (2*)
		2	Bunga	Mixed dipterocarp	1	0	0	32	0	7 (1*)
95-165	20 not sampled	0	Bunga	Agroecosystem		NA				
1,600-2,175	1	1	North Peak	Mossy forest	5	3 (1 E, 2 V)	4 (1*)	7	2 V	4 (3*)
		2	North Peak	Mossy forest	13	3 (1 E, 2 V)	8 (1*)	6	2 V	6 (5*)
1,500-1,900	2 not sampled	0	Mt. Guinlajan	Mossy forest		NA			NA	
1,450-1,790	3	1 not sampled	Ulohan sa Dapitan	Montane forest		NA			NA	
		2	Ulohan sa Dapitan	Montane forest	5	3 (1 E, 2 V)	4 (1*)	11	3 V	6 (3*)
1,450-1,600	4	0	Sitio Pungol	Montane forest		NA			NA	
700-1,400	5	1	Mt. Capole/ Sebucal	Dipterocarp	12	2 (1 E, 1 V)	6 (1*)	1	0	0
		2	Mt. Capole/ Sebucal	Dipterocarp	7	2 V	4 (2*)	3	1 V	2 (1*)
1,400-1,550	6	0	Lake Duminagat	Agroecosystem	8	2 V	5 (1*)	4	1 V	1 (1*)
1,000-1,400	7	0	Gandawan	Agroecosystem		NA			NA	
1,235-1,290	8	1+	Masawan	Agroecosystem	6	0	3 (1*)	5	1 V	1 (1*)
		2+	Masawan	Agroecosystem	8	1 V	5 (1*)	4	0	0
		##	Masawan	Agroecosystem						
800-1,200	9	0	Sebucal	Almaciga forest	10	1 V	5 (1*)	7	1 V	4 (2*)
600-985	10	0	Sebucal	Agroecosystem	7	0	3 (1*)	5	0	1

SR - species richness; TS - threatened species; ES - endemic species; CE - Critically endangered; E - endangered; V - vulnerable; NA - not applicable; ## - bird data only; 1+ and 2+ - data excluding birds
*Mindanao endemic

Table 2. Continued...

Elevation (masl)	Sampling Site	Subsite	Location	Vegetation Type	Reptiles			Birds		
					SR	TS	ES	SR	TS	ES
600-885	11	0	Peniel	Plantation forest	3	1 V	2 (1*)	No Species Captured		
600-610	12	0	Peniel	Agroecosystem	4	0	2 (1*)	3	0	0
300-475	13	1	Mialen	Mixed dipterocarp	6	0	3 (1*)	3	1 V	3 (1*)
		2	Mialen	Mixed dipterocarp	6	0	3 (1*)	1	0	0
300-475	14 not sampled	0	Mialen	Agroecosystem		NA			NA	
195-445	15	1	Toliyok	Mixed dipterocarp	8	0	2	5	0	4
		2	Toliyok	Mixed dipterocarp	5	0	2 (1*)	3	1 V	3 (1*)
175-465	16	0	Mamalad	Mixed dipterocarp	8	0	3 (1*)	3	0	1
165-465	17	0	Mamalad	Agroecosystem	3	0	1	1	0	0
165-420	18 not sampled	0	Toliyok	Agroecosystem		NA			NA	
100-250	19	1	Bunga	Mixed dipterocarp	7	0	4 (1*)	2	0	0
		2	Bunga	Mixed dipterocarp	6	1 V	3 (1*)	1	0	0
95-165	20 not sampled	0	Bunga	Agroecosystem		NA				

SR - species richness; TS - threatened species; ES - endemic species; CE - Critically endangered; E - endangered; V - vulnerable; NA - not applicable; ## - bird data only; 1+ and 2+ - data excluding birds
*Mindanao endemic

three species were captured for amphibians, none for reptiles, and only one species for non-volant mammals.

On one hand, the low canopy cover (35%) of this site, as found by the Terrestrial Ecosystem Master Project (TEMP) flora study, may be the factor underlying the low species count of the other vertebrate groups, in particular, the herpetofauna. As emphasized in the previous discussion, the canopy cover of a site significantly contributes in the approximation of the microclimate below the canopy. A more open canopy entails a less humid microenvironment, and therefore a less suitable habitat for amphibians and reptiles. Correlated with low humidity was the decrease in pteridophyte and bryophyte density in these sites, which could serve as important refuge sites for herps. The decrease in these types of plants may have ultimately affected the herpetofaunal population depending on them, thus, the low species richness observed.

On the other hand, birds and volant mammals may have just used subsite 1 of sampling site 5 (dipterocarp forest, 700-1,400 masl, northern aspect of Mt. Capole) as a place to take advantage of food resources, but otherwise may be actually occupants of subsite 2 (southern aspect of Mt. Capole), which was exceptionally species-rich. Birds and bats, unlike the other group of vertebrates, are highly mobile species and could easily fly from the southern side to the northern side of the mountain, and vice versa. So, although a low canopy cover was recorded for subsite 2, a high species count for birds and mammals was observed.

The considerably high species richness recorded for sampling site 10 (agroecosystem, 600-985 masl) was remarkable considering that this is an agroecosystem site, having a simple structural organization and offering very few available microhabitats. The high species richness occurring in this site may be accounted to the high number of reptilian and bird species captured. Results showed that the reptilian species richness occurred highest in this site with 26 species, while the amphibians were also represented in considerable proportions with six species. The avifauna was also relatively high with 60 species, while the mammalian group was represented in moderate proportion, with seven species of volant mammals and five species of non-volant mammals. Although amphibians and reptiles are highly forest-dwellers, the dense growth, however, of ferns and *Imperata cylindrica*, as well as the abundance of ground cover plants, such as sweet potato, yam, onion, seedlings, and bushes, could have provided adequate cover for these species, thus, enabling them to successfully thrive even in a non-forest area like the agroecosystem site of Sebucal (sampling site 10). Also, the close proximity of this site to an original forest may have accounted for the relatively high species richness of herps recorded. Brown and Alcala (1964) observed that the structurally simple non-forest communities, such as agroecosystems, could still support a significant population of herps if it is in close proximity with other vegetation types, especially original or secondary-growth dipterocarp forest. Thus, it may be suggested that it was the close proximity of this agroecosystem site to an original forest which enabled the forest species of amphibians and reptiles to find suitable microhabitats in an otherwise non-forest community, that even a number of endemics, which were, in general, exclusively forest dwellers, were able to exist.

Moreover, the basking behavior of reptiles could also account for their unusual high capture rate in this site. Reptiles perform basking behavior usually prior to becoming active, i.e., they locate a site that would expose themselves to direct sunlight (Zug 1993). The agroecosystem site with its lack of canopy cover, therefore, is an ideal place for reptiles to bask. It is then likely that the reptilian species had been using this agroecosystem site as a basking place, thus, their high capture rate.

The relatively high species richness for the avifauna occurring in this agroecosystem site may have been affected by the increase availability of food plants. The opening of a part of a forest and its conversion to an agricultural area generally encourages the settling of a large number of generalist feeders and even those that are commensals of man, as well as invites the occasional foraging of the primary forest dwellers due to an increase in food resource, i.e., fruiting intensity. It should be noted that although this agroecosystem site was relatively species-rich, most of the birds comprising this area were widespread and only a small fraction (42%) were endemic. Birds that are widespread in distribution are mostly the generalist feeders, while the endemics are usually the specialist and primary forest dwellers. It is, therefore, possible that the high species richness in this agroecosystem site may be due to the occurrence of higher resource abundance, i.e., fruiting intensities, which may have served as an attractant for many widespread generalist feeders and for some primary forest frugivores and omnivores (Peh *et al.* 2004).

The low to moderate species richness of the mixed dipterocarp sites may be attributed to the vegetation structure found in these areas. Although a wide array of tree species, like *Lithocarpus* and *Shorea*, had been identified to dominate these sites, the vegetation stands composing these areas may be considered young as these areas had just been recently reforested owing to the clear-cutting operations that had occurred in the past. As organisms flourish better in older forest than in younger ones (Mitchell *et al.* 1997), this clarifies the low abundance observed among mixed dipterocarp forest sites. Furthermore, results from the flora inventory conducted revealed that the tree stands in these areas were not as tall as those trees found in sites that were once part of an old-growth forests, and they were widely spaced, thus creating a low canopy cover of about 60 percent. Consequently, it could be gleaned that the structural make-up of these mixed dipterocarp sites was less complex and as such could have possibly induced a microclimate that is less conducive for the survival of the different terrestrial vertebrates. For instance, the low canopy cover of 60 percent in the mixed dipterocarp sites permits an increase in the exposure of the area below the canopy to sunlight, thereby approximating a microclimate that is rather dry or less humid. As amphibians are moisture-sensitive (Heatwole 1997) and reptiles are moisture-selective organisms (Alcala 1976), an alteration of their suitable microclimate would have a negative impact on their population. Hence, the low species richness and abundance observed in mixed dipterocarp sites.

The alteration of the preferred microhabitat of birds and mammals in these mixed dipterocarp sites may have also affected their population, thereby accounting to the minimal species count recorded. The low species count with fewer endemics may be the result of unsuitable habitat for certain species adapted to taller forests. Similar findings for birds have been obtained by Peh *et al.* (2005), where they have observed low species richness in areas they referred to as mixed-rural habitat, the characteristics of which matched the mixed dipterocarp sites of this study; while highest species richness have occurred among primary forests. Another notable finding of Peh *et al.* (2005) was the observation that the species composing the mixed-rural habitat are mostly the common and widespread species and only very few are primary forest dwellers. It was suggested that the presence of small remnants of pioneer shrubs and trees in the mixed-rural habitat contributed to the persistence of some primary forest avian species. It was further suggested that the close proximity of the mixed-rural habitat to primary forests may have encouraged some of the primary forest birds to commute to such habitat to exploit food resources, but otherwise depend on the forest for all other aspects of their life cycles. Similar results had been obtained in the mixed dipterocarp forest sites sampled for this study, where only a few endemics, which were forest dwellers, had been recorded. Since these mixed dipterocarp sites are also in close proximity to an original forest, it may be suggested that the explanations raised by Peh *et al.* (2004) also apply in these sites.

The low to moderate species richness and abundance also occurring in the agroecosystem sites was attributable to the simple structural organization composing these areas. Floristic survey by the TEMP flora group revealed an area dominated by cogon grass (*Imperata cylindrica*), a vegetation type that offers land vertebrates very few suitable microhabitats. Brown and Alcala (1964) noted that the pronounced lack of available microhabitats among grasslands and agroecosystems, as well as their high exposure to direct sunlight made them unsuitable for herpetofaunal survival and development.

The same was true for birds and mammals. The absence of vertical stratification in the vegetation arrangement of agroecosystems decreased species richness. For instance, in a forest ecosystem, where layering in the vegetation structure occurs, different birds occupy different strata, i.e., a particular bird group occupies the canopy layer, while another group occupies the subcanopy and the lower layers. Therefore, in the absence of such stratification in an agroecosystem, the distribution of the species depending on them would also be affected. Furthermore, the complexity in vegetation composition of forests had also allowed the development of specialization in the feeding habits of birds. Such association of birds to particular forest trees and plant structure greatly influences their distribution, as the absence of these trees in the agroecosystem would also mean the absence of the bird species in that area, thus, the low species richness.

Relatively low species richness was recorded for the mossy forest sampling site, i.e., subsites 1 and 2 (1,600-2,175 masl). This scenario may be attributed to the altitudinal location of this site. The pattern of species richness is that it decreases with increasing elevation toward depauperation at very high altitudes (Navas 2002). This trend has been widely demonstrated for many taxa and is the widely accepted general pattern (Rahbek 1995). Results showed that this depauperation of species with elevation also occurred among the different vertebrate groups in this mossy forest of Mt. Malindang, as relatively low species richness was recorded in spite of the two subsites being primary forests.

Changes in the abundance of certain types of breeding sites with altitude may affect amphibians (Inger and Steubing 1992). At high altitudes, such as those occupied by subsites 1 and 2 of sampling site 1 (mossy forest, 1,600-2,175 masl), the terrain becomes so steep that most breeding habitats formed by rainfall are shallow, swift, and diminish quickly in volume because of rapid runoff. The steep gradient of land surfaces at high altitudes promoting rapid runoff of surface water and causing the scarcity of lentic mirochabitats, such as side pools, slowly-moving and standing waters, can therefore restrict the dispersal of species requiring such kinds of microhabitats for their reproduction (Inger 1954). In effect, the restriction in the variety of potential breeding sites became an important factor in the decrease of species richness and diversity with elevation.

Temperature, in conjunction with other factors, probably limits the altitudinal distribution of some reptiles in the mountain ranges in the Philippines (Alcala 1976), such that no reptiles were captured at the mossy forest sites of Mt. Malindang. Reptiles, like amphibians, are ectothermic organisms, which do not possess the physiological means of maintaining constant body temperature. Their body temperature is largely dependent on the temperatures of the environment. At high altitudes mossy forest sites, the temperature is usually no higher than 15°C and even dropped to as low as 8°C. As metabolic activities occur efficiently at relatively high temperatures and considering that they are ectotherms, it is very likely that the temperature range at the mossy forest sites are beyond the temperature range for which most reptiles can exist and sufficiently maintain their metabolic activities. Their being ectotherms may have served as a physiological constraint that restricted their existence at the high altitude mossy forest sites of Mt. Malindang.

Bird species richness at the mossy forest sites may have been affected by changes in vegetation structure and floristic composition with altitude. Numerous studies have shown that the numbers and kinds of birds that occur are related to the physical and biological attributes of the habitat in which they live. Generally, these studies have found that the diversity of bird species increases with the structural complexity of the vegetation (Neave *et al.* 1996). In the temperate forests of Australia, studies by Neave *et al.* (1996) revealed that bird assemblages vary with changes in the structure and floristics of the vegetation and seasonal cycles in climate. Species richness was found to be greatest in moist forests found at mid and low elevations throughout the year. These results were related to the relatively high tree basal area and a tall shrub stratum, which indicated a more structurally diverse and productive habitats. This, in turn, was related to the greater availability of water and soil nutrients along creeks and gullies at the mid and low elevations compared to the drier upper slope and ridge habitats. The mid and low elevations were likely characterized by high plant species richness and multiple layers of vegetation.

Although a tropical forest, changes in the floristic and structure of the vegetation with altitude also occurred at these two mossy forest sites of Mt. Malindang. Floristic survey of the TEMP flora group revealed a relatively different flora composition and structure at the mossy forests, which are located at the topmost elevation, compared to the montane and dipterocarp forest sites of lower elevations. In comparison to the other forest sites, flora species richness and basal area of trees at the mossy forests were lower, and although layering of vegetation had occurred, complexity was relatively less compared to the other forest sites where a complex arrangement of many saplings, shrubs, and tree ferns contributed much to its diversity. The decrease in floristic diversity with altitude had most likely affected the diversity of the birds at the mossy forest sites.

Figure 2 shows the results of TWINSPAN analysis. Cluster 4, the mossy and montane forests in Mt. Malindang, was distinctly different from the rest of the clusters, indicating that ecological specialists and mostly endemic and threatened species inhabit this vegetation type. The dipterocarp and almaciga forests of Mt. Malindang belonged to a different cluster, which could mean a varied array of species, mostly endemics, inhabiting these sites. Clusters 1 (agroecosystem) and 2 (mixed dipterocarp) were found to belong to the same cluster, which indicated that generalists species abound in these two types of vegetation.

It is important to point out that most of the endemics seemed to be clearly confined to the forested habitats since the forest sites either have a 50 percent or greater level of endemism. Also, majority of the threatened species were recorded in the forest sites. The results clearly demonstrated the critical importance of forests for the long-term survival of endemic fauna.

Although endemics were also present in the mixed dipterocarp and agroecosystem sites (clusters 1 and 2), the results clearly showed that changes in the structural and floristic composition as a result of forest degradation affect species composition, as more widespread species were recorded than endemics in the disturbed mixed dipterocarp sites and agroecosystem sites. As most endemics are generally dwellers of forest that are undisturbed or with minimal disturbance, their presence in the mixed dipterocarp and agroecosystem suggested the persistence of such species in these habitats rather than their positive adaptation to such habitats. Results further indicated that conservation of the montane and mossy forests (cluster 4) and the dipterocarp and almaciga forests (cluster 3) on Mt. Malindang would also protect the forest species of fauna, which were mostly endemic and threatened species, inhabiting the area.

The presence of agricultural trees and pioneer shrubs and trees in the mixed dipterocarp and agroecosystem may have contributed to the persistence of the endemics, but it was less likely that they could truly survive in these highly disturbed sites. As pointed out in the preceding discussion,

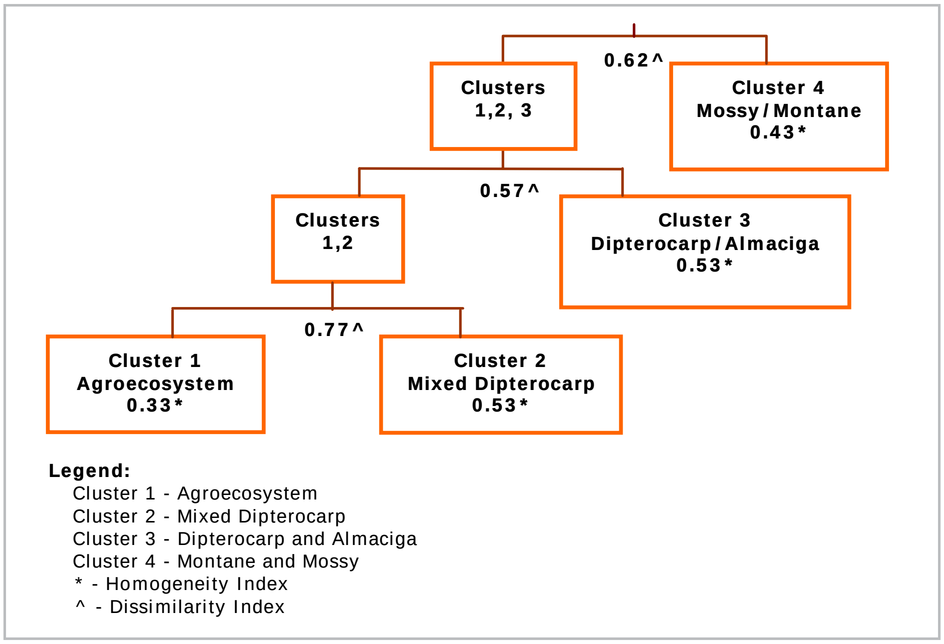

Figure 2. Cluster analysis using TWINSPAN.

since the mixed dipterocarp and agroecosystem sites were located near the primary forest, it was more likely that the endemics had just used these sites to exploit resources but were otherwise exclusively dependent on the forests for all other aspects of their life cycle. This implied that the mixed dipterocarp and agroecosystem sites may not serve as a functional habitat for many forest species. Also, the mixed dipterocarp and agroecosystem sites with its simpler structural organization compared to the old growth forests, very much likely would not be able to offer species with sufficient cover and may, thereby, serve as an ecological trap, increasing the vulnerability of the forest species to predation, thus increasing their non-suitability as a habitat to restricted-range endemic species.

Other factors, such as sampling biases and weather conditions at the time of sampling, may have occurred, thereby, affecting the results obtained. For instance, constant heavy rains, which occur almost everyday in the forests, may have affected the capture results in the sense that birds rarely go out during this time. Reptiles were also rarely captured whenever it rained heavily. This difficulty in reptilian capture was compounded by the fact that these organisms were highly cryptic. Nevertheless, species effort curves plotted indicated sufficient sampling conducted as moving to another site was always in consideration of an asymptotic curve achieved per site. Thus, it may be suggested that the effect of sampling biases on the variation in the vertebrate species richness observed in the different sites was minimal, and that these variations were largely due to changes in vegetation structure and composition, whether this be a result of altitudinal changes or forest degradation.

Transporting the cluster data into biodiversity map (Figure 3) shows low species richness in the agricultural and mixed dipterocarp sites, which are found in the sampling sites established in Barangays Bunga, Mamalad, Tolyok, Mialen, and Peniel. The montane and mossy forests of North Peak and Barangay Lake Duminagat were moderately species-rich areas, while the almaciga forest in Barangay Sebucal was highly species-rich. Very high species richness was shown in the dipterocarp forest of Sebucal and part of Peniel, which was the plantation forest. It is interesting to note that the agroecosystem sites, which were probably conversions of the dipterocarp forests to give way to agriculture, had spread to the upper elevations of 1,000-1,550 masl. As expected, with the occurrence of anthropogenic disturbance, a relatively low species richness was observed in the area. Interestingly, despite the apparent disturbance on the upper elevations of the mountain range, the mossy, montane, and dipterocarp forests were still found to be species-rich areas. The biodiversity map indicates the need to conserve the forested sites, as well as maintain and not further expand the agroecosytem areas to ensure long-term conservation of the biodiversity in the area.

In the enforcement of conservation policies, the different forest sites must, therefore, be listed as priority areas, as

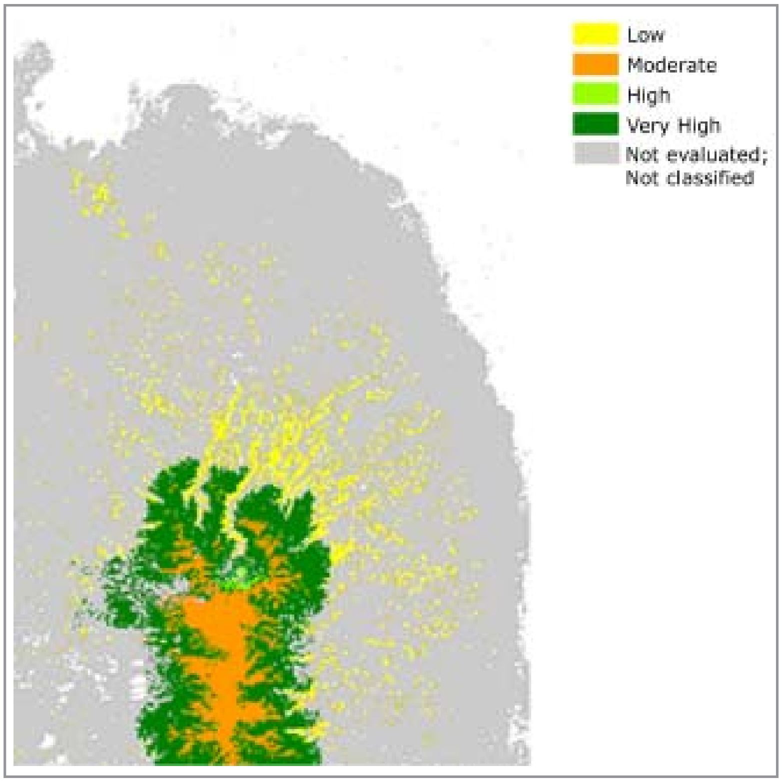

Figure 3. Cluster data translated into a biodiversity map showing biodiversity value, which is low in agroecosytems, moderate in lowland dipterocarp, mixed dipterocarp, mixed lowland dipterocarp, and mossy forests, high in almaciga forest, and very high in montane and submontane dipterocarp forests.

results have clearly shown that the maintenance of areas with mature forests is critical for the existence of a high terrestrial vertebrate richness and to curb eventual species loss. Taking into consideration the high level of endemism and the high number of threatened species recorded, the forest sites were highly significant to the continued existence of these species with critical population. Also, although relatively low in species richness with few endemics, the mixed dipterocarp and plantation forest site, if left untouched or undisturbed could play a role in the conservation of widely distributed primary forest species (Lindenmayer and Franklin 2000 as cited in Peh *et al.* 2005). Thus, these sites that had just been recently reforested must be allowed to regenerate with minimal human disturbance to improve habitat quality for forest species. Finally, connecting the fragmented forest habitats of Mt. Malindang through the establishment of habitat corridors may be a good option to promote their long-term viability.

Locally-Threatened Species and Interrelationship with Socioeconomic and Cultural Activities

Some of the species that were found to be in the threatened list based on IUCN (2004) were observed to be stable or abundant on Mt. Malindang. On the contrary, some species that have stable status as per IUCN criteria were found to be locally threatened due to some resource utilization practices. Among the faunal groups, amphibians had a higher level of endemism, and majority of the species had threatened status. Based on interviews, two species had stable conservation status but these same two species were locally threatened (Table 3). The two amphibian species were hunted by the local people as a source of food. In fact, during the field sampling in Barangay Peniel, it was gathered that one particular person in the community was highly skilled in *pangiwag*, which is the use of torch to hunt and gather frogs at night, preferably during moonless nights when a high catch is more likely. Using this method, about two sacks of frogs could be gathered by a skilled person in one night. Other frogs were either very small to

Table 3. List of threatened fauna species in Mt. Malindang.

FAUNAL GROUP	SPECIES	LOCAL NAME	CONSERVATION STATUS (IUCN 2004)	CONSERVATION STATUS MT. MALINDANG (based on interviews)
Amphibians	*Ansonia mcgregori*	*Tikatik*	Vulnerable	Stable
	Ansonia muelleri	*Tikatik*	Vulnerable	Stable
	Platymantis guentheri	*Baki/Bak-Bak*	Vulnerable	Stable
	Limnonectes magnus	*Dampawang/Baki/Bak-Bak*	Stable	Locally threatened
	Limnonectes parvus	*Baki/Bak-Bak*	Vulnerable	Stable
	Nyctixalus spinosus	*Baki/Bak-Bak*	Vulnerable	Stable
	Philautus acutirostris	*Baki/Bak-Bak*	Vulnerable	Stable
	Philautus poecilus	*Baki/Bak-Bak*	Vulnerable	Stable
	Philautus surrufus	*Baki/Bak-Bak*	Endangered	Stable
	Philautus worcesteri	*Baki/Bak-Bak*	Vulnerable	Stable
	Rana granducola	*Baki/Bak-Bak*	Stable	Locally threatened
	Rhacophorus everetti	*Baki/Bak-Bak*	Vulnerable	Stable
	Icthyophis mindanaoensis		Vulnerable	Stable
Avifauna	*Buceros hydrocorax*	*Kalaw*	Near threatened	Locally threatened
	Penelopides affinis	*Tagiptip*	Stable	Locally threatened
	Haliastur indus	*Banog*	Stable	Locally threatened
	Pithecophaga jefferyi	*Agila*	Critically endangered	Locally threatened
	Spizaetus cirrhatus	-	Vulnerable	Stable
	Gallus gallus	*Manok ihalas*	Stable	Locally threatened
	Chalcopaps indica	*Manatad*	Stable	Locally threatened
	Macropygia phasianella	*Takwaw/Manokon/Manok-manok*	Stable	Locally threatened
	Aceros leucocephalus	*Angik*	Near threatened	Locally threatened
	Trichoglossus johnstoniae	*Pestra*	Near threatened	Locally threatened
	Prioniturus montanus	*Pestra*	Near threatened	Locally threatened
	Phapitreron amethystina	*Mangutot*	Stable	Locally threatened
	Phapitreron leucotis	*Alimukon/Limukon/Alimukin*	Stable	Locally threatened
	Loriculus philippensis	*Kolasisi/Kusi*	Stable	Locally threatened
	Prioniturus discurus	*Pestra/Kalawihan*	Stable	Locally threatened
	Centropus viridis	*Kokok/Sibukok/Saguksok*	Stable	Locally threatened
	Alcedo argentata	*Tabantis*	Endangered	Locally threatened
	Actenoides hombroni	*Bukla*	Vulnerable	Locally threatened
	Ficedula basilanica	*Pirot*	Vulnerable	Stable
	Lonchura malacca	*Maja*	Stable	Locally threatened
	Lonchura leucogastra	*Maja*	Stable	Locally threatened
Volant mammals	*Acerodon jubatus*	*Kabog*	Endangered	Locally threatened
	Alionycteris paucidentata	*Kuwaknit*	Vulnerable	Stable
	Haplonycteris fischeri	*Kuwaknit*	Vulnerable	Stable
	Rhinolophus subrufus	*Kuwaknit*	Vulnerable	Stable
Non-volant mammals	*Urogale everetti*	*Mugsaw*	Vulnerable	Locally threatened
	Crucidura beatus	-	Vulnerable	Stable
	Sus philippensis	*Baboy sulop/Baboy ihalas*	Lower risk	Locally threatened
	Cynocephalus volans	*Kagwang*	Vulnerable	Locally threatened
	Paradoxurus hermaphroditus	*Milo/Badlas/Lubing*	Stable	Locally threatened
	Viverra tangalunga	*Maral/Tinggalong*	Stable	Locally threatened

be consumed or were not known to be edible, thus they were not hunted and were locally stable.

Of the 19 locally-threatened avifauna species, 12 had stable conservation status as per IUCN criteria. But the alarming thing was that the nine bird species (4 Philippine endemics, 5 Mindanao endemics) that were in the red list and also threatened locally were endemic, which included the Philippine endemic *kalaw*, *Buceros hydrocorax; tagiptip*, *Penelopides affinis; angik*, *Aceros waldeni; agila, Pithecophaga jefferyi;* and the following Mindanao endemic: *angik*, *Aceros leucocephalus; pestra, Trichoglossus johnstoniae; Prioniturus montanus; tabantis, Alcedo argentata;* and *bukla*, *Actenoides hombroni*. These bird species were also locally threatened because they were large enough to be source of food, thus, they are oftentimes hunted by the local people, as well as others from the neighboring *barangays*. Among the volant mammals, only the Philippine endemic *kabog,* Golden-capped fruit bat or Zorro Volador Filipino, *Acerodon jubatus,* was in the threatened list and also threatened locally. For the non-volant mammals, the Mindanao endemic *mugsaw* or Mindanao tree shrew, *Urogale everetti*, and the Philippine endemic *kagwang* or Flying lemur, *Cynocephalus volans*, had vulnerable status and were also locally threatened.

Respondents from different communities on Mt. Malindang Range admitted that although the diversity of fauna remains, the abundance of the fauna at present was much lower compared to what they had observed in the 1940's. In the past, animals were seen even within the community's residential area, but these animals fled to the forested areas probably due to the increased disturbance of their original habitat. Based on interviews, the species that were commonly observed to be decreasing in number were *angik* or Writhed hornbill (*Aceros waldeni* or *Aceros leucocephalus*) and *kalaw* or Rufous hornbill (*Buceros hydrocorax*). Other bird species that also decreased in number included *banog* or Philippine hawk eagle (*Spilornis cheela*); *pestra,* which included the Blue-naped parrot, *Tanygnathus lucionensis*, Mindanao lorikeet, *Trichoglossus johnstoniae,* Montane racquet tail, *Prioniturus montanus*; *tagiptip* or Tarictic hornbill, *Penelopides affinis*, *agila* or Philippine eagle, *Pithecophaga jefferyi*, and *piriku* (parrots).

Among the mammals, *kagwang* or Flying lemur (*Cynocephalus volans*) and *milo* or Common palm civet (*Paradoxurus hermaphroditus*) were also apparently decreasing in number as perceived by the communities. This decreasing trend of population of the mentioned avian and mammalian species could mean that these species are locally threatened.

Faunal status is dependent upon a number of causal factors. Foremost of these are the degree of disturbance, utilization practices, and the rate of exploitation over time. When such causal factors continue to exist at a fast rate, the number of threatened species would undoubtedly increase.

Faunal utilization was done primarily through hunting. Based on the data gathered by the SECS team through interviews, hunting was an activity confined to the men in the community, as it demands skill and risk. Because Subanens believe that resources are owned by the spirits, an *apal* (ritual) is performed prior to hunting. The ritual is not only a form of communicating with or asking permission from the spirits, but also aids hunters to identify as to which areas are allowed or prohibited.

Interview results on resource utilization indicated that the hunters' favorite bird preys were *manok ihalas* or Red jungle fowl (*Gallus gallus*)*, alimukon* or White-eared brown dove (*Phapitreron leucotis*)*, kalaw*, *tagiptip*, and *manatad* or Common emerald dove (*Chalcophaps indica*). *Manok ihalas*, *manatad,* and *alimukon* had stable conservation status under the IUCN criteria, but appeared to be locally threatened on Mt. Malindang due to the resource utilization pressure. In one instance of the SECS interviews, a Subanen was found to have seven *alimukon,* which was captured for recreation only. But the Subanen later admitted that when the family runs out of viand, the *alimukon* is utilized for food. Based on faunal survey data, only two individuals of *tagiptip* were caught in the mist net in Sebucal and Toliyok sampling areas, while the *kalaw* were only recorded during transect surveys. However, in the riparian faunal survey by the Aquatic Ecosystem Master Project (AMP) team, only the *tagiptip* was recorded. IUCN (2004) considered these two Philippine endemic bird species as near-threatened (*kalaw*) and endangered (*tagiptip*).

Interviews also revealed that the commonly hunted mammals were *baboy ihalas* or Wild pig (*Sus philippensis*), *unggoy* or Long-tailed macaque (*Macaca fascicularis*), *tinggalong* or Malay civet (*Viverra tangalunga*), *binaw* or Philippine brown deer (*Cervus* sp.), *laksoy* or Philippine tree squirrel (*Sundasciurus philippinensis*), and *ilaga* or mice/rats. *Binaw* and *milo* had stable conservation status based on IUCN 2004, but these were apparently locally threatened since they were utilized as food. Faunal survey data indicated that only one *milo* was trapped. The presence of this animal in the sampling sites was based on sightings and interviews. On the other hand, the *baboy ihalas* and *unggoy* were perceived by communities to be locally abundant, in fact, they were considered as pests in the farms. *Tinggalong*, *laksoy,* and *ilaga* had stable conservation status, but were hunted for food, making them locally threatened. *Ibid* (Sailfin or monitor lizard) was the only reptilian species hunted for food.

Some animals that were not hunted included the *kulaknit* or bats and *halas* or snakes. *Halas* were feared, while *kulaknit* was not considered as food. This could be the reason why the bats *Alionycteris paucidentata*, *Haplonycteris fischeri*, and *Rhinolophus subrufus* were not locally threatened, although these species had vulnerable status (IUCN 2004). Among the amphibians, only *baki/bak-bak* or Giant Philippine frog, *Limnonectes magnus,* and *baki/bak-bak* or Variable-backed frog, *Rana granducola*, were considered edible. Consequently, all the amphibian species were perceived to have stable status at the local level.

Some respondents remarked that the reason animals were trapped is because these animals, particularly wild pigs and monkeys, are becoming pests in their *baul* (farms). Wild pigs and monkeys competed with the livelihood of farmers and the subsistence of communities. In fact, there were instances when farmers no longer till areas that are far from the communities because much effort is consumed on guarding the crops from attacks of wild pigs and monkeys. The biodiversity map, that was drawn based on the results of the study, however, indicated that the reason for the abundance of the so called pests in the farms was the location of these farms or agricultural sites at high elevation near forest edges, where these animals that attack on farmers' crops are naturally found.

It was learned from the interviews conducted that the local people used different kinds of traps. These traps, designed to trap specific kinds of animals, were made of local materials, like bamboo, rattan, vines, abaca fiber, and wood. The *pusil* or *de bomba* (air guns) and *pingpong* (trap made of explosives in the form of a pingpong ball) use explosives to kill the animal. Monkeys, according to farmers, were getting clever and managed to evade the traps set, which led the people to resort to *de bomba*. Other local traps were *lit-ag* for *milo, baboy ihalas,* and *langgam; tirador/pitik* and *pali-untod* for *langgam; balag-ong* and *ingpit* for *milo; sugyong/suyak* and *panudyang* for *baboy ihalas; lugpit/panggal*, *pasgong, panontod,* and *bukakang* for *unggoy; balatik* for *baboy ihalas* and *binaw; lugpit* for *ilaga;* and *pana* for *baki*.

Frequency of hunting widely varied from two to three days to once a week to four times a year. Some could trap as much as 20 birds a week, while some claimed to have trapped animals only once a week or none at all. Preference of animals for hunting was based on the palatability of meat, in which case, the *baboy ihalas* and *binaw* were the favorite animals. However, hunters admitted that deer were already very scarce in Mt. Malindang. Trapping of monkeys and wild pigs was both a means of defense and revenge, *"kay kawatan man na sila"* (they are thieves) since monkeys and wild pigs feast on the crops and vegetables in the farm.

Majority of the Subanens hunt for subsistence or consumption purposes only. A few people sell the meat at a minimum of PHP 50 to a maximum of PHP 120 per kilo. Community accounts in Mialen indicated that in the past, people from other areas, like those from Toliyok and Oroquieta City, came into their area to hunt. They also revealed that people from Oroquieta treated hunting as a form of recreation. This was the time when shooting became a favorite hobby of urban people.

Based on interview data, hunting was mainly a form of defense against pest animals. Livelihood and subsistence were only secondary. The minimized incidence of hunting or trapping was because the catch could not compensate for the effort due to the decreasing faunal population. In fact, in the 1990s, hunting or trapping success was less as compared to the 1950s. When trees, which are the food sources and habitat of game animals, were lost, the animals also decreased, hunting success was very low, and the effort could not be compensated. From the data gathered by the SECS team, hunting as a cultural practice was diminishing particularly for Barangays Mansawan, Gandawan, and Lake Duminagat.

As documented by the SECS team, another reason for the decrease in the incidence of hunting was the prohibitions stipulated in RA 9147, an Act providing for the conservation and protection of wildlife resources and their habitats. The influence of religion, particularly the *Piniling Nasud* or *Katolikano*, which were the dominant religious affiliation of people in Mansawan and Lake Duminagat, respectively, also played a role in the decrease of hunting activities. *Piniling Nasud* prohibits harming of any living thing, while *Katolikano* requires that hunters perform a ritual first before any extraction could occur. *Katolikano* Subanens believe that all animals have owners, *"tanan mananap naay nanag-iya"* (all animals have owners), which they referred to as *diwata*. As such, in Gandawan and Lake Duminagat, an *apal* (ritual for hunting and fishing) was done before installing traps.

These indicated that faunal extraction *per se* was not the main cause of the decreasing population of animals observed at present. Hunting appeared to be maintained at a subsistence level with minor contribution to the household economy. Most of the respondents interviewed admitted that hunting was done for consumption purposes and only very few sell the meat of the animal. The decrease of faunal population in Mt. Malindang Range was more probably due to large-scale logging in the past and other forms of habitat destruction, like *kaingin*, conversion of the forested sites to agricultural areas, and expansion of farming areas both in the past and at present. Trees were cut due to massive logging that occurred in the 1950s to 1982. The respondents commented that wild pigs, monkeys, and other animals attacked their crops and competed with the communities' source of subsistence and livelihood because the food sources of animals, like trees, were lost. Consequently, some animals moved uplands, where there are forested areas and where trees still thrive. However, other animals, particularly wild pigs and monkeys, moved outside ther habitat range to search for food sources wherever they are available, most often in the agricultural areas.

Biodiversity Indices

Table 4 shows the species richness, diversity, and evenness of vertebrate faunal species of each subsite in a sampling site in Mt. Malindang. Species richness (S) refers to the number of species sampled per subsite. Diversity is statistically determined using the Shannon diversity index. Shannon-Wiener values of <1 represent low diversity, and values of >3 represent high diversity. The Pielou evenness (E) index is determined to show the distribution pattern of species. Evenness value of 1 in the scale of 0-1 indicates a more or less even distribution.

The agroecosystem area in Sebucal (Sampling site 10, 600-985 masl) supported the highest species richness relative to all other sites (S=104). This was followed by sampling site 5, dipterocarp forest (700-1,400 masl), subsite 1 (S=98) and subsite 2 (S=100), and the almaciga forest, sampling site 9 (800-1,200 masl, S=95). It was noted that the high species richness observed in the agroecosystem of Sebucal was attributed to the presence of more number of reptilian species in the area. This area was also situated near a dipterocarp forest on one side and a mossy forest on the other side. It was highly probable that this agroecosystem site was used as foraging areas of the forest species. It was observed that temperature in the area was relatively higher so that reptiles mostly thrive in this area. Generally, species richness in the agroecosystem areas of other sampling sites was relatively low. However, species richness in sampling site 3, subsite 2 (montane forest, 1,450-1,790 masl, Ulohan sa Dapitan, S=78) and in sampling site 1, subsite 1 (mossy forest, 1,600-2,175 masl, S=70) was relatively higher compared to the agroecosystem and mixed dipterocarp forests in other sampling areas.

Species diversity was relatively highest in the montane forest of subsite 2 (sampling site 3, Ulohan sa Dapitan) with a value of H'=1.52. This was followed by the dipterocarp forest in Sebucal, subsite 2 (sampling site 5, 700-1,400 masl) having a value of H'=1.496; almaciga forest in Sebucal (sampling site 9, 800-1,200 masl)) with a value of H'=1.426; dipterocarp forest in subsite 1, sampling site 5 (700-1,400 masl) of Sebucal/Mt. Capole (H'=1.394); and mossy forest of North Peak (sampling site 1, subsite 2, 1,600-2,175 masl) having a value of H'=1.358.

Species richness and diversity of vertebrate fauna observed from the sites sampled could be attributed to the variations in resource spectra of these ecosystems, degree of habitat destruction, competition, and climate. The agricultural areas were not highly stratified in terms of food resources. In fact, plant diversity was also lower. This could explain the generally low faunal diversity in the agricultural and mixed dipterocarp sites. The availability of various plant species had significant implication on species richness and diversity of vertebrate fauna considering that plants provide both the food and microhabitat for the vertebrates. On the other hand, the moderately high diversity in the montane, mossy, almaciga, and dipterocarp forests could be attributed to the most specialized species that are highly dependent on forest plants for food. Most of these specialized species were rare, endemic, and threatened. These species could hardly survive in an open agricultural area where food of their preference was relatively scarce. Most of the species in agricultural areas were common. An agricultural area may be dominantly occupied by a one or two species, but the dipterocarp, almaciga, montane, and mossy forests were inhabited by more endemic species. The habitat disturbance in an agricultural area was greater than in dipterocarp, montane, and mossy forest, thereby reducing the survival rate of rare and endemic species. Competition was greater in agricultural area compared to the dipterocarp, almaciga, montane, and mossy forests since the species thriving in the area mostly have the same food preference so that they tend to compete for the same food at the same time. Agricultural areas did not offer more hiding places against predators relative to the dipterocarp, almaciga, montane, and mossy forests. The high level of disturbance in the area increased the chances of competition and predation. Climate was one factor affecting species richness and diversity. This effect could be observed in an elevational gradient. Compared to montane and mossy forest, it was noted that species richness was greater in dipterocarp forest sampling site 5 (700-1,400 masl) with S=100. Some species cannot thrive in areas where the temperature is relatively lower, like in the mossy forest (site 1) where few species could adapt to this condition.

Table 4. Computed values for species richness, diversity, and evenness of vertebrate faunal species found per sampling site in Mt. Malindang.

Elevation (masl)	Sampling Site	Subsite	Location	Vegetation Type	Biodiversity Indices Richness (S)	Diversity (H')	Evenness (E)
1,600-2,175	1	1	North Peak	Mossy forest	70	1.358	0.736
		2	North Peak	Mossy forest	59	1.264	0.714
1,500-1,900	2	0	Mt. Guinlajan	Mossy forest		NA	
	not sampled						
1,450-1,790	3	1	Ulohan sa Dapitan	Montane forest		NA	
		not sampled					
		2	Ulohan sa Dapitan	Montane forest	78	1.52	0.803
1,450-1,600	4	0	Sitio Pungol	Montane forest	50		
						Transect Data Only	
700-1,400	5	1	Mt. Capole/Sebucal	Dipterocarp	98	1.394	0.7
		2	Mt. Capole/Sebucal	Dipterocarp	100	1.496	0.748
1,400-1,550	6	0	Lake Duminagat	Agroecosystem	66	1.131	0.621
1,000-1,400	7	0	Gandawan	Agroecosystem	58		
						Transect Data Only	
1,235-1,290	8	1+	Mansawan	Agroecosystem	30	1.35	
		2+	Mansawan	Agroecosystem	42	1.282	
		##	Mansawan	Agroecosystem	41		
800-1,200	9	0	Sebucal	Almaciga forest	95	1.426	0.721
600-985	10	0	Sebucal	Agroecosystem	104	1.283	0.636
600-885	11	0	Peniel	Plantation forest	64	1.363	0.755
600-610	12	0	Peniel	Agroecosystem	51	1.291	0.756
300-475	13	1	Mialen	Mixed dipterocarp	71	1.144	0.618
		2	Mialen	Mixed dipterocarp	63	1.146	0.637
300-475	14	0	Mialen	Agroecosystem		NA	
	not sampled						
195-445	15	1	Toliyok	Mixed dipterocarp	60	1.177	0.662
		2	Toliyok	Mixed dipterocarp	53	1.005	0.583
175-465	16	0	Mamalad	Mixed dipterocarp	66	1.166	0.641
165-465	17	0	Mamalad	Agroecosystem	52	0.972	0.566
165-420	18	0	Toliyok	Agroecosystem		NA	
	not sampled						
100-250	19	1	Bunga	Mixed dipterocarp	52	0.896	0.522
		2	Bunga	Mixed dipterocarp	42	0.83	0.511
95-165	20	0	Bunga	Agroecosystem		NA	
	not sampled						

NA - not applicable; ## - bird data only; 1+ and 2+ - data excluding birds

Evenness indices of the sampling sites showed values which were relatively close with all values less than 1. Generally, the present data indicated a moderately even distribution. This could be attributed to the variation in the distribution pattern of resources, microclimate, and degree of competition among organisms in the sampling sites so that species tend to distribute themselves in this kind of fashion. Graham (1983) reported that physico-chemical and weather conditions, food, predation, and competition were among the most important environmental factors affecting the distribution and abundance of species. Some areas of the sampling sites may have more available resources in terms of food and microhabitat, lower degree of competition, and suitable climate for their survival.

Community-based Biodiversity Monitoring and Conservation

Traditional beliefs and value systems are bodies of knowledge that are closely related to the natural environment and to human interactions with and within the environment (Lovelace 1984). The close interaction and dependence of communities to their environment have allowed them to develop relationship with the resources found in their environment. As in any other indigenous communities, the Subanens link themselves with their environment and use the resources in the environment. In the case of fauna, wild pig, birds, and deer are not only sources of food or proteins, they are also means of recreation and form of communication.

Indeed, the fauna have a role in the culture of Subanens as transpired from interviews and documentation of their local knowledge. A number of communities interviewed shared that the call of the *alimukon* sends them a sign that it is not good to leave the area, thus, any travel scheduled on that day has to be postponed. The call of *pungak* (Giant scops owl, *Mimizuki gurneyi* or Grass owl, *Tyto capensis*) indicate that there is wild pig in their farm, while the call of *pisupit* (Plaintive cuckoo, *Cacomantis merulinus* or Brush cuckoo, *C. variolosus* or the Oriental cuckoo, *Cuculus micropterus*) is a signal that it is *"ting baul na"* (start of farming). In the absence of the clock, communities relied on the *kalaw* to tell the time. Calls of *bakbak* indicate that rain is coming or it is going to be a full moon. In the past, monkeys were not hunted because monkeys were, accordingly, humans and not to be eaten.

Because of the Subanens' close interaction, local knowledge was developed and enhanced over the course of time. Some Subanen could identify food sources, as well as habitat preferences of fauna.

Communities also observed that fauna are abundant when food availability is at peak so hunters coincide their activity with the fruiting season of trees, as preys are more visible. For instance, birds are abundant in the months of March to April and in August to September when trees are fruiting. Indeed, most trees have fruiting season during summer, while August to September is a migration season for birds. Wild pigs and monkeys are more abundant from July to August, in time for the harvesting of corn. In fact, some respondents observed that monkey already know how to peel corn and take out the cob, and even take out the coconut meat. Aside from phenology, hunters also observe the reproductive activity of preys. According to a hunter interviewed by the SECS team, hunting was limited or even stopped during the rainy season because this is also the mating period of wild boars. In Barangay Lake Duminagat, *dugmon* (dormant) and *ting-anak* (birthing) in the month of December are observed by hunters; they refrain from hunting during this period. An off-season for hunting minimize disturbance, especially during breeding season of animals, and give ample time for young animals to grow. Prior to hunting, an *apal* (ritual) is done to guide hunters as to where hunting is allowed or prohibited.

These indicated that communities had their traditional practice of monitoring the status and conserving the faunal resources. These measures are inherent in their culture as a way to protect the resources and ensure that such resources sustain their needs over time. The belief in the spirits as guardians or owners, the performance of *apal* (ritual) to know which areas were allowed or prohibited for hunting, the knowledge on seasonal activity of animals to minimize disturbance, the knowledge on food and habitat of animals, the use of local traps for controlled hunting, and the observance of the off-season for hunting are beliefs and practices that are practical ways for community biodiversity monitoring and conservation.

Most of the respondents agreed that planting trees and prohibiting the hunting of animals thru local ordinances were the means of averting the gradual decrease of faunal population. For communities, trees are sources of food and serve as shelter or nests of fauna so it is important to plant trees to bring back the forest. According to one respondent in Toliyok, when forest is denuded, animals have no shelter and no sources of food. Another respondent in Sebucal suggested that there should be somebody to protect the animals.

Inasmuch as communities opt to protect the fauna, other respondents were confronted with more pragmatic and realistic views. When most of the communities suggested to protect the forest and plant trees, two respondents in Mialen did not agree to restore the forest, *"kay mawala* *ang panginabuhi-an"* (our source of livelihood will be lost). The abundance of coconut trees was more preferred as it entails money. A respondent in Lake Duminagat said that, *"ang mga mananap dili mahurot, nagpalayo lang. Lit-agon ra ang naa sa tanumon… lit-ag para panghadlok kay mahurot ang tanom kung dili lit-agon"* (animals are not totally lost, they just move away. Animals that are trapped are those in the farms… the trap is a way of scaring the animals to prevent them from consuming the crops and vegetation). One Subanen in Bunga also shared that it was not feasible to stop hunting. Exploitation of fauna is a way to counteract the economic crisis and lack of livelihood.

Interventions to biodiversity conservation and management have to explicitly address the lack of livelihood sources and opportunities. Communities will continue to utilize the fauna, and the rate and degree of extraction may increase if the primary source of livelihood is not improved. However, there are already entry points where the project can intervene. The community beliefs and practices are cultural ways of monitoring and conserving fauna. The desire to protect the fauna and the forest was present, as expressed by communities in interviews and during validation meetings. In fact, some of the participants in the validation meeting expressed that to conserve the fauna, hunting of animals should be stopped. The influence of religion and the practice of cultural beliefs may also be considered as a means to inculcate the value of biodiversity conservation. The drive and motivation to put into action this desire had to be enhanced which may include, but not limited to, increasing awareness of the diversity and the threatened status of fauna through IEC.

Biodiversity conservation and management is about survival. Thus, the survival of fauna depends largely on addressing the survival of communities.

Community Validation

During the community validation meeting in Mansawan, when the output of the fauna study was presented, participants were asked of their learnings and insights. Participants from Barangays Mansawan, Gandawan, and Liburon reiterated that people hunt animals, particularly wild pigs and rats, because they destroy or eat the crops in their farms. Snakes were killed since they are considered dangerous and can even kill people. It was then explained that animals moved down and encroached their farms because the food sources in their forest habitat were either lost or very meager. The proliferation of rats was brought about by the killing of snakes, their natural predator. One participant then suggested that animals, especially those that have important functions or roles, had to be protected. Remaining forests should also be protected since, based on the findings of the study, most of the threatened and endemic birds were confined to dipterocarp, montane, upper montane, and mossy forests. It was also suggested by one participant that communities should be given materials on the output of the study to be used as reference on determining the animals have to be protected.

In the validation meeting in Bunga, Toliyok, and Mialen cluster, it was learned that the people practiced biodiversity conservation through discriminate hunting of wild pigs. Only wild pigs that are about 40 kg or more were hunted since, according to the participants, it is a waste of bullets to hunt small species. This implied conservation since wild pigs bigger than 40 kg could have already reproduced, which was, in a way, a form of sustainable harvesting of resources.

In Peniel, as the different figures of vertebrate species found in their *barangay* were shown, the residents readily offered the local names of the different species. The following are the species that they have readily identified: *Rattus everetti* and other rat species – *b'labaw; Trichoglossus johnstoniae – kalawilan; Centropus viridis – tortor; Turdus – ngyarek; Macronus striaticeps – unas-unas; Leonardina woodi – mantic;* and *Mimizuku gurneyi – ngiwngiw*.

As to the management of these resources, the people had clearly recognized the need to protect the forests to ensure the survival of the species. They, however, asked if the project could help address their problem on how to bring their produce to the market so that their family income may be augmented and if BRP could help facilitate the construction of better roads. Since soil analysis was done, they also asked for the kind of crops that they could cultivate and successfully grow in the soil type that they have. They also inquired about how they can effectively raise mahogany at the lower elevations since they have observed that these species successfully thrive in the upland portions of their *barangay*.

It was observed that although the people have shown some concern on the conservation of forests, the issues that were most pressing to them were on livelihood and the means by which they could uplift their financial status. Most, if not all, of their comments were centered on livelihood. Although the importance of forests had been realized, recommendations on conservation strategies and the management of resources were not given much consideration, suggesting that concern over what to feed the mouth takes precedence over anything else.

In the Toliyok-Bunga-Mialen cluster, the community agreed that Mialen had a higher vertebrate fauna recorded compared to the two other *barangays*. They further confirmed that *Ichthyophis*, which they locally call *dahilog*, and *Draco* species, which they call *hambobokag,* and *tabantis, bukla, pongak, tagiptip, odto-odto, manok ihalas* or wild chickens were present in the three *barangays*.

The *barangay* captain of Mialen explained that *odto-odto* have several types. One type have a red tail (*pula ikog*), another have yellow and black spots or with blue spots all over the body. The following were the local names of some collected specimens: *dragon nga pula (Terpsiphone cinnamomea), taloto sa lubi, (Cryptodactylus annulatus),* and *banog or tikwi (Haliastur indus).*

The local people expressed their preference in having only a few snakes living in the area because they considered them to be very danagerous. They also noted that *binaw* or deer, which were present before, no longer exist today. Hunting or gathering of wildlife for food was practiced. Hornbills and doves were, according to the participants, good for roasting. *Milo* (palm civet) was good for *tinunuan* or cooked with coconut milk, while wild pigs were roasted, cooked as *adobo* (meat in vinegar and soy sauce), or cooked in broth. *Unggoy* (monkey), on the other hand, were killed because these animals are considered as pests for they steal corn in the field.

Wild pigs were caught by means of *lit-ag* (trap), nets (the method locally called *batong* or *mamatong*), and guns. It was learned that the hunters only hunt wild pigs weighing 40 kg or more, owing to the high cost of bullets. This showed that the people were not indiscriminately hunting the animals but had a sense of conservation and economics.

In the community validation in Barangays Lake Duminagat and Sebucal, one participant said that *kabog, Acerodon jubatu*s, and *kagwang, Cynocephalus volans,* were present in the forested sites of their *barangay*. Majority said that rodents were known to them not only as *b'labaw*, but also as *balagtok; Paradoxorus hermaphroditus* as *milo/badlas/ lubing; Viverra tangalunga* as *maral/tinggalong;* and *Limnonectes magnus* as *dampawang/baki/bak-bak*. Most of the participants from the two *barangays* knew only two species of frogs, *Limnonectes magnus* and *Rana granducola*. These frogs are usually found near the creek or river. They are usually hunted (*mangiwag*) as a source of food. One participant said that frogs were hunted because there was not enough food source available. Of the socioeconomically important species presented, *mugsaw, Urogale everetti,* was not considered important by the people from Barangay Sebucal. This species was not hunted for food, however, other *barangays* like Mansawan and Lake Duminagat considered *mugsaw* as a food source. In addition, *laksoy, Sundasciurus philippinensis, maya, Lonchura malaca,* and *Lonchura leucogastra* were not considered as socioeconomically important by both *barangays*. The participants said that whenever these species are found, they are killed and thrown away because they are considered as pests in the farm. *Unggoy, Macaca fascicularis*, and *baboy sulop/baboy ihalas, Sus philippensis*, were also known pests in the area, however, they were also good sources of food for the family. Moreover, an excess in meat of *S. philippensis* was sold to the neighbors. Participants agreed that forested sites should be protected, particularly the threatened and endemic species found therein, and even if there was high species richness observed in the concerned *barangays*, sustainable use of these resources should be practised.

In Mamalad, local names were verified. The participants said that the local name of *Pycnonotus urostictus* was *baluwig* and not *boluntaryo bulyong*, as it was called in other *barangays*.

One participant asked whether killing pests, such as *maya* and *banog*, was a threat to biodiversity. To this, the concept of food chain and the importance of every component in the ecosystem was explained.

The participants also expressed their thoughts on the status of biodiversity in their area, the factors causing such, and the things that could be done to lower the risk of biodiversity loss. One participant blamed the government for allowing the regeneration of forest with non-native species of plants. Their sentiments were expressed as they stressed that most of the illegal logging was done before their generation and that they are now suffering the effects of such, as they are no longer allowed to utilize the resources in the protected areas. They added that those in the government would, undoubtedly, harvest what they are going to plant today. The *barangay* captain of Mamalad answered that the blame could not be placed solely on the government because the community was part of the government itself. Instead, he asked each member of the community to cooperate and unite for a common cause in protecting the forest and conserving biodiversity.

In all these validation meetings, materials used during the presentation were given to the *barangays*.

Recommendations for Increasing Awareness on Biological Diversity and Conservation

Using the TWINSPAN analysis, the five clustered vegetation types had consistent results in terms of species richness and degree of endemism. The dipterocarp was found to be the most diverse, followed by almaciga, mossy/

montane, mixed dipterocarp, and agroecosystem. Clustering of vegetation types also revealed that mossy forest was a distinct habitat type. Threatened and endemic fauna were mostly confined in primary forest ecosystems, i.e., dipterocarp, almaciga, montane, and mossy. The results further revealed that most Philippine endemics inhabited dipterocarp and almaciga, while Mindanao endemics favored mossy and montane forest types.

The different clusters are ecologically important as it support distinct vertebrate fauna species. Dipterocarp and almaciga forests are naturally favored by many wildlife species because they offer a diversity of plants used by animals for foraging or roosting. Most of the species of reptiles and amphibians normally inhabit areas with less than 1,000 masl elevation. Mossy forest is ecologically distinct. This implies that specialist species could be found in this forest type. However, there were fewer species here compared to dipterocarp and almaciga due to some limitations, like temperature and type of vegetation. Mixed dipterocarp is actually a combination of agro and forest ecosystems, which made this habitat an ecotone that acts as wildlife corridor to facilitate movement of species. Although agroecosystem had the least number of species, there are still endemic species that existed therein.

Awareness on biological diversity have to start with knowledge on the status of the fauna and the condition of its habitat. The number of endemic and threatened species should be emphasized vis-à-vis the condition of the habitat where these species are found. During the validation meeting in Mansawan, a participant requested that communities be given copies of the endemic and threatened fauna so that they would know what species to protect.

Wildlife animals are indicators of how stable or stressed the environment is. Each vegetational type is a preferred habitat of wildlife and supported the range of ecological requirements for species to survive. The destruction or loss of the habitat is also a loss to wildlife. Any form of habitat destruction would translate to an increasing number of threatened species. The continued existence of the different vegetational types is very important for the survival of fauna. As such, it is strongly recommended that no further destruction or opening up of areas for agroecosystem be done on forested sites. Strict protection and regulation of use have to be afforded to dipterocarp, almaciga, montane, and mossy forests since these supported a higher number of endemic and threatened fauna.

To make sure that awareness of and concern for fauna diversity could be sustained, research findings should be translated to IEC materials that communities and even other institutions and agencies could refer to. IEC materials could come in the form of flyers showing the photo and relevant information of a particular species of fauna (i.e., local and scientific names and distribution in Mt. Malindang, status, and the habitat type of the species). Pamphlets or brochures focusing on endemic and threatened fauna in Mt. Malindang could be disseminated to make people aware of how biologically rich the area is, but at the same time, show how vulnerable it is to habitat loss and how crucial it is for the survival of the endemic and threatened species. Knowledge on the endemic and threatened fauna may encourage people not to hunt these species for their continued survival.

Values formation, particularly on the conservation and protection of wildlife fauna, should start at an early age; booklets or primers on biodiversity could be produced and distributed to various primary schools. Such booklet or primer should contain a general information of Mt. Malindang, a concise introduction on the concept of biodiversity and conservation, and species profile indicating the local, common, and scientific names, local and IUCN status, and habitat. Activity workbooks that make use of the findings of the research study would also be effective among young people. It is also suggested that data gathered in this study be used in lectures and discussions in science subjects in primary and secondary schools within the Misamis Occidental and nearby provinces.

Dissemination of IEC materials could be an instrument to solicit support for the conservation of fauna. Knowing that these species occur in Mt. Malindang could create a sense of pride and instill moral responsibility in protecting the biological resources. A flagship species, such as the Mindanao endemic Malindang tree frog, *Philautus surrufus*, which could serve as Mt. Malindang's mascot for conservation may also be used to gather more support for biodiversity conservation on Mt. Malindang.

Integrated Development and Conservation Strategies

To minimize forest destruction and prevent habitat loss, conservation strategies have to be viewed at a much broader scale using the landscape approach. Each ecosystem and vegetational types have to be protected since each type performs a specific ecological role for the survival of wildlife fauna. Attention has to be afforded to dipterocarp, almaciga, and mossy forests since these supported a greater number endemic and threatened fauna. However, vegetational types with less species richness and endemicity, like mixed dipterocarp and agroecosystem, need to be protected as well. Mixed dipterocarp and agroecosystem not only provide habitat to wildlife fauna, but also serve as livelihood areas of the communities. As noted in interviews, communities were forced to hunt fauna for consumption and defense against animal attacks in their farms.

Community-based conservation strategies have to be employed at the local level. This included making use of their existing resource utilization practices, like using local traps, observing seasonal activities of animals to minimize disturbance, hunting only matured wild pigs of about 40-50 kg, and belief in spirits. These practices are already forms of conservation and monitoring of biodiversity in their respective areas. To strengthen these existing conservation practices, local ordinances could be passed to make these practices local conservation laws.

Communities should also realize that the economic value of forest is not only in terms of monetary value. Forests have intangible ecological services (e.g., water infiltration, carbon sequestration, pollutant trapping, flood and erosion control, ecosystem stability and productivity), as well as tangible values, such as source of water, food, medicine, housing materials, fuel, etc.

Community leaders and legislators at various levels could make use of the research data for local and even national policy formulation. Policies should aim for the conservation and protection of Mt. Malindang without jeopardizing the livelihood sources of the communities. Policies are targeted not only to conserve the biological resources and protect Mt. Malindang, but also to ensure that the livelihood of the communities in the area were improved and sustained.

The forest land use plan of the province should highlight the ecological importance of Mt. Malindang and its environs to the overall ecology of the province. It should utilize the integrated data and information from the different studies and projects of the BRP, i.e., terrestrial, aquatic, and socioeconomic and cultural studies.

Declaring flagship species, with preference to endemic and/or threatened species of fauna found in Mt. Malindang, is another intervention to promote conservation at the provincial level. Flagship species put Mt. Malindang on the spot of ecotourism, as well as attract organizations and countries working for biodiversity conservation and management.

SUMMARY AND CONCLUSION

Vertebrate faunal diversity was assessed in the 14 sampling sites representing different vegetation types in Mt. Malindang using participatory method and landscape approach. Survey results showed a total of 278 species, 117 endemic species, and 30 threatened species. Seventy-seven herpetofaunal species were recorded, composed of 26 anurans, 20 skinks, and 31 snakes with 59.69 percent, 58.33 percent, and 37.5 percent endemism, respectively. High species richness and endemism for the anurans occurred in the dipterocarp and almaciga forests sites. Skinks and snakes, on the other hand, had high species richness and endemism at the agroecosystem sites.

A total of 161 bird species belonging to 15 orders and 46 families, with 67 (40.99%) Philippine endemics, including 23 (34.85%) Mindanao endemics, were identified using the mist net and line transect techniques. Bukidnon woodcock, *Scolopax bukidnonensis,* was caught in a locally-made trap called *balag-ong*. Of the Mindanao endemics, two were endangered, namely, Silvery kingfisher, *Alcedo argentata*, and Giant scops owl, *Mimizuku gurneyi;* and two vulnerable species, namely, the Blue-capped kingfisher, *Actenoides hombroni*, and the Mindanao scops owl, *Otus mirus.* Another six species of the near-threatened category based on IUCN 2004 were Mindanao lorikeet, *Trichoglossus johnstoniae,* Zamboanga bulbul, *Hypsipetes rufigularis*, Mindanao cuckoo shrike, *Coracina mcgregori*, Philippine mountain shrike, *Lanius validirostris*, Apo sunbird, *Aethopyga boltoni,* and the Olive-capped flowerpecker, *Dicaeum nigrilore,* while the rest of the bird species recorded were of stable conservation status. Moreover, a total of 19 species of bats, 13 of which were fruit bats and six were insect bats, belonging to three families was captured in Mt. Malindang. Endemism was high at 47.37 percent (9), including 22.22 percent (2) Mindanao endemic.

Captured Philippine endemic bat species recorded one endangered bat, the *Acerodon jubatus,* and three vulnerable species (*Alionycteris paucidentata*, *Haplonycteris fischeri,* and *Rhinolophus subrufus*). The widespread *Cynopterus brachyotis* was the frequently netted bat.

A total of 21 species of non-volant mammals belonging to 10 families was identified in Mt. Malindang. Endemism was also high at 66.67 percent (14), with 42.86 percent (6) Mindanao endemics. Three of the Mindanao endemics, *Urogalle everetti, Crucidura beatus,* and the *Cynocephalus volans,* were of vulnerable status, while the rest had stable conservation status.

TWINSPAN analysis results showed that the mossy and montane forest cluster was a vegetation type different from the rest of the vegetation clusters, indicating that ecological specialists and endemic and threatened species are found in this vegetation type. Translating the cluster data into a biodiversity map revealed that the forested sites (dipterocarp, almaciga, mossy, and montane forests) were the most diverse areas.

A total of 28 faunal species were identified to be utilized by the local people either as a source of food or for small-scale pet industry. These included two amphibians (*Limnonectes magnus* and *Rana granducola*); 16 birds (*Buceros hydrocorax, Penelopides affinis, Haliastur indus, Gallus gallus, Chalcophaps indica, Macropygia phasianella, Aceros leucocephalus, Trichoglossus johnstoniae, Prioniturus montanus, Phapitreron amethystina, Phapitreron leucotis, Loriculus philippensis, Prioniturus discurus, Centropus viridis, Alcedo argentata,* and *Actenoides hombroni*); one volant mammal (*Acerodon jubatus*); and five non-volant mammals (*Urogale everreti, Sus philippensis, Cynocephalus volans, Paradoxurus hermaphroditus,* and *Viverra tangalunga*). Some of these species, like the *Loriculus philippensis*, were sold to the market for extra income. Species that were considered as pests included *Lonchura malacca* and *Lonchura leucogastra*, locally-known as *maya, Macaca fasicularis* (*unggoy*), *S. philippensis*, *Rattus argentiver*, *R. everetti*, and *R. rattus*. The once thought by laymen to be found only in Bohol, the Philippine tarsier, *Tarsius syrichta,* was captured in Mt. Malindang.

Results indicated very rich fauna and endemism on Mt. Malindang. With the present results, six species of amphibians, three reptiles (1 skink and 2 snakes), 35 birds, five volant mammals, and three non-volant mammals were added to the earlier survey on Mt. Malindang conducted by Tabaranza *et al*. (2000). The numbers of threatened animals had also increased to 30 faunal species, with 12 amphibians, nine birds, four volant mammals, and five non-volant mammals compared to the earlier record in 2000 by Tabaranza *et al.* of only 20 threatened faunal species with two amphibians, 14 birds, one volant mammal, and three non-volant mammals. Several threatened species were found despite the pronounced disturbance made by man, where some of the areas had been converted for agricultural purposes. Although the result of the study was very encouranging, destruction and disturbance to the habitat still remain a major threat to the survival of these animals. In the formulation of conservation and management plan for Mt. Malindang, the forested sites where mostly endemic and threatened species were found should be listed as priority areas for conservation as results have clearly shown that these forest sites were highly significant to the continued existence of vertebrate species with critical population.

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ASSESSMENT OF SOIL PROPERTIES AND ECOLOGICAL DIVERSITY IN MT. MALINDANG RANGE[1]

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Conversion of forest to agricultural lands is a serious problem in Mt. Malindang. Absence or scarcity of information on the drastic effects of forest cover loss and any form of disturbance keeps the denudation of forest and soil degradation unabated. This study, therefore, was conducted to assess the soil physico-chemical and biological properties, and the change of such properties with the increasing degree of disturbance. Samples were taken from undisturbed and disturbed forests, and agro and grassland ecosystems above and below the 1,000 meters above sea level (masl) landscape of Mt. Malindang. Participation of local communities was enlisted, partly for capacity building and in another, for the continuity of conservation activities beyond the duration of the project.

Results showed that the highest amount of organic matter (OM) was retained by the undisturbed (20.2%) and less disturbed ecosystems. Consequently, these ecosystems held the highest cation exchange capacity (CEC) that ranged from 43 to 57 $cmol_c$ kg^{-1} soil, and had low bulk densities (0.4 Mg m^{-3}) indicative of well aggregation. In contrast, forestlands converted into agricultural lands and later abandoned into grasslands, had reduced their properties close to critical values. Earthworm population was diverse in natural ecosystem (3.8 per 2.5 m^2) or where disturbance was limited to small-scale timber cuttings. In contrast, agro and grassland ecosystems were wholly dwelt by *P. corethrurus*. Root hair plant-feeding nematodes were abundant in all sites, except in arable corn and grassland at <1,000 masl, where semi-endoparasitic species associated with crops dominated. Soil respiration rate was lowest in the grassland ecosystems (21.59 CO_2 -C kg $ha^{-1}d^{-1}$). Thus, in any human-induced forest disturbance, it is not only the forest cover that is lost, but the soil as well. Earthworms and nematodes species composition and a number of bio-physico-chemical soil properties served well as indicators of this disturbance.

RATIONALE

Soil is an essential part of the biosphere and is vital for the continued existence of life on Earth. It is a crucial component of terrestrial ecosystems and a determinant of their capacity to produce goods and services. It functions as biological absorbent, distracter, and neutralizer of different pollutants (Urushadze 2002), and it holds water and nutrients (Sanchez 2002). It also holds a huge population of living organisms (soil biota) whose diversity is more extensive than any other environment in the world when all living forms are considered. This is the soil biota, which decomposes organic materials, cycles nutrients, and regulates gas fluxes to and from the atmosphere, and the biota that contains representatives of all groups of microorganisms, as well as microfauna. Soil, in short, not to mention the specific roles the soil biota played, delivers many of our basic needs and plays a central role in sustaining the biosphere and functioning of our environment (Sanchez 2002).

Unfortunately, despite the role they played in protecting our natural ecosystems, the soil and the soil communities and the vital functions they perform are still poorly understood. Lack of knowledge on the incredible complexity of soil and the organisms that made it their home is probably the singular reason that there is a seemingly continued disregard of this vital component of the natural ecosystems. Such a disregard was true in the Mt. Malindang Range ecosystems, the research site of the study.

Mt. Malindang Range is one of the ecologically valuable areas in Mindanao and is an important biodiversity refuge. Yet, the whole range, with its varied ecosystems, from the mossy forest (at its highest altitude) down to the coastal areas, is in fact, ecologically threatened. The pressures

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come from many fronts: from subsistence farmers living and encroaching inside the park (DENR 1999) and farming on steep slopes; from logging, commercial or small scale, which has denuded mostly the formerly thickly forested lands; and from political and economic power holders, and other interested groups (military or insurgent) (SEAMEO SEARCA 2000) within the range who would probably risk a fortune just to claim a stake on the land. All these led to soil degradation, then to loss of biodiversity, and the repercussion goes beyond local boundaries. Of people dependent on such resources, soil degradation is simply understood as depletion or loss of a natural productive resource. Biodiversity and its key function in maintaining the stability of (soil) ecosystems is hardly understood (SEAMEO SEARCA 2000).

Investigating, therefore, the soil properties and their relationship to soil biodiversity would help develop truly sustainable land use and, thus, ultimately protect Mt. Malindang and its natural ecosystems. In doing the investigation, key groups of organisms and some specific soil properties and processes whose conditions, or presence or absence, are a tell tale of soil health and its environment, were given particular attention.

REVIEW OF LITERATURE

Mt. Malindang Range Natural Park, located in the Province of Misamis Occidental, is a watershed and a catchment area. It was proclaimed as a National Park and Watershed Reserve on 19 June 1971 by Republic Act (RA) 6266. On 2 August 2002, through Proclamation Number 228 and pursuant to the provisions of RA 7586, the range was proclaimed as a natural park, which also made it a protected area. With 78 rivers emerging from the mountain's rugged volcanic landscape (SEAMEO SEARCA 2000) and with about 15 major catchment basins (DENR 1999), the range is undeniably the lifeblood of the provinces of Misamis Occidental, Zamboanga del Norte, and Zamboanga del Sur. DENR (1999) noted that the range, particularly the park, is an important biodiversity refuge. Diverse endemic faunal and floral species are found in the old-growth and mossy forests, several more other species have yet to be identified or discovered, others may already be threatened or endangered, and some may no longer exist. .

The park also occupies a total land area of 53,262 hectares (ha), consisting of 24,511 ha forestland, 13,320 ha shrubland of open and denuded land, and 14,297.25 ha open and cultivated land (SPOTSAT, June 1992). The soils are mostly undifferentiated except in the buffer zones and down to the lowlands.

The forest cover, only approximately 23,000 ha remaining, are still declining fast, especially over the last decade, due to the conversion of forest to agricultural land and eventually to human settlements. This demand for the biological resources had, of course, resulted in high rates of biodiversity loss, making Mt. Malindang one of the "hotspots" in the Philippines needing high priority for protection and conservation.

Assessment of soil quality includes not just the physical and chemical, but the biological properties as well. Some soil organisms and their activities are, in fact, considered potential indicators of physical or chemical disturbances in the soils. One such group of organism is earthworm. Earthworms are considered as ecosystem engineers. They are sensitive to low soil moisture and soil management practices such as soil tillage, application of organic matter, pesticides, and inorganic fertilizers. Their population density tends to increase with increasing organic matter inputs and decrease with soil disturbance, e.g., tillage (Lee 1985 as cited by Blair *et al.* 1996), thus making them valuable organisms in most agricultural soils.

Another group is the nematodes. These organisms are microscopic, unsegmented, threadlike worms that can be found in soils and sediments of all terrestrial and aquatic ecosystems. They are also called eelworms, threadworms, or roundworms. They are the planet's most abundant metazoan, where four of every five multicellular animals are nematodes. They occupy the films of water around soil particles, or water-filled pore spaces, and occupy any niche that provides an available source of organic carbon in marine, freshwater, and terrestrial environments (Bongers and Ferris 1999). They graze on microbial populations and are present throughout the entire soil food web, i.e., there are plant feeders, hyphal feeders, bacterial feeders, algal feeders, carnivores, and omnivores. Nematodes, both free-living and plant-parasitic, possess several attributes that make them useful ecological indicators (Freckman 1988). For one, they have short generation time that allows them to respond quickly to changes in food supply (Bongers 1990). In another, they also contribute directly to the mineralization of nutrients for plant growth, and thus have important effects on soil characteristics relevant to soil quality.

OBJECTIVES

Given the need to save Mt. Malindang Natural Park from the inevitable degradation, the study was conducted to assess the soil physico-chemical and biological properties of the mountain range, and to study the changes of such properties with increasing ecosystem disturbance.

METHODOLOGY

Participatory Approach

Before the final proposal was drawn up, a series of consultations with the local communities, from the local government units and line agencies down to the *barangay* levels, was conducted to ensure that the purpose of the project was communicated to them, to solicit their inputs, and to enlist their participation and commitment in the conduct of the study and to the eventual conservation and protection of the park. Incorporated in some of these meetings were capacity building trainings, particulary on field sampling, which resulted to developing a number of "local researchers". They also became an important source of information in the selection of sampling sites.

Sampling Sites and Soil Sampling

Sixteen sites, situated within the Mt. Malindang protected area, spread over eight *barangays* in three municipalities and one city, were selected for the study. These sites were grouped according to elevation (above and below 1,000 masl) and into four different ecosystems based on the degree of disturbance (undisturbed forest, disturbed forest, agro, and grassland) (Table 1). In each site or location, at least three plots of 20 x 20 m were established. Within each plot, composite soil samples were collected for chemical and physical analyses, which included pH, OM, total nitrogen (N), phosphorus (P), and potassium (K), chemical properties (e.g., CEC), and soil bulk density and texture (physical properties). Moreover, *in situ* soil respiration was measured using Draeger tubes. Pits were also dug on selected sites, and relevant site information were gathered. Exposed profiles were described, and samples were taken for eventual soil classification. Some details on sampling are given below.

Sampling for Biological and Chemical/Physical Analyses. Using a soil auger, about 100 probes were collected from the 0-20 cm soil depth following a regular zig-zag pattern, covering the whole area of the selected plot. In the field, the cores were homogenized and composited into one soil sample. A subsample of about 700 g fresh weight (for nematode analyses) was stored in a cool box, the remaining soil (for chemical/physical analyses) was stored at room temperature. The 700 g sample was stored at 4^{o}C until further use for nematode extraction.

Earthworm Sampling/Analyses. Within each 20 x 20 m plot, 10 subplots were selected at random for earthworm sampling. Each subplot, which measures 50 x 50 x 30 cm, was dug. The soil block was put on a plastic sheet and all earthworms present were collected by hand. The earthworms were killed in a 70 to 90 percent ethanol and stored in 10 percent formaldehyde. After which, total number and species composition were counted and

Table 1. Sampling sites at different ecosystems in Mt. Malindang.

Elevation	Ecosystems			
	Undisturbed Forest	Disturbed Forest	Agroecosystem	Grassland
> 1,000 masl	Mt. Guinlajan (6 plots) North Peak (6 plots)	Small-scale timber extraction: a. Mt. Ulohan sa Dapitan (6 plots) b. Mt. Capole (6 plots) c. Old Liboron (3 plots) Logged-over a. Pongol (3 plots) Secondary-growth forest a. North Peak (1 plot)	1st arable: a. Lake Duminagat/ Cabbage (3 plots) 2nd Arable: a. Lake Duminagat Agro (3 plots) b. Gandawan Agro (3 plots)	a. Lake Duminagat (1 plot) b. Gandawan (2 plots)
< 1,000 masl		Small scale a. Mialen (3 plots) Logged-over: a. Peniel (3 plots) Agroforestry a. Mamalad (3 plots)	Coco a. Mialen (3 plots) Corn a. Bunga (3 plots) b. Mamalad (3 plots)	a. Peniel (3 plots)

identified for each plot. Species new to science were stored for further taxonomic description.

Bulk Density (BD) Sampling. From each plot, three spots (randomly selected) to represent three replicates were sampled. Using a core sampler with known volume, an undisturbed sample was taken at 0-10 cm depth and at 20-30 cm depth. These comprised a total of six bulk density samples per plot.

Soil Respiration. In each of the field plots, soil respiration was measured using the closed chamber Draeger Tube syringe method described by Parkin and Doran (1996). Two measurements were made in each plot.

Nematode Analyses. Nematodes were extracted from a 100 g fresh weight soil sample stored at 4°C, using the elutriator technique as described by Oostenbrink (1960). Total numbers of nematodes were counted and then stored in four percent formaldehyde until identification. Nematodes were identified to family and genus level. Then they were assigned to trophic groups according to Yeates *et al.* (1993).

Soil Chemical and Physical Analyses. The composite soil sample was used for the chemical soil analyses. After drying and sieving, the soil was analysed on total carbon (C) and N, available P, exchangeable K, pH, cation exchange capacity (CEC), and soil texture according to standard procedures. The OM content was calculated from the total C content. Bulk density was calculated after drying the soil at 105°C for12 hours.

RESULTS AND DISCUSSION

Soil Morphology and Classification

The Mt. Malindang soils were relatively young, sandy loam and clay loam in texture, moderately strong to very strongly acid in reaction, and high in organic matter. Soils on steeper slopes were shallower, more stony/rocky, and less developed. Two soil orders, Inceptisols (Profiles 1, 4, 5, 6, 7, and 8) and Entisols (Profiles 2 and 9) were found. From Table 2, it can be seen that the studied soils, except Profile 8 in Barangay Peniel, may most likely have andic properties as shown by its bulk density values and the nature of its parent material. The information available, thus far, could only point to the presence of andic properties in these soils. Shoji *et al.* (1993) reported that andic materials contain a considerable amount of allophane, and allophanic soils have low bulk density, high exchange capacity, and high phosphate adsorption. They denote the properties of amorphous clays that characterize volcanic ashes that weather rapidly in humid or perhumid climates (Wambeke 1992). Such soils have good physical make-up and essentially fertile when first cleared for cultivation but deteriorate fast with continued use over time, particularly so that these soils are concentrated mostly on sloping areas.

Physico-chemical Properties

Examination of the upper 0-20 cm surface of the soils, supported by nine pedons spread throughout the project site, showed that the undisturbed ecosystems were

Table 2. Classification of the studied soils.

Profile No.	Epipedon	Subhorizon	Classification (Soil Survey Staff 1996)
1	ochric	cambic	Clay-skeletal over sandy loam superactive acid isothermic andic eutropepts? Dystropepts?
2	ochric	none	Very fine/clayey-skeletal superactive acid isothermic lithic/andic? Troporthents
4	ochric	nearly cambic	Loam over sandy loam superactive acid isothermic andic? Eutropepts? Dystropepts?
5	ochric	cambic	Loamy–skeletal superactive acid isothermic andic? Eutropepts? Dystropepts?
6	ochric	cambic	Sandy loam skeletal over loam skeletal superactive acid isothermic andic? Dystropepts
7	ochric	cambic	Loamy sand skeletal superactive acid? isothermic andic? Dystropepts
8	ochric	cambic	Fine over fine-skeletal semi active to active acid isothermic to isohyperthermic andic? Typic Eutropepts? Dystropepts?
9	ochric		Fine/clayey-skeletal semi active to active acid isothermic to isohyperthermic andic? Troporthents

distinctly better off than the disturbed ecosystems relative to a number of soil parameters, such as %OM, CEC, and bulk density. Primary data on the chemical and physical properties of the soils are given in Tables 3, 4, 5, and 6. It also showed that in a number of parameters, i.e., pH, available P, total N, exchangeable K, and texture, most of the ecosystems studied were similar, and if there were any seeming dissimilarities, these were not statistically significant.

The variation of soil pH among ecosystems, for instance, the values of which were generally within the range of strong acid (5.3) to very strong acid (4.9) (Table 3), was so slight to be counted for anything significant statistically. The natural supply of phosphorus was another property that soils in Mt. Malindang have in common - low supply. The available phosphorus of the soils under all ecosystems studied, whether undisturbed or disturbed, was below the optimum level (Table 3). Where Bray P2 method is used for extraction, as is the case of this study, a value less than 15 ppm is considered low and plant response to fertilizer addition is most likely (Landon 1991). The Bureau of Soils and Water Management (BSWM) criteria, although using the Olsen Method, consider 6 ppm and lower as marginal or unfavorable to crops.

Phosphorus levels were so uniformly low that neither elevation nor type of ecosystem nor specific site location, which in many ways indicative of degree of disturbance, seemed to make any difference. The very strong acid condition of the soils may have played an important role in this regard. As earlier pointed out, pH is one of those factors affecting P mobility in the soils. Highly acidic or basic soils have almost no P available to the plant, except that which is released from decaying organic matter.

As regards potassium levels of the studied soils (Table 3), the values were generally above the established criteria on critical value of available potassium, and variation among ecosystems was again not significant. A significant variation was only observed when land use types were compared (Table 4). Even then, only coco and first arable were significantly higher than the rest of the land use types. It was suspected that previous practice of liming done on the land contributed to the difference. The other possibility was the presence of more weatherable, rich in potassium minerals in this specific plot. This could not be verified at present because of absence of data on mineralogy.

On soil texture the forest ecosystems, disturbed and undisturbed, both revealed heavier textures, a characteristic that could help forest soils moist all year round. Although profile investigations showed that these soils were generally slightly plastic and slightly sticky when wet, the particle size analysis showed still higher percentages of sand. This could indicate particle dispersion problems for suspected andic material in the area. Incomplete dispersion in simple mechanical analysis is a problem for andic soils.

What have been mentioned, so far, were soil properties that did not differ significantly in both the undisturbed and disturbed ecosystems. There were, however, soil properties which clearly made the undisturbed ecosystem distinctly better off, at their present state and potential, than the disturbed ecosystems. The properties that stand out in particular are %OM, CEC, and bulk density (BD).

Organic Matter (%OM). The organic matter content ranged from 8.5 to 20.2 percent (Table 3). These values were relatively higher than what an ideal soil is supposed to contain (Brady and Weil 1999) and very much higher than most of the soils across the Philippines. Further, these values made clear that the undisturbed (primary) forest is a cut above the rest of the ecosystems in terms of OM richness. Among disturbed ecosystems, the amount of OM went down with their degree or state of disturbances.

Meanwhile, although high organic matter values at higher elevation, which incidentally is the elevation where undisturbed forest ecosystem is found, could be attributed to the lower temperature and wet environmental condition that favors accumulation of residues and reduced decomposition, yet the dramatic change in organic matter content from primary forests to grasslands, both above and below 1,000 masl was obviously not due to elevation differences only.

Comparison by land use types (Table 4), which indicated varying degrees of disturbance, confirmed that more OM was lost as disturbance progresses into grassland (Peniel). Not even reforestation, as in the case of plantation forest in Peniel (6.6%), could raise OM content approximately as high as the North Peak level (24.9%), the undisturbed ecosystem. The consequential loss or decline of the natural levels of soil organic matter following cultivation was well established. According to Syers and Craswell (1995), soils developed for agriculture inevitably show a decline in organic matter because, first, tillage and other agricultural practices increase the rate of decomposition of soil organic matter by mixing the surface soil and increasing the number and intensity of wetting and drying cycles; second, the inputs of plant C are generally less in a disturbed or cultivated system than in natural environment. The reduction in return of organic residues to the soil is as much as ten-fold (Goh 1980).

Table 3. Soil chemical properties of the different ecosystems.

Ecosystem	OM %	pH 1:1 H_2O	Avail P ppm	Total N %	Exch K $cmol_c$/kg soil	CEC $cmol_c$/kg soil
Undisturbed forest	20.2^{c}	4.9^{a}	2.1	0.5^{b}	0.2	57.0^{c}
Disturbed forest	15.0^{b}	5.4^{b}	1.4	0.5^{ab}	0.5	40.1^{b}
Agroecosystem	10.3^{ab}	5.2^{ab}	1.3	0.4^{ab}	0.5	27.5^{a}
Grassland	8.5^{a}	5.3^{ab}	1.0	0.3^{a}	0.3	23.6^{a}

*Means with same letter are not significantly different at 5% level (Duncan) using SPSS

Table 4. Soil chemical properties at different land use types.

Land Use Types	OM %	pH 1:1 H_2O	Avail P ppm	Total N %	Exch K $cmol_c$/kg soil	CEC $cmol_c$/kg soil
Small-scale timber extraction	16.0^{cd}	5.5^{bc}	1.6^{ab}	0.51^{abc}	0.54^{ab}	43.16^{d}
Logged-over	11.98^{abcd}	4.9^{ab}	0.8^{a}	0.45^{abc}	0.18^{a}	30.96^{bcd}
Agroforestry	4.9^{a}	4.6^{a}	0.5^{a}	0.2^{a}	0.20^{a}	20.48^{ab}
First arable	14.8^{bcd}	5.4^{bc}	1.9^{ab}	0.69^{c}	0.73^{b}	43.15^{d}
Last arable	14.3^{bcd}	5.4^{bc}	2.6^{b}	0.57^{bc}	0.28^{a}	29.77^{ab}
Coco	10.6^{abc}	5.7^{c}	0.5^{a}	0.35^{ab}	1.16^{c}	34.87^{bc}
Corn	6.6^{ab}	4.8^{ab}	0.5^{a}	0.19^{a}	0.30^{a}	17.14^{a}
Grassland	8.5^{abc}	5.3^{bc}	1.0^{ab}	0.29^{a}	0.38^{a}	23.58^{abc}

*Means with same letter are not significantly different at 5% level (Duncan) using SPSS

Cation Exchange Capacity (CEC). The CEC values of the ecosystems regardless of elevation are listed in Table 3. These values were all above the adequate level (20 $cmol_c$ kg^{-1} soil) for plant growth set by the BSWM (CARE-BSWM 2002). The undisturbed forest was observed to have the highest CEC value (57 $cmol_c$ kg^{-1} soil). Grassland, on the other hand, had the lowest (23.6 $cmol_c$ kg^{-1} soil), followed by the agro and the disturbed forest ecosystems, in increasing order. The CEC difference between undisturbed and disturbed forest was quite significant and both had CECs significantly higher than agro and grassland ecosystem. Obviously, CEC decreases with ecosystem disturbance.

Incidentally, ecosystems with high CECs were the ecosystems with high OM contents. Figure 1 shows the trend and the relatively high R^2 value (R^2=0.998) of the relationship. Higher CEC means higher negative charge and higher capacity of soil to hold cations, a measure of soil's fertility. CEC coming from humus (OM) even plays a prominent role, sometimes a dominant one in soils (Brady and Weil 1999).

Organic matter maintains equilibrium with climate, vegetation, and other environmental conditions. It depletes rapidly if this equilibrium is disturbed by inappropriate management practices (Wambeke 1992). It is, therefore, a must that the management of these soils is oriented in maintaining sufficient amounts of organic matter.

*Bulk Density (BD)***.** The bulk densities of the studied soils in each ecosystem are presented in Table 5. The values were unusually low for mineral soils, ranging from 0.4 to 1.1 at 0-20 cm depth or 0.43-1.03 Mg m^{-3} at 20-30 cm. However, against the backdrop of high OM content of most soils, these BD values seemed plausible. Mineral particle densities (PD) usually ranged from 2.5 to 2.8 Mg m^{-3}, while organic particles were usually less than 1.0 Mg m^{-3}. Thus, where OM is observed to be comparatively high, bulk density is also relatively low. Undisturbed forest, in this study, had significantly the least BD value. This was also the ecosystem with the highest OM (Table 3). Soils in the disturbed ecosystems, grassland, and agroecosystems in particular, on the other hand, which may have lost much of their OM from human activities as presented earlier, had much higher bulk densities.

Biological Components

Soil Respiration. Soil respiration was highest in agroecosystem (Table 6). Tillage, which is known to bring in more oxygen to the soil and expose organic matter to organisms, had obviously contributed to the increase of CO_2 evolution from the soil. Comparatively, although the

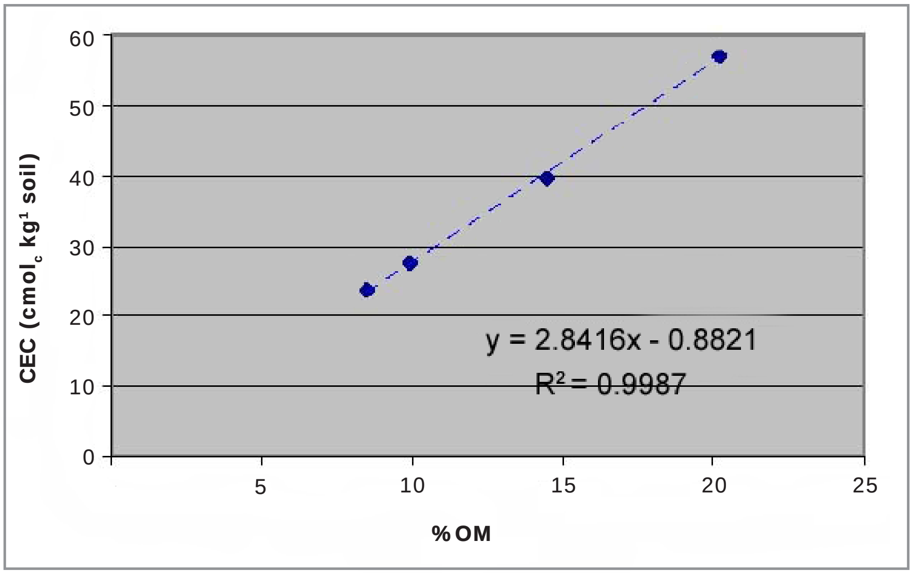

Figure 1. Relationship of OM and CEC of the different ecosystems.

Table 5. Soil physical properties of the different ecosystems.

Ecosystems	BD Mg m^{-3}	SAND %	SILT %	CLAY %	Textural Class
Undisturbed forest	0.4[a]	36.5	23.8	39.7	Clay loam
Disturbed forest	0.7[b]	33.3	33.5	33.2	Clay loam
Agroecosystem	0.9[bc]	37.9	27.6	34.5	Clay loam
Grassland	1.1[c]	41.2	27.4	31.4	Clay loam

*Means with same letter are not significantly different at 5% level (Duncan) using SPSS

Table 6. Soil nematode and earthworm abundance and soil respiration in different ecosystems.

Ecosystems	Earthworm (Ind. per 2.5 m^2 at 0.30 m depth)	Earthworm (No. of sp. per 2.5m^2 at 0.30 m depth)	Nematode (No. of Ind. per 100 g soil)	Soil respiration (CO_2 -C kg ha^{-1}d^{-1})
Undisturbed forest	9.5[a]	3.8[b]	583.3[a]	41.34[b]
Disturbed forest	74.6[ab]	3.4[b]	921.7[a]	41.49[b]
Agroecosystem	113.8[b]	1.0[a]	910.7[a]	43.16[b]
Grassland	111.0[b]	1.0[a]	805.0[a]	21.59[a]

*Means with same letter are not significantly different at 5% level (Duncan) using SPSS
Similar ecosystems at different altitudes were averaged

difference was not statistically significant, the undisturbed ecosystem had lower respiration rate than that of the disturbed or agroecosystem. The grassland ecosystem seemed to be an exception. It had the lowest respiration value among ecosystems when, in fact, it was the most disturbed, albeit in not too long a distant past. The reason possibly lies on the amount of organic matter available for decomposition. Grassland, incidentally, had also the least OM (Tables 3 and 4).

As an indicator of biological activity, soil respiration is often times regarded as a positive indicator of soil quality. Higher respiration rate means more nutrients released from organic matter and improved soil structure, among others. In this perspective, agroecosystem had the richer soil. High respiration, however, does not always indicate good soil quality. It is understood that biological activity is also a direct reflection of the degradation of organic C compounds in soil (Parkin *et al.* 1996). It indicates loss of carbon from the soil system. Viewed from this perspective, the agroecosystem in this study must have retained the least organic matter than the forest ecosystems. Indeed, based on the amount of organic matter present in these ecosystems (Table 3), the observation was true. All, except grassland, had high OM content, and the undisturbed ecosystem had more compared to other ecosystems.

However, based on the general soil respiration class ratings of Woods End Research (1997), the biological activity in the present ecosystems studied was less than ideal. The soil has an ideal state of biological activity, adequate organic matter, and active populations of microorganisms only if its CO_2 production reaches the range of 40 to 72 CO_2-C ha^{-1} d^{-1}.

Earthworm. Pontoscolex corethrurus, an exotic species introduced from Brazil, is the earthworm type that inhabits the grassland and agroecosystems. It is the only species found in those ecosystems. In other ecosystems, varied species, possibly some would be new to science, were found. The undisturbed mossy forest had notably higher number of species per unit area than the disturbed forest. Forest ecosystems, disturbed or not, had much more diverse species of worms than grasslands and agroecosystems (Table 6). In terms of the number of individuals, however, the latter two gave the greater numbers at both elevations (below or above 1,000 masl). The species presence, however, was limited to one - *P. corethrurus*. It is well to note that, in forests, particularly the undisturbed ecosystems where bigger and more colorful species were found, organic matter and surface litters are abundant. This may explain why the latter species of earthworms were mostly present.

*Nematodes***.** Table 6 shows that the number of individuals per unit weight soil (100 g) was not significantly different among ecosystems and was rather low compared with soils in the temperate regions. But when grouped according to feeding habits, plants-feeders came out to be the most abundant in all sites studied. Among this group, root-hair feeders dominated except in arable corn and grassland at <1,000 masl. In grassland ecosystem, it was the semi-endoparasitic group which was abundant at all elevation, while the ectoparasitic plant-feeding nematodes were most abundant in forest ecosystems at >1,000 masl.

When relative abundance of nematodes with some environmental parameters as passive variables were subjected to ordination analyses (PCA), the result showed that the forest ecosystems, located in the upper part of the ordination plot (Figure 2) and characterized by low bulk density, and high organic matter and CEC, had relatively high abundance of nematodes.

Further ordination analyses (RDA) on the 10 sites with nematode data (Table 7) showed that 58 percent of the variation in the nematode population could be described by the environmental variables. In fact, all variables together could explain 84 percent of the variation within the nematode dataset.

CONCLUSION

The soil characteristics, both physical and chemical properties, all pointed out that they were at their optimum or best levels in ecosystems where occurrence of human activities was almost absent or none at all. These ecosystems kept the organic matter values high, pH levels acceptable, and retained relatively good amounts of N or P in the soils. These were also the ecosystems which had loamy textural classes and low bulk densities, indicative of well aggregation, presumably because of high amount of OM (Figure 3). In contrast, forests converted into agricultural lands and later abandoned into grasslands, although in general not as damaged as it could possibly be, had reduced their properties close to critical values.

Thus, there is reason to believe that the good quality of the soil is in part maintained by the integrity of the forest cover. Disturbance due to logging and conversion of land use to agroecosystems without proper soil management, which incorporates mitigating measures, could ultimately compromise soil quality. As cultivated lands become increasingly infertile overtime, while the demand for food or the population growth remains or even increases, conversion of forest to agricultural lands remains the only option. In time, the grassland or wasteland areas increase,

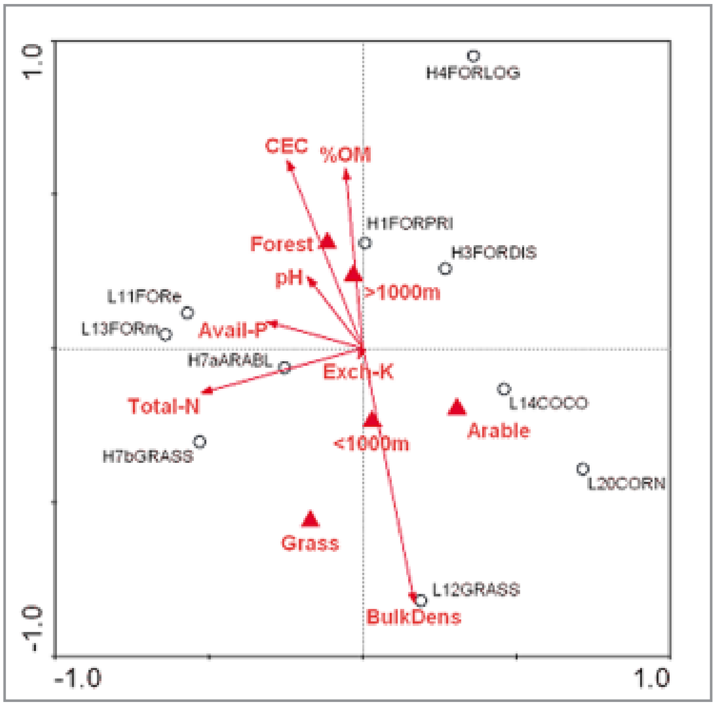

Figure 2. PCA of nematodes showing the position of the10 sampling sites (o) and some soil physical and chemical properties.

Table 7. Results of a RDA on the 10 sites with nematode data.

Axes	1	2	3	4	Total Variance
Eigenvalues	0.305	0.185	0.112	0.072	1.000
Species-environment correlations	0.993	0.997	0.959	0.929	
Cumulative percentage variance					
of species data	30.5	49.0	60.2	67.4	
of species-environment relation	36.4	58.4	71.7	80.3	
Sum of all eigenvalues					1.000
Sum of all canonical eigenvalues					0.840

Total-N was not included because data were missing for two sites; CEC and bulk density were excluded from the analyses because of strong autocorrelation with other parameters.

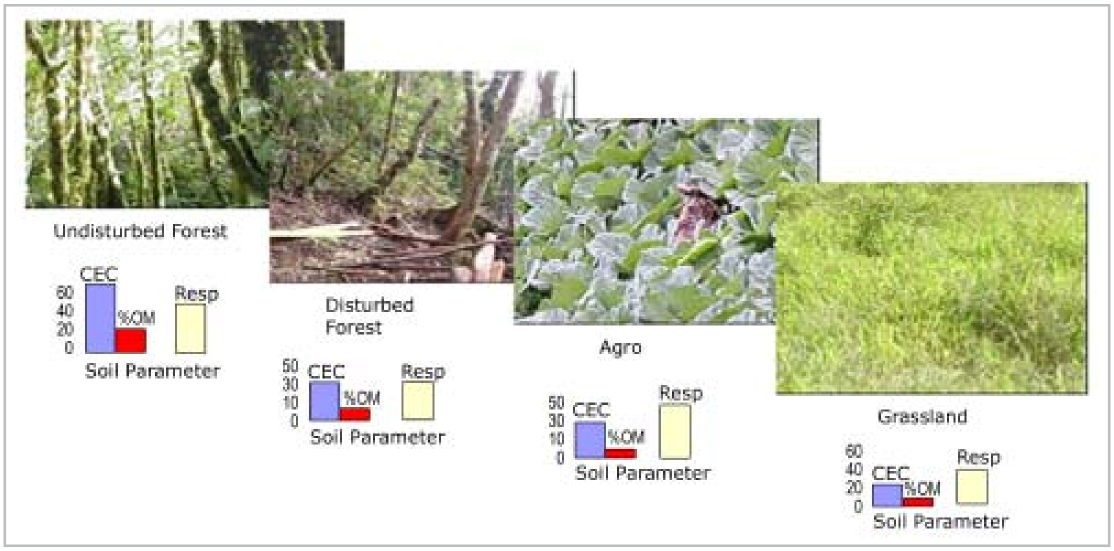

Figure 3. Reduction of soil quality with degradation of ecosystems.

while the areas of the forestlands decrease, correspondingly.

RECOMMENDATIONS

The best way to break the cycle of abandoning old farms and opening new ones, in all instances putting forests under serious threats, is to keep the existing farms productive. Two general approaches may be considered for the purpose. First, prevent or minimize soil erosion. Second, keep the level of organic matter high. There are specific techniques or proven technologies for each approach. Soil loss is prevented by adapting structural measures, such as terraces, simple or bench, waterways, and gully control structures. Erosions are minimized too by making some agronomic measures, such as contour cultivation and close planting, strip cropping, mulching, cover cropping, minimum tillage, and vegetative barriers. Use of compost and farm manure, green manuring, crop rotation, and soil moisture conservation are measures that keep soil organic matter level high.

Thus, specific to Mt. Malindang, the following are the recommendations of this study:

In coordination with the DENR or the Office of the Park Superintendent, delineate or classify the areas currently under cultivation into two: one group are areas on which cultivation should absolutely be discontinued, and another on which, by necessity and social consideration, a certain degree of cultivation is allowed. On one group, implement rainforestation, on the other, perform massive contour farming program and its variation, like agroforestry.

Effective actions, however, against soil degradation require more than the enumerated techniques above. After all, most of these technical solutions are not new and have been around for some time and proven to work at training stations and demonstration sites. What is required, undoubtedly, is greater intervention by the government. It must be obliged to create social and economic conditions under which the technical and management solution could work.

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PARTICIPATORY INVENTORY AND ASSESSMENT OF PLANTS IN MALINDANG RANGE NATURAL PARK, MINDANAO ISLAND, PHILIPPINES[1]

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Despite the recognized value of the Mt. Malindang Range Natural Park as a major biodiversity refuge, little has been done to conserve and protect its flora. The commercial and social demand for floral resources has resulted in biodiversity loss. Thus, Mt. Malindang Range Natural Park is one of the hotspots in the Philippines needing high priority for protection and conservation. As such, it is important that plants be inventoried and assessed so that strategies for their sustainable use can be effectively implemented.

Site selection, establishment of sampling plots, and inventory were done with the local researchers. Using TWINSPAN analysis, floristic classification, vegetation types, and maps were produced and assessed to determine the status of biodiversity.

Participatory inventory and assessment of the forest ecosystems delineated eight types - mossy forest, montane forest, dipterocarp forest, almaciga forest, two types of mixed dipterocarp forest, lowland dipterocarp forest, and plantation forest. Each forest type is characterized by a specific combination of plant species. The forest ecosystems showed a total of 1,284 species, composed of 873 angiosperms, 20 gymnosperms, 283 pteridophytes, 85 bryophytes, and 26 lichen species. It also revealed 56 endangered and locally-threatened species.

Among the forest types, the almaciga forest was found with the most number of endemic species, followed by the montane and the mossy forests. The lowest species richness and endemism were found in the plantation forest. In general, the forest types scored high on the species diversity index. It is expected that this species diversity index would increase when the forest is be protected and properly managed by the local people inhabiting the park.

The forests in the Mt. Malindang Range Natural Park were still rich in biodiversity and endemic species. However, threatened species were high due to land conversion and resource utilization.

INTRODUCTION

The high biodiversity in the Philippines is attributed to the large number of islands and the presence of many high mountains. Mindanao, the second largest island in the Philippine Archipelago, supports a wide variety of plants. However, like the rest of the archipelago, the area covered by natural forests is rapidly decreasing with only 29 percent remaining, most of which are located in upland ranges.

Mt. Malindang Range Natural Park, located in the Province of Misamis Occidental, is the only representative natural forest in the Zamboanga Peninsula Biogeographic Zone (Myers 1988). However, it is one of the upland ranges where biodiversity has been severely threatened due to the conversion of the forest to agricultural land and human settlements. The commercial and social demand for the biological resources has resulted in high rates of biodiversity loss. Economically important and endemic plant species are threatened by habitat loss and unsustainable utilization. Mt. Malindang has become one of the "hotspots" in the Philippines that has to be highly prioritized for protection and conservation (Ong *et al.* 2002).

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The study was conducted to generate knowledge on the critical flora resources of Mt. Malindang. Through the participatory approach, it intended to provide a better understanding of plant species diversity and availability so that resources could be shared and managed effectively.

REVIEW OF RELATED LITERATURE

Ecosystem and Species Diversity

Mindanao has an estimated forest cover of 30,960 km^2, which is 24.55 percent of its total land area of 126,092 km^2 (=10,060,900 hectares [ha]). It has a wide spectrum of ecological diversity, namely, beach forest, mangrove forest, freshwater swamp forest, limestone or karst forest, forest over ultrabasic or ultramafic soils, lowland dipterocarp forest, montane and mossy forests, and grassland vegetation (CI 2002).

The flora of Mindanao is largely allied to that of the Papuasian-Australasian, and to a lesser degree, Bornean via the Basilan-Sulu-Tawi-tawi island arch and Zamboanga. The Papuasian-Australasian affinity is best exemplified by the present distribution range of the following genera – *Eucalyptus* (Myrtaceae), *Discocalyx* (Myrsinaceae), *Heterospathe* (Arecaceae), and *Sararanga* (Pandanaceae) (Fernando 2001, Zamora and Gruezo 2000). On the other hand, the Bornean affinity is demonstrated by the distribution ranges of *Salacca* and *Plectocomia* (Fernando 2001, Ashton 1993).

Plant Communities

Plant communities may be considered subdivisions of a vegetation cover. Likewise, vegetation consists of a mosaic of plant communities in a terrestrial landscape. Wherever the cover shows more or less obvious spatial changes, one may distinguish a different community. These changes may be caused by spatial changes in species composition, changes in spacing and height of plants, changes in life forms of plants, which in turn may correspond to spatial changes in the environment (Mueller and Heinz 1974).

Different plant communities reflect the prevalence of different abiotic factors such as climate, relief (altitude and aspect), soil, water conditions, and eventually land use. The close relationship of a plant community to the site on which it occurs led to the introduction of the term ecosystem. The vegetation specialist maps plant communities as to their location, extent, and distribution. Many vegetation ecologists assume that the plants in a community are interdependent and that communities are integrated entities.

Biodiversity Inventory and Assessment

There are 12,000 species of plants credited to the Philippines, consisting of 8,000 flowering plants (Madulid 1995), 1,023 ferns (Amoroso 1997), 77 fern allies, and 3,000 non-vascular plants (Zamora 1991).

Out of the 12,000 Philippine plant species, there are 72 species listed officially as endangered (Tan *et al.* 1986, Gruezo 1990). Furthermore, Madulid (1991) reported that of the 8,000 species of flowering plants, 23 genera and about 3,500 species are endemic to the country.

Among flowering plant families, the Orchidaceae, Rubiaceae, Myrtaceae, and Moraceae have the greatest number of endemic species, while Gramineae, Liliaceae, Ulmaceae, Leguminosae, and Rutaceae have lower endemism. The gymnosperms are poorly represented with only 33 species and 18 percent endemism, while the pteridophytes have 30 percent endemism (Zamora and Co 1986, Amoroso 1997).

Salgado (1990) reported 958 species of ferns belonging to 151 genera in 31 families. In Mindanao, a total of 574 species was recorded; in Mt. Kitanglad alone the number reached as high as 410 species (Amoroso *et al.* 1996). Mindanao is also rich in fern allies. Of the 79 species of fern allies in the Philippines, 68 are found in Mindanao (Amoroso and Rufila 2001).

The flora of the Philippines is rich in endemic forms. An endemic plant is presumably evolved locally and therefore constitutes part of the unique plant life of the country. Zamora and Co (1986) reported that of the 930 species of Philippine ferns, 278 are endemic species while six are endemic genera: *Psomiocarpa*, *Thayeria*, *Tectaridium*, *Podosorus*, *Nannothelypteris,* and *Copelandiopteris*. It is interesting to note that in contrast to the high specific endemism of the local fern flora (about 33%), generic endemism is rather low (about 4%). This low generic and high specific endemism can be explained by the geologic history of the country. One explanation is the evidence that the archipelago has not been separated long enough from the neighboring islands to develop many endemic genera. Because a genus is a more distinct entity, it requires a longer period to evolve (Zamora and Co 1986).

A study in the three forest sites in Mindanao, i.e., Mt. Kitanglad and Mt. Apulang in Bukidnon, and Marilog in Davao, revealed high endemic species. Eighty-nine endemic species were recorded, which is approximately 32 percent of the total endemics in the Philippines (Amoroso *et al.* 1996). Of these, *Tmesipteris* and *Isoetes* are reported to be endangered (Tan *et al.* 1986). Another

Philippine species, *Botrychium daucifolium*, has been listed as one of the 10 most threatened plants in Malaysia (Kiew *et al.* 1985).

A study of economic fern and fern allies in Mindanao revealed the presence of 71 species. However, many of these species are now dwindling in population and becoming rare due to over harvesting and disturbance of their habitat brought about by shifting cultivation, logging, and conversion of forest land to agricultural zones (Amoroso 1993, Amoroso *et al.* 1996).

Inventory and assessment of plant species are aimed to measure and quantify biodiversity. They describe species richness and abundance (Gruezo 1997, Amoroso *et al.* 1996, Polacks 2000, Arances *et al.* 2004), number of endangered, rare, and extinct species (Cali *et al.* 1999, Arances *et al.* 2004, Tan *et al.* 1986, Gruezo 1990), species functions and relations (Gruezo and Gonzales 1997), biodiversity indicators (Noss 1990, Reid 1994, Ticsay-Ruscoe 1997, Gruezo and Gonzales 1997), species distribution (Madulid 1995, Gonzales and Dans 1997, Lubos 2000), species uses and ecological importance (Saniano 1981, Agbayani 1996, Burton 1996, Arances *et al.* 2004), and enumeration and status of certain groups of species (Rojo 1996 and 1999, Pipoly and Madulid 1996, Gonzales 2000, Amoroso 1997, Amoroso *et al.* 2000, Alava 2000), among others.

Sampling Techniques

There are various strategies in selecting plots that will be used in the field for vegetation analysis: (1) random sampling, (2) stratified sampling, and (3) random-stratified sampling. There are also various methods used to gather samples: (1) point sampling, (2) line sampling, and (3) quadrat sampling (Iskandar and Kotanegara 1993).

In quadrat sampling, Iskandar and Kotanegara (1993) formulated two techniques: simple quadrat plot and double quadrat plot. For forest vegetation with different strata, the double quadrat plot technique is recommended since subplots can be identified within the quadrat plot for the different growth forms (trees, shrubs, herbs, and vines). The optimum sizes of quadrat plots are: tree layer 20 x 20 m or 10 x 10 m; herb layer 1 x 1 m until 5 x 5 m; and shrubs layer/seedlings 4 x 4 m until 5 x 5 m. The shape of the plot may either be square, rectangular, or circular, as long as the plot size is uniform and representative.

MATERIALS AND METHODS

Location of Study Sites

The research sites are located in the Municipalities of Don Victoriano, Misamis Occidental (Mansawan, Gandawan, and Lake Duminagat), Oroquieta City (Sebucal, Mialen, Toliyok, and Bunga), Lopez Jaena (Peniel), Calamba (Mamalad and Siloy), and Concepcion (Small Potongan and Marugang). These municipalities are within the watersheds and have tributaries to the two major river systems, Layawan and Langaran, and all within the Mt. Malindang Protected Area.

Participatory Approach: Organizing and Training Local Researchers

To enhance awareness on the Biodiversity Research Programme (BRP) and elicit community cooperation and participation, the Terrestrial Ecosystem Master Project (TEMP) conducted a community information drive, meetings, and consultations with the *barangays* included in the project, namely, Sebucal, Mialen, Toliyok, and Bunga in Oroquieta City; Mamalad in Calamba; and Peniel in Lopez Jaena, Misamis Occidental (Figure 1).

The TEMP and Socioeconomic and Cultural Studies (SECS) teams conducted trainings on capability building for research assistants, researchers, and local researchers. The participants were given hands-on exercises on collecting and preserving flora and fauna specimens, as well as collecting and analyzing data in the field. They also attended a training-workshop on plant taxonomy, herbarium processing and management.

Vegetation Analysis and Mapping

Two approaches were integrated to come up with a vegetation map of the northern landscape of both the vegetation structure (physiognomy), as well as floristic composition of the plant communities (Figure 2). The first approach was the “top-down” or deductive approach, which analyzed remote sensing images, while the second was the inductive or “bottom-up” approach which analyzed field data. The top-down strategy focused on the different vegetation structures and their geographical distribution. The bottom-up gave an insight on the content of the different plant communities. The floristic composition provided the basis for the assessment of community diversity, community threat, and the economically important plants for the community.

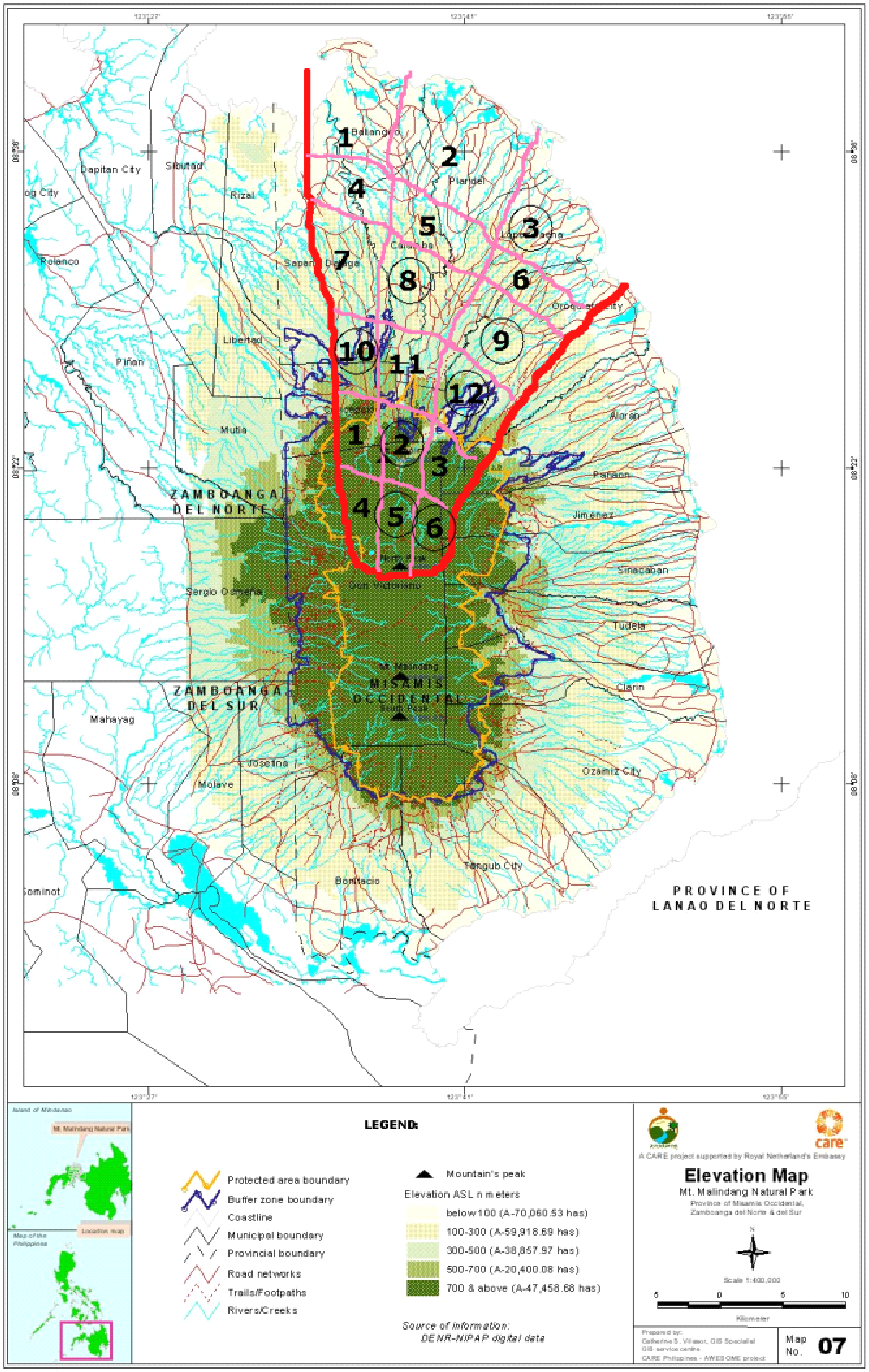

Figure 1. Map showing the selected (circled) grid sections within the catchments or watersheds of Mt. Malindang Natural Park, which have tributaries to the Langaran and Layawan Rivers.

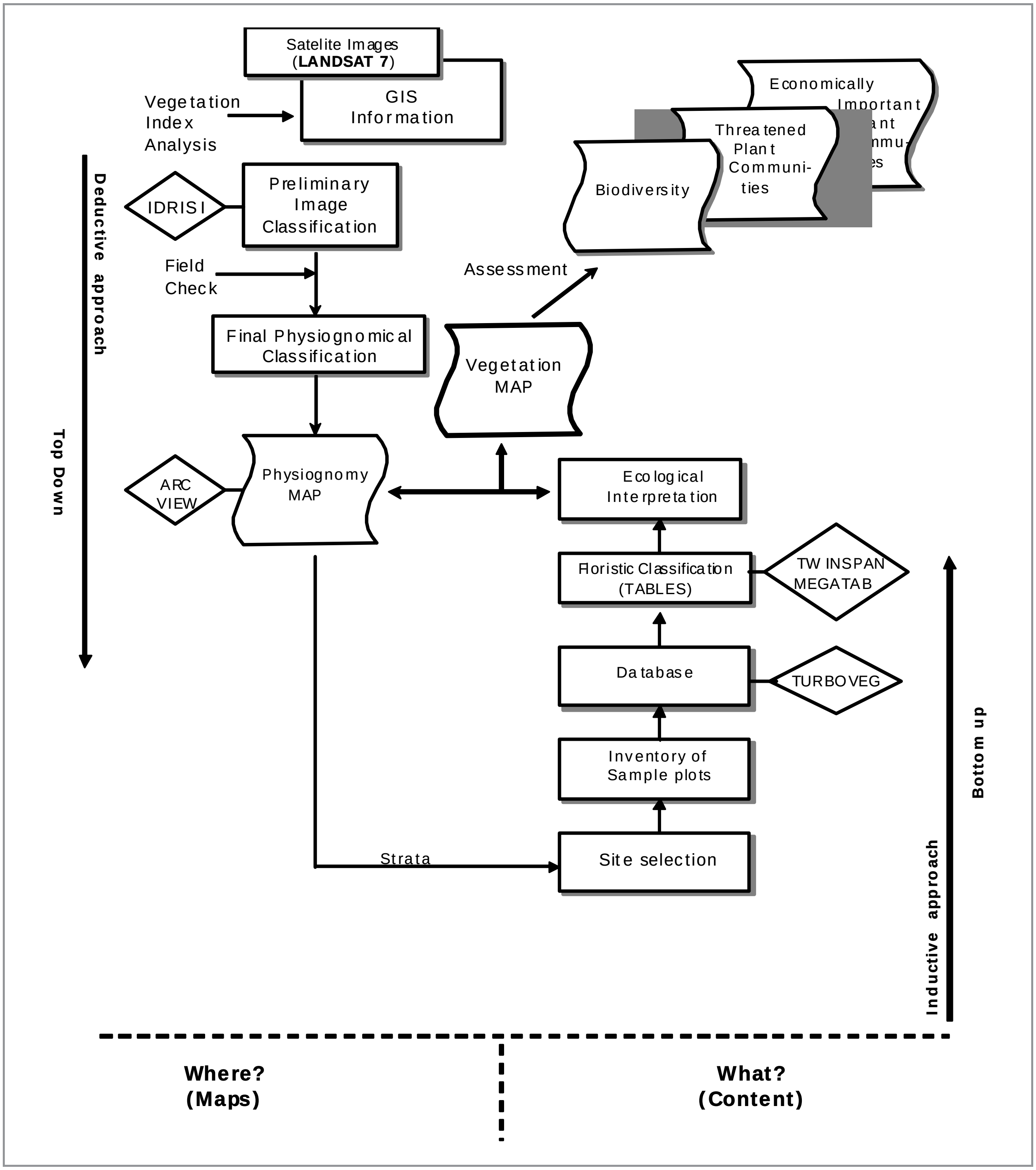

Figure 2. Methodology of vegetation analysis.

Vegetation Strata

Healthy canopies of vegetation have a very distinctive interaction with energy in the visible and near-infrared regions of the electromagnetic spectrum: absorption of energy in the blue and red region of the visible light, and high reflection of energy in the infrared region. Green vegetation indices were calculated through a combination of the visible red and the near-infrared bands of the satellite images. The range of vegetation indices was divided into different strata. The spatial representation of these strata was compared with altitude data. Some of these combinations were assumed to represent mossy forest and montane forest, mixed dipterocarp forest, and agroforestry. The almaciga forest type was based on the predominance of the almaciga species and cannot be detected by biomass/altitude combinations.

Site Selection and Establishment of Sample Plots

Using the LANDSAT 7 imagery maps, the segment of the Mt. Malindang area comprising the Langaran and Layawan Rivers was selected for the field study. The segment was then divided into grids (Figure 1). Sample grid selection for field studies was based on a proportional distribution of the grids over different vegetation strata, representing the elevation gradient, which were found in the image processing of satellite information. The grids contained the sampling sites for the research on the forest ecosystems, the agroecosystems, and the grass-dominated fallowed areas. The choice of the plots within the sites was executed according to the subjective sampling method. Random sampling was not possible due to the limited accessibility of the area.

For the forest ecosystems, different sampling sites were set up on the north and south slopes (within the same grid) because sunlight exposure was considered a relevant ecological factor. The number of sample plots per sample site was six.

For the tree layer, the dimensions of the sample nested plots in the study area were 20 x 20 m. Within the plots, all trees with diameter at breast height (DBH) of 10 cm or more were recorded and their corresponding total heights were measured. Within the plot, a subplot of 5 x 5 m was laid out at a representative location to inventory the tree saplings, shrubs, herbs, pteridophytes, vines, and palms. Inside the 5 x 5 m subplot, a 1 x 1 m quadrat was established to record bryophytes and lichens.

In the agroecosystem, the gardens along the foothills, both in the northern and southern exposures, were observed. The sampling procedure followed was a transect-mosaic approach (random sampling). The gardens along the transect were mapped and numbered on each exposure. Six gardens were selected randomly for sampling: 20 x 20 m, 5 x 5 m, and 1 x 1 m sample plots, subplots, and quadrats. The species and varieties of crops, shrubs, fruit trees saplings and herbs (weeds, grasses, and ornamental plants) were inventoried (Tables 1 and 2).

Altogether, 220 sample plots were established: 133 plots in the agroecosystem and 87 plots in forest ecosystems (15 in mossy forests, 21 in montane forests, 6 in almaciga forests, 12 in submontane-dipterocarp forests, 8 in lowland dipterocarp forests, 12 in mixed dipterocarp forests, 7 in mixed lowland dipterocarp forests, and 6 in plantation forests).

Two Subanen researchers and three Subanen laborers per *barangay* helped establish the plots and conduct inventory and assessment of plant species in the forests and agroecosystems.

Data Input

The vegetation plot data consisted of species information and data variables. Species data consisted of species names found in the plot linked to their corresponding cover-abundance values. Data variables included ecosystem type, plot name, date, altitude, slope, and aspect.

Because the vegetation in the plots were measured and recorded using different methods and scales (DBH measurements, frequency, and cover percentage), the values were integrated into a common simple ordinal scale to make floristic classification possible. Under this method, each species should occur only once in the list and should not appear under different growth forms (e.g., tree and sapling) so as not to disturb the classification procedure, which is based on floristic composition (Tables 1 to 3).

After the recoding of the cover-abundance value, the species information was interactively stored in a database using the software Turboveg. This required input of complete flora list of the Mt. Malindang. The cover-abundance value and the vegetation layer data were added under each species. After the data input, Turboveg was used to make all types of selection, and to transform these selections to output files, which then became ready for clustering.

Floristic Classification

The floristic classification was done with the help of the program TWINSPAN (Hill 1979). This program is a divisive clustering technique that is used worldwide in vegetation

Table 1. Integration of the 20 x 20 m plot data in three classes: trees with 10 cm DBH up including palms, pandan, and tree ferns.

Number	DBH		
	10-20	20-40	>40
1 – 2	1	1	1
3 – 5	1	2	3
6 – 10	2	3	3

Table 2. Integration of 5 x 5 m plot data in three classes: saplings, shrubs, herbs, vines, and pteridophytes.

Number	Class
1 – 3	1
4 – 10	2
> 10	3

Table 3. Upgrading scheme for tree species class due to high presence of saplings.

Number of saplings	DBH		
	10-20	20-40	>40
1 – 3	1 - > 1	1 - > 2	1 - > 3
4 – 10	1 - > 1	2 - > 3	3 - > 3
> 10	2 - > 2	3 - > 3	3 - > 3

research. The TWINSPAN ordering method is based on the mathematical algorithm of reciprocal averaging and results in a new matrix that shows a block structure along the main diagonal line of the matrix. The different blocks represent unique sample-species combinations, which form the basis of the delineation of plant communities that are somehow homogeneous with respect to their species composition.

Final Arrangement and Interpretation of Tables

The phytosociological table produced by TWINSPAN was further organized using Megatab, a program that manually rearranges tables. It can handle a maximum of 24,000 relevées and 5,900 species and can also produce synoptic tables. In addition, it can simplify many technical procedures, such as adding new relevées and combining species, that used to require help from an expert.

Sorting synoptical tables requires use of consistent principles for the classification of the status level of species. Comparing different clusters, a species may be differential for a cluster or group of clusters or not. The following criteria were applied to exclusive differential, selective differential, and preferent differential species:

- Exclusive differential species
  >10% presence in the community and 0% in the other community
- Selective differential species
  Presence in the community >50% and in the other community <25%.
- Preferent differential species have significant higher cover-abundance values in the community as compared with other communities.

Ecological Interpretation

The data variables in the phytosociological table were the first source of ecological information, which can easily be correlated with the detected plant communities. In mountainous areas such as Mt. Malindang, altitude plays a decisive role on the highest levels of classification. At the lower levels of classification (determining variants of communities), altitude, slope, soil type, and water conditions play critical roles.

Vegetation Map: Integration of Classification and Physiognomical Maps

Ecological information obtained through the Geographic Information System (GIS) was used to modify the physiognomical map into a realistic vegetation map.

Borders irrelevant to plant communities were deleted, while, where necessary, new borders were added. For example, in the ecological analysis, when a clear floristic difference was found between north- (315-45^{o}) and south- (125-235^{o}) facing slopes, appropriate borders were added to delineate such changes; the same was done when different forest types were found at different altitudes. Some vegetation types may only occur in very small areas, and therefore not chartable at such a minute scale. In such cases, that vegetation type was usually combined with the adjacent vegetation type into a complex type. Another method was by mapping the small areas (when they are low in number) as point information with symbols.

Data Analysis

Different parameters for measuring the magnitude of floral species diversity were used. These included: (1) relative density, (2) relative frequency, (3) relative dominance, (4) species importance value, and (5) species similarity.

Density (D) - individuals of a species were counted and the density value were derived using the following formula:

$$\text{Density} = \frac{\text{Number of individuals}}{\text{Area sampled}}$$

Relative Density (RD)

$$\text{Relative Density} = \frac{\text{Density of species A}}{\text{Total Density of all species}} \times 100$$

Frequency (F) - the plots in which species A occurred were counted and frequency value were computed using the following:

$$\text{Frequency} = \frac{\text{Number of plots in which species A occurs}}{\text{Number of plots examined}}$$

Relative Frequency

$$\text{Relative Frequency} = \frac{\text{Frequency value for species}}{\text{Total of frequency values for all species}} \times 100$$

Dominance (Cover)

$$\text{Species Dominance} = \frac{\text{Species basal coverage values}}{\text{Area sampled}}$$

Relative Dominance (RD)

$$\text{Relative Dominance} = \frac{\text{Dominance of species A}}{\text{Total Dominance of all species}} \times 100$$

Species Importance Value (SIV) - is a rough and overall estimate of the influence or importance of plant species in the community. The importance value (SIV) was computed using the following:

SIV or ni = RD + RF + Rdom

where: RD = Relative Density
RF = Relative Frequency
Rdom = Relative Dominance

Shanon Index of General Diversity (H)

$$H = -S \left(\frac{ni}{N}\right) LN \left(\frac{ni}{N}\right)$$

where: H = Species diversity
ni = Importance value of species A
N = Total importance value of all species

Similarity Index (SI)

$$SI = \frac{C}{A + B - C}$$

where: C = Number of species present in both sites A and B
A = Number of species present in site A
B = Number of species in site B

Tree Profiling

For tree profiling purposes, the locations of all accounted trees within one of the six 20 x 20 m plots per site (center plot) were determined. For this purpose, the plot was subdivided in smaller plots of 5 x 5 m. The tree species and the number of individuals per species were recorded. Profiling of all trees (10 cm DBH and up) was done at the center plots for the north and the south-facing slope. The trees' DBH, height, crown diameter, position in the plot, association (overlap with other trees), and all other aspects of stand structure were measured. Representative specimens were collected and processed for herbarium specimen vouchers.

Assessment of Conservation Status of Floral Species

Assessment of the conservation status of plant species reveal whether the plants are endangered, endemic, depleted, rare, economically and/or socio-culturally important. The plants were classified according to the definitions provided by the International Union for Conservation of Nature (IUCN), Mace and Stuart (1994), Rojo (1999), Merrill (1926), Zamora and Co (1986), and Statistics on Philippine Protected Areas and Wildlife Resources (2000):

a. Endangered species - actively threatened with extinction; its survival is unlikely without protective measures
b. Endemic species - confined to a certain geographical region or its parts
c. Rare species - not under immediate threat of extinction but occurring in such small numbers or in such localized or specialized habitats that it could quickly disappear if the environment worsens
d. Depleted species - although sufficiently abundant for survival, the species have been nearly depleted and in decline as a result of natural causes or human activities
e. Economically-important species - based on known uses.

Based on the conservation status assessment of the plant species, the list of threatened species was prepared. A separate list of locally-threatened species was likewise prepared based on the number of individuals per plot. The lists were merged and compared to the list of species used by the people, as determined by the SECS team. The usage intensity of the species was calculated from household to community level. This information indicated the pressure the demand of the species exerted on the resource base.

Status of Indigenous Knowledge within the Community

Indigenous knowledge (IK) on phenomenal occurrences, beliefs, and local species indicators were extracted from the locals in several *barangays* using focused group discussions (FGDs) and key informant (KI) interviews. Instances, like flowering and fruiting of certain species which indicate certain phenomena, position of the moon that indicate appropriate planting date of crops, activities of some insects that indicate drought and heavy rains and the like, as well as religious beliefs on how trees are to be treated and when to plant crops were included.

KI information from both the flora data and the SECS data were synchronized using scientific/technological knowledge. The results and insights served as inputs to the formulation of floral diversity monitoring and conservation practices.

Biodiversity Monitoring and Evaluation System (BIOMES)

The instrument for biodiversity monitoring and evaluation was developed by Central Mindanao University and the Bukidnon Resource Foundation (BRF), Incorporation. A training-workshop was held involving the members of the community monitoring teams, TEMP researchers, and participants. A training manual on Biodiversity Monitoring and Evaluation (BIOME) System was developed consisting of ten modules.

Training-Workshop on Taxonomic Techniques

A training on taxonomic techniques was conducted to teach local researchers inventory techniques, grouping of plants by habit (tree, shrub, herb, and vine) and taxonomic grouping (bryophytes, lichens, ferns and fern allies, gymnosperms, and angiosperms). The participants were also taught proper documentation, collection, and pressing of specimens for herbarium vouchers.

RESULTS AND DISCUSSION

Vegetation Types and Plant Communities

Mt. Malindang Range Natural Park, with a total surface area of 53,262 ha, has been a protected area since 2002. The remaining forest, covering approximately 33,000 ha, is still a natural tropical rain forest. The forest covers the higher portion of the mountain (up to 2,475 m) and the steep slopes at lower altitudes. The forested area declined dramatically during the last decades (Figures 3 and 4).

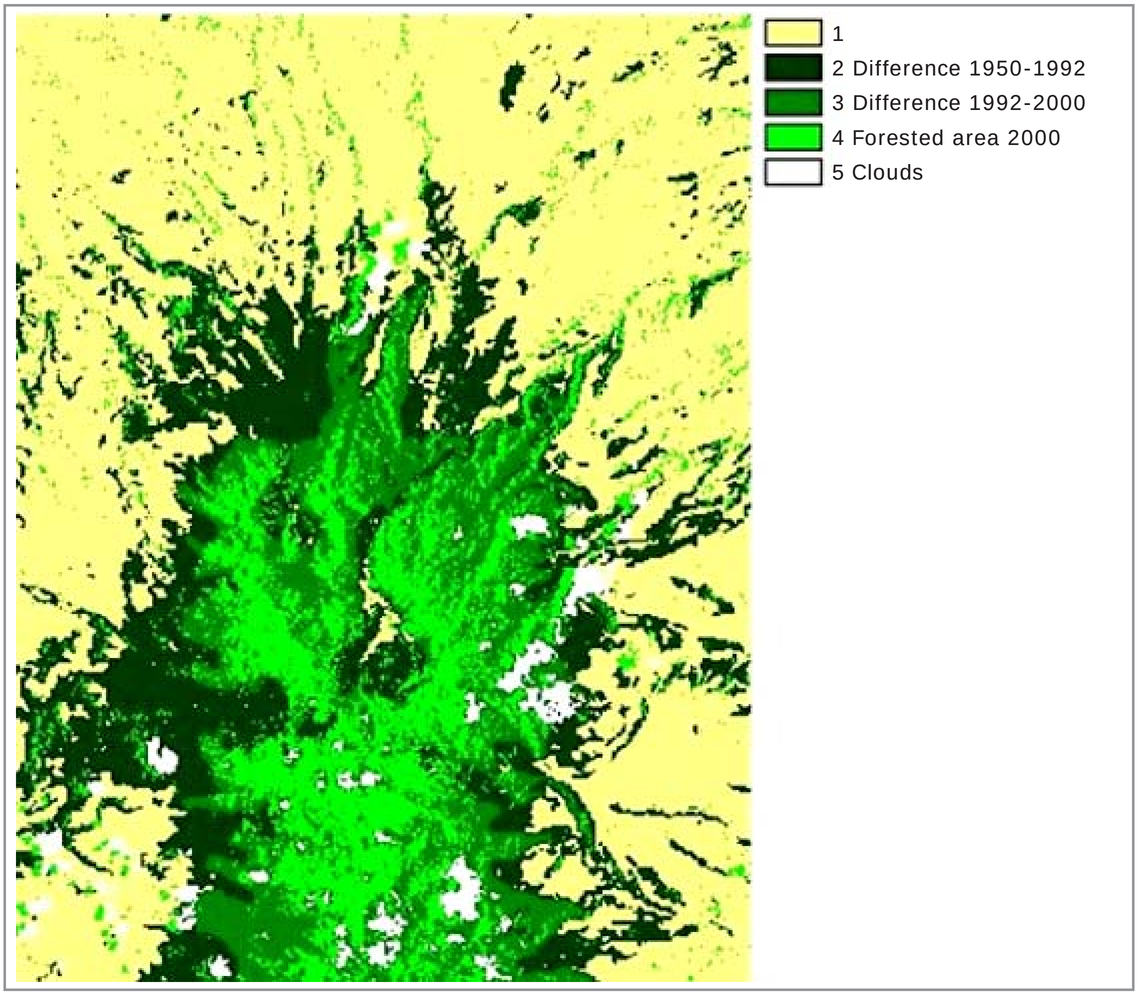

Figure 3. Map showing the decline in forest cover in Mt. Malindang Natural Park from 1950 to 2000.

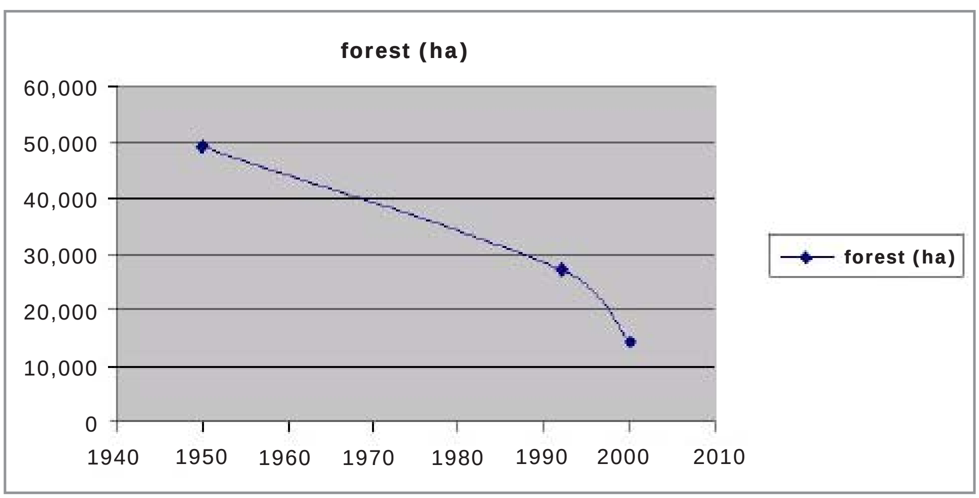

Figure 4. Drastic decline in forest cover of Mt. Malindang Natural Park from 1950 to 2000.

Analyses of maps and satellite images revealed that forest decline still continue, especially on the more accessible sites. The decline was attributed to rampant shifting cultivation.

Plant Communities

Classification of 87 relevées of the forest area showed two different groups of vegetation types, which had only few species in common. The first group comprised mossy forests and montane forests, both above 1,400 meters above sea level (masl). The second group was that of forest communities occurring below 1,400 masl. This included the submontane forests (almaciga and dipterocarp), colline (mixed dipterocarp and plantation forests), and lowland (lowland dipterocarp and mixed lowland dipterocarp forests) (Table 4 and Figure 5). The colline and lowland forests were fragmented and occurred predominantly on steep slopes and were not accessible for farming. Aside from forests area, there was an arable area located at 1,400 m asl, below the agroecosystem (Table 4). This was planted with vegetables, cereals, and agroforestry species, but a larger portion was permanently occupied by grass-dominated fallowed areas.

Mossy and Montane Forests

The mossy and montane forests had several species in common, the most frequent of which were *Plagiogyria pycnophylla, Elaeocarpus calomala, Mastixia premnoides*, and *Macaranga dipterocarpifolia*. The last species was also present in forests at lower altitude. A group of species occurred both in the montane forest and on the southern slopes of the mossy forest. Examples of these were *Lithocarpus philippinensis, Polyosma philippinensis,* and *Racophyllum spectabile*. Many species had adapted to high zones in the mountain, except the northern slopes with higher altitude. This also applied to species that appeared only on southern slopes in both forest types, e.g., *Cinnamomum mercadoi* and *Meteoriopsis squarrosa*.

Mossy Forest: Ascarina philippinensis - Xanthomyrtus diplycosifolium Community

Diagnostic Species

Aside from the endemic *Ascarina philippinensis* and *Xanthomyrtus diplycosifolium,* the community was characterized by four additional species, namely, *Ilex* sp., *Phyllocladus hypophyllus, Elaeocarpus calomala,* and *Dacrycarpus cumingii*. The latter two species were present in the montane forest at lower density.

Structure and Vegetation Profile

The mossy forest was characterized by the presence of small trees with proproots and aerial roots coming out from one to a few meters from the base of irregularly shaped tree trunks. The presence of proproots indicated the adaptation of trees to steep slopes, which was prevalent in this zone. The proproots seek new resources of nutrients in crevices, and the aerial roots give extra support to the growing tree. As in other mossy forests in the Philippines, the trees were dwarfed and their trunks gnarled, especially those that grew near the mountain peak, due to strong wind pressure. Compared with those in montane forests, the trees were shorter by 10-20 m. The tree layer was also relatively denser (75-85% cover). The canopy layer was composed of the two dominant plant species. The branches and trunks of trees and the forest floor were largely covered with mosses, thus the name mossy forest.

Subdivision

The *Ascarina philippinensis - Xanthomyrtus diplycosifolium* community was divided into two variants according to slope aspect. The variant on the southern slope was richer in species and contained more endemics. Among the differential species (not found in forests on the northern slopes) present were three species of mosses, *Aerobryum speciosum, Lopidium strithiopteris,* and *Meteorum subpolytrichum;* an endemic vine, *Freycinatia multiflora;* and an endemic tree, *Dacrydium elatum*.

Floristic Diversity

The number of plant species per plot varied. The communities on the north-facing slopes had lower species richness (21 per plot), compared with the south-facing slopes (more than 30 species per plot). The number of endemic species recorded for these slopes were five and nine, respectively (Table 5 and Figure 6). It had a diversity index of 1.85 (Figure 7). A total of 256 species had been recorded in this community, from which more than half belonged to ferns (pteridophytes) and mosses (bryophytes), plants typically adapted to grow in moist places. This forest type was characterized by high plant diversity, i.e., high species richness and endemism, many of which were economically important species. The number of threatened species was relatively low.

Ecology

The mossy forest, usually found at altitudes ranging from 1,700 to 2,450 masl, is also known as the cloud belt, due to the persistence of clouds (Brown 1919). Relative moisture and rainfall were highest compared to other forest ecosystems. Due to the high precipitation and leaching, soils were usually acidic (pH 4.6-5.1). The slopes could go as steep as 75°.

Distribution

The *Ascarina philippinensis - Xanthomyrtus diplycosifolium* community was observed in Mt. Peak Tandayan and Mt. Guinlajan in Barangay Lake Duminagat, Don Victoriano, Misamis Occidental. Mt. Peak Tandayan, commonly referred to as North Peak, is also a mossy forest (zonal forest type above 1,700 m) and covers almost the entire area in the altitudinal belt.

Land Use

The mossy forest stabilize the hydrological regime and local microclimate, and protect the soil from erosion. It also provide the local people with food and medicines (from plants and animals) that were scarce or unavailable in the lowland. The average number of species that provided non-timber forest products (NTFP) was 11 per plot.

The mossy forest remained relatively intact, except in the mountain peaks where the ground cover vegetation was damaged due to trampling of occasional campers. Selected sites in the mossy forest of Mt. Guinlajan also remained intact because they are considered sacred and are used by the Subanens for religious ceremonies.

Montane Forest: Clethra lancifolia - Impatiens montalbanica Community

Diagnostic Species

The *Clethra lancifolia - Impatiens montalbanica* community was characterized by 10 tree species restricted to this forest type. Some of them were *Clethra lancifolia, Ficus glandulifera*, *Ficus septica,* and *Melicope confusa.* Although these species differentiate the montane forest from the mossy forest, they may also occur at low densities in the mixed dipterocarp forest at lower altitudes. Among the typical and frequent herbaceous species of this community were *Impatiens montalbanica*, *Marattia sylvatica,* and *Trichomanes pallidum*. However, *Lithocarpus philippinensis* and *Macaranga dipterocarpifolia* were the two most dominant tree species.

Structure and Tree Profile

The montane forest was characterized by trees taller (on the average) than those observed in the mossy forest. The height of the tree layer was 30-35 m and with 90 percent species crown cover. Trees with big trunks were also found here. *Lithocarpus philippinensis, L. mindanaensis, and Mastixia premnoides* were endemic species that had the largest canopy cover. The shrub layer did not grow more than 5 m and with 10 to 15 percent cover. The moss layer was less conspicuous than in the mossy forest.

Subdivision

Just like the mossy forest, the montane forest community was divided in two variants: a species-rich variant on the south-facing slopes, and a floristically less developed variant on the north-facing slopes. A group of about 20 species characterized the south slope variant, though individual plant presence was relatively low. The diagnostic feature of the south variant group was its lower number of species and lesser density.

Floristic Diversity

The communities on the north-facing slopes were less abundant in species (24 per plot), than on the south-facing slopes (29 species per plot). The number of endemic species was very high on both slopes, with 10 species on the average. Only the almaciga forest, which occurred only in small patches, contained the highest number of species and endemics (Table 5 and Figure 6). In total, 263 species have been recorded from the plots in the montane forest; nearly half of the taxa were ferns (pteridophytes) and mosses (bryophytes), both plant groups that prefer dark and moist places. This vegetation had a very high plant diversity based on species richness and endemism (Figure 6) and with a diversity value of H=2.0; it was considered the highest among vegetation types (Figure 7).

Ecology

The montane forest was situated at an altitude of 1,400 to 1,700 masl. Relative moisture and rainfall were also high in these parts. The slopes were considerably less steep than in the mossy forest, with an average of 30° as compared to 60° in the mossy forest. Soil pH in the montane forest was somewhat higher, indicating that they were less acidic.

Distribution

The communities were observed in Mt. Ulohan sa Dapitan in Barangay Lake Duminagat and Mt. Pungol in Barangay Gandawan.

Land Use

Since the lowland forests had mostly disappeared, the lower montane forest became the most important source of non-timber forest products, such as wild food plants, firewood, building materials, round wood, and medicines, for local people. The number of economically important species was higher in the montane forest than elsewhere because lower slopes of the forest had been increasingly converted to agricultural land and cash crops plantation. Fifteen NTFP species were found on both the south- and north-facing slopes.

Almaciga Forest: Agathis philippinensis - Cinnamomum mercadoi Community

Diagnostic Species

The almaciga forest was the best identified plant community of Mt. Malindang due to the presence of large number of characteristic species, many of which were endemic and threatened. Samples of these were: the constant character species *Agathis philippinensis, Cinnamomum mercadoi, Astronia cumingii,* and *Ziziphus angustifolius.*

Structure and Tree Profile

The almaciga forest was characterized by 90 percent dominance of the tree species *Almaciga philippinensis,* the largest (180-230 cm in diameter) and the tallest (35-45 m in height). Although threatened and endemic, it had the highest canopy cover. Another frequent species was *Syzygium* sp. The herb layer covered 50 to 60 percent of the forest. The shrub layer was patchy, covering only five percent and did not grow higher than 3 m.

Floristic Diversity

Communities of these forests were the most rich in species (33 per plot) compared to all other forest types in Mt. Malindang (Table 4). They occurred only in small patches. The number of endemic and threatened species was on the average 13 and six, respectively (Table 5). A total of 157 plant species were recorded in the plots, dominated by flowering plants (angiosperms), half of the taxa were identified as ferns (pteridophytes), and less were mosses (bryophytes). The forest had a high diversity value of 1.97 and extremely high plant diversity based on species richness, endemism, and threatened species as compared to other forest vegetation types (Table 5 and Figure 6).

Ecology

This submontane forest was found to be between 1,200-1,400 masl. The moisture and rainfall were relatively high. The slopes (20° on the average) were less steep as compared with the submontane dipterocarp and lowland forests, with slopes of almost 50° and 65°, respectively. It also occured on different rock types: andesite, porphyritic andesite, and scoria. Soil pH was low or acidic: averaging 4.7; soil texture was that of clayloam, which explained the high moisture content.

Distribution

This community was observed in the southeastern side of Barangay Sebucal.

Land Use

Almaciga forest is an important source of NTFP, such as building materials, firewood, and, most importantly, resins from the bark of *Agathis philippinensis*. This forest help in protecting the soil from erosion and stabilize the local microclimate, which had a high biomass. However, because of their accessibility to the local communities, the forests are greatly threatened. Cutting of old-growth almaciga for house construction and heavy collection of resins from the trunks were observed.

Submontane Dipterocarp Forest: Ficus minahassae - Bischofia Community

Diagnostic Species

The *Ficus minahassae - Bischofia* community in submontane dipterocarp forest was characterized not only by the abundance of *Ficus minahassae* and *Bischofia,* but by many other species, most of them in low presence. This forest was also strongly differentiated against almaciga forests by *Shorea polysperma* (threatened, endemic, and economically important). Constant species found were *Shorea mindanaensis, Meliosma* sp., *Palaquium luzoniense* (all threatened, endemic, and economically important), and *Vavaea amicorum*, all of which occurred also in almaciga forests and some (*Shorea mindanaensis* and *Meliosma* sp.) in colline forests. The community contained a large number of character species; many NTFP species and endemic plants were also observed (Table 5).

Structure and Tree Profile

The forest type had distinct layers: a canopy layer consisting of tall trees with big buttresses, like *Shorea polysperma, S. mindanaensis,* and *Ficus* sp., covering 60 to 75 percent. The buttresses extended to about a meter from the tree and its function was to support it. The other layers were made up of smaller trees, shrubs, climbing bamboos, palms, vines, and several species of *Freycinetia* twining around the tree branches.

Floristic Diversity

The communities of the submontane dipterocarp forests were also very rich in species (28 per plot) (Table 5). The number of endemic and that of threatened species were high as well, with eight and six species on the average, respectively; with a diversity value of 1.91 (Figure 7). A total of 219 plant species was recorded in the plots, dominated by flowering plants or angiosperms (Table 8). The number of ferns (pteridophytes, 20%) and that of mosses (bryophytes) were considerably lower than in the forests of higher altitudinal belts.

Ecology

The submontane forest was found at an altitude ranging from 900 to 1,100 masl. Moisture and rainfall in this kind of forest were not as high as in other forest communities mentioned. The community thrived on very steep slopes, with a 50° average, with sandy loam soil and andesite type of rocks. Soil pH was less acidic (6 on the average) than in the almaciga forests.

Distribution

This forest was observed only in Mt. Capole in Barangay Sebucal, Oroquieta City.

Land Use

The submontane dipterocarp forest is an important source of forest products, such as food, firewood, building materials, timber, and medicines, for the local people. In addition, the dipterocarp forest stabilize the hydrological regime, protect the soil from erosion, and stabilize the local microclimate in the forest. The lower parts of the submontane dipterocarp forests had been logged in the past and/or converted to other land uses, such as agricultural fields and plantations.

Lowland Dipterocarp Forest: Ficus variegata - Selaginella moellendorfii Community

Diagnostic Species

The lowland dipterocarp forest was characterized by a group of 12 species, which occurred in low presence, e.g., *Ficus variegata, Selaginella moellendorfii*, the endemic *Macaranga grandifolia,* and the threatened *Toona calantas*. The community was less rich in species (20 per plot) and endemics (Table 5) compared to the montane dipterocarp forests. Important constant tree species in this community were *Knema glomerata, Shorea contorta,* and *Shorea mindanaensis,* all endemic, threatened, and economically important.

Structure and Vegetation Profile

This forest was characterized by tall dipterocarp trees, which also occurred in the submontane dipterocarp and mixed dipterocarp forests. This tree layer of 20-25 m high covers about 60 percent.

Floristic Diversity

The number of plant species in the communities of the lowland dipterocarp forests was relatively low. Endemism was also low (Table 5). A total of 144 plant species were recorded in the plots with a diversity value of 1.87 (Figure 7).

Ecology

The lowland dipterocarp forest was a secondary forest type. Its stands occurred in patches located at altitudes ranging from 220 to 500 masl. Moisture and rainfall were less compared to that in the submontane dipterocarp forest. Both forests types were found on slopes adjacent to the Layawan River. The slope where the lowland forest was found was less steep than that of the other forest types (25° on the average) and the soil consisted mainly of sandy loam. Soil pH was moderately acidic (5.5 on the average), which was approximately equal to the pH in the submontane dipterocarp forest.

Distribution

This forest was observed in Barangay Mialen, Oroquieta City and Barangay Mamalad, Calamba, Misamis Occidental.

Land Use

The secondary forest type was found in patches as a result of logging. *Kaingin* and shifting cultivation further reduced the area occupied by the forest community. In addition, forest products, such as firewood, building materials, and timber, were continuously extracted from the forest causing the deterioration of the remaining habitat.

Mixed Dipterocarp Forest: Syzygium - Sticherus laevigata Community

Diagnostic Species

The mixed dipterocarp forest in the Mt. Malindang area was represented by the *Syzygium - Sticherus laevigata* community. This community was typified by a large group of more than 20 character species, from which *Syzygium* was constant. A threatened endemic species within this group was *Arthocarpus blancoi*. *Hydrangea chinensis* was endemic as well, but this shrub was also observed at higher altitudes in the montane forests with low presence. *Shorea palosapis,* an endemic and threatened tree species, was constant in the community, but also occurred at a lower presence in the lowland dipterocarp forest. Species richness was more or less equal to the lowland dipterocarp: 19 per plot. Many trees within this community were NFTP species.

Structure and Vegetation Profile

The mixed dipterocarp forests were the remaining patches of the original natural forests (Figure 6). The trees had buttresses and produced proproots for support, an adaptation feature of plants growing on steep slopes. The growth form was characteristic of *Syzygium*. The height of the tree layer ranged from 25 to 30 m, covering about 70 percent. The canopy species included: *Lithocarpus* sp., *Shorea palosapis* (threatened and endemic), and *Caryota cumingii* (endemic). The herb layer species with high presence was the fern *Sticherus laevigata,* which usually grow in open areas. With its long creeping rhizomes and extensive roots system, it can be useful in preventing soil erosion.

Floristic Diversity

The diversity of this forest community was more or less the same as that of the lowland dipterocarp forest. The colline forest plots contained a total of 181 recorded plant species. The number of threatened species was high (3 species), and the number of endemic species was moderate (Table 5). The ferns and other herbaceous plants were less represented in this community.

Ecology

This forest type was located at an altitude ranging from 450 to 900 masl. The moisture and rainfall were less compared to the other forest types. The slopes were quite steep (40° on the average). The soil consisted of sandy loam. Soil pH was acidic (averaging 4.5).

Distribution

This forest was observed in Barangay Bunga, Oroquieta City; Barangay Peniel, Lopez Jaena; and Barangay Mamalad, Calamba, Misamis Occidental.

Land Use

The forest was found in patches due to logging. It could be expected that continuous cutting down of trees for firewood, building materials, and wood timber in the remaining forest would further reduce the area. Cultivation in this forest was not possible due to its steep slopes.

Lowland Mixed Dipterocarp Forest: Diplodiscus paniculatus - Lithocarpus spp. Community

Diagnostic Species

Lowland forest on steep slopes was assigned to the *Diplodiscus paniculatus - Lithocarpus* spp. community. Species richness was relatively low compared to other colline forests (16 per plot) (Table 4). The group of character species represented mainly trees, which were classified as NFTP species and one endemic palm species (*Caryota cumingii*).

Structure and Vegetation Profile

This community was observed as patches of remnant natural forest with a low tree layer (height of 20 to 25 m), covering about 55 to 60 percent. The canopy species observed were *Lithocarpus* spp. and *Shorea* sp. *Lygodium auriculatum* and *Homalomena philippinensis* were dominant in the herb layer.

Floristic Diversity

Species richness was relatively low compared to other dipterocarp forests (Table 5); this was reflected in a low diversity value of 1.56 (Figures 6 and 7). A total of 97 plant species in the plots were recorded. The low species richness and diversity may be due to the steepness of the area.

Ecology

This lowland forest type was located at an altitude ranging from 220 to 450 masl. The recorded moisture and rainfall were less than in the other forest communities. The slopes were very steep (65° on the average), and rocky since the parent material was mainly sandy loam.

Distribution

The forest was observed in Barangay Toliyok, Oroquieta City.

Table 4. Vegetation types and floral communities with their location, altitudinal ranges, and sites.

Vegetation Type		Plant Community	Location	Altitude (masl)	Site / Subsite
I.	Mossy forest	*Ascarina philippinensis - Xanthomyrtus diplycosifolium* community	North Peak, Lake Duminagat Mt. Guinlajan, Lake Duminagat	1,800-2,185 1,700-1900	1 (1, 2) 2
II.	Montane forest	*Clethra lancifolia - Impatiens montalbanica* community dominated by *Lithocarpus philippinensis*	Mt. Ulohan sa Dapitan, Lake Duminagat Mt. Pungol, Gandawan	1,450-1,700 1,400-1,600	3 (1, 2) 4
III.	Almaciga forest	*Agathis philippinensis - Cinnamomum mercadoi* community	Old Liboron	1,200-1,400	9
IV.	Submontane dipterocarp forest	*Ficus minahassae - Bischofia javanica* community	Mt. Capole, Sebucal	900-1,100	5 (1, 2)
V.	Lowland dipterocarp forest	*Ficus variegata - Selaginella moellendorfii* community	Mialen and Mamalad	220-500	3 (1, 2) and 16
VI.	Mixed dipterocarp forest	*Syzygium - Sticherus laevigata* community	Peniel and Mamalad	450-900	11 and 16
VII.	Mixed lowland dipterocarp forest	*Diplodiscus paniculatus - Lithocarpus* sp. community	Toliyok	220-450	15 (1, 2)
VIII.	Plantation and degraded forest	*Acacia mangium - Cocos nucifera* community	Peniel and Bunga	120-900	11 and 19
IX.	Agroecosystem	Vegetables: *Sechium edule - fistulosum* community	Mansawan, Gandawan, and Lake Duminagat	>1,000	6, 7, and 8
		Cereals: *Oryza sativa - Zea mays* community	Sebucal, Mialen, Toliyok, Bunga, and Peniel	<1,000 <1,000	10, 12, 14, 17, and 20 14, 17, and 20
		Agro-forestry: *Cocos nucifera - Lansium domisticum* community	Mialen, Toliyok, and Bunga	>1,000	6, 7, and 8
		Grass-dominated fallowed areas: *Cyathea* spp. - *Paspalum conjugatum* community	Mansawan, Gandawan, Lake Duminagat, Sebucal, and Peniel	<1,000	10 and 12

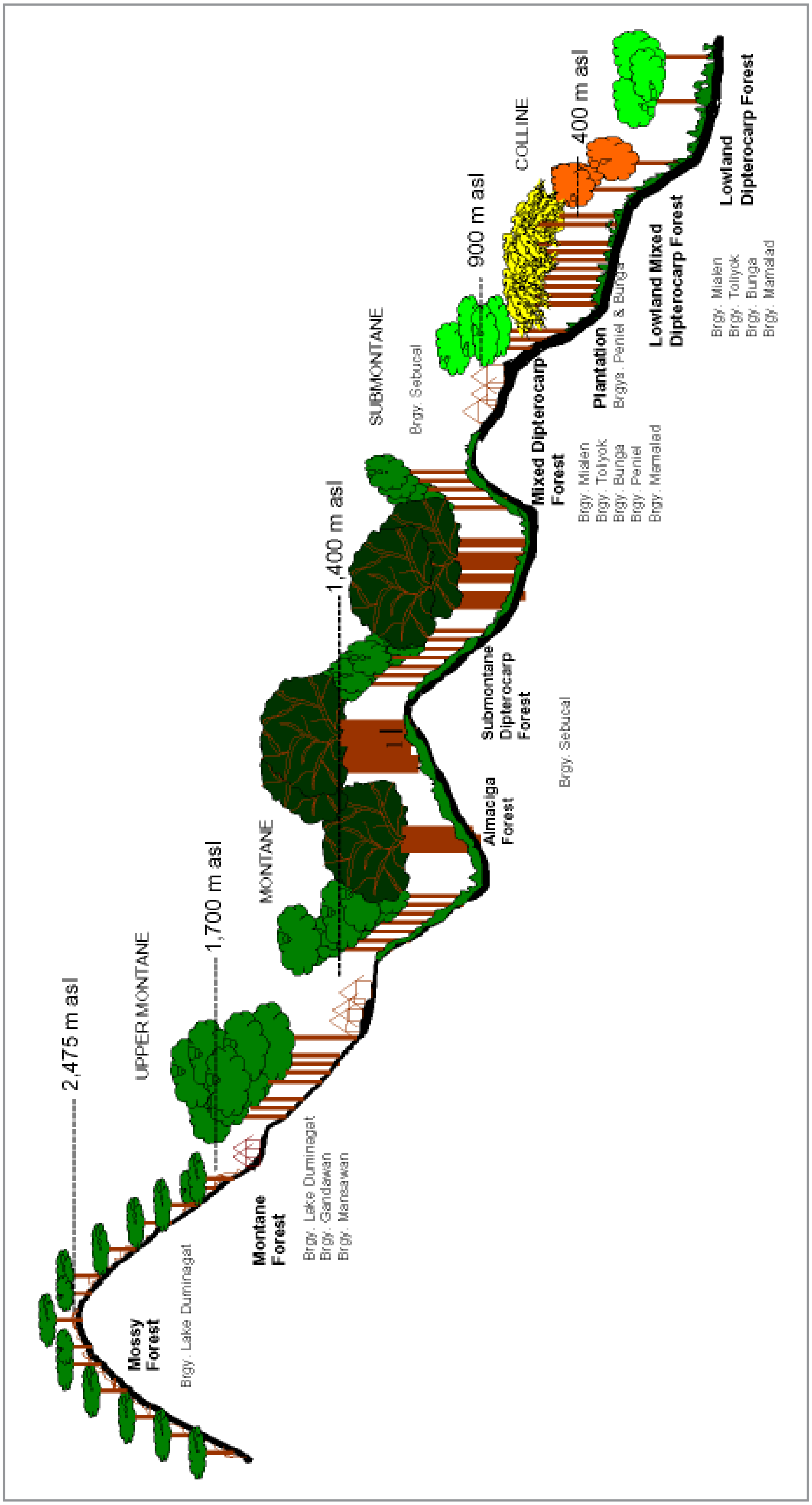

Figure 5. Transect diagram of the different forest ecosystems in Mt. Malindang Range Natural Park.

Table 5. Biodiversity values in the different ecosystems.

Vegetation	Species Richness	Rank	Endemism	Rank	Threatened	Rank	Economic	Rank	Mean
Mossy - N	20.8	II	4.8	II	0.66	I	10.6	III	2.5
- S	30.8	IV	8.5	III	0.66	I	11.1	III	3.2
Montane - N	23.9	III	9.45	IV	0.61	I	12.8	IV	2.75
- S	29.1	IV	10	IV	0.75	I	14.9	V	3.2
Almaciga	32.7	V	12.8	V	5.8	V	13	IV	4.75
Dipterocarp submontane	28.0	IV	7.6	III	5.8	V	11.2	III	3.5
Dipterocarp lowland	20.3	III	5.2	II	4.0	IV	9.6	II	3
Mixed dipterocarp	19.4	II	4.5	II	2.5	III	8.8	I	2
Mixed lowland	15.7	I	2.7	I	1.1	II	9.7	II	1.5
Plantation	11.2	I	2.2	I	0.67	I	8.2	I	1

Legend:
N – North facing slope
S – South facing slope

Rank
I Low
II Moderate
III High
IV Very high
V Extremely high

Mean
1-1.5 = low biodiversity
1.6-3.0 = moderate biodiversity
3.1-4.5 = high biodiversity
4.6-6.0 = extremely high biodiversity

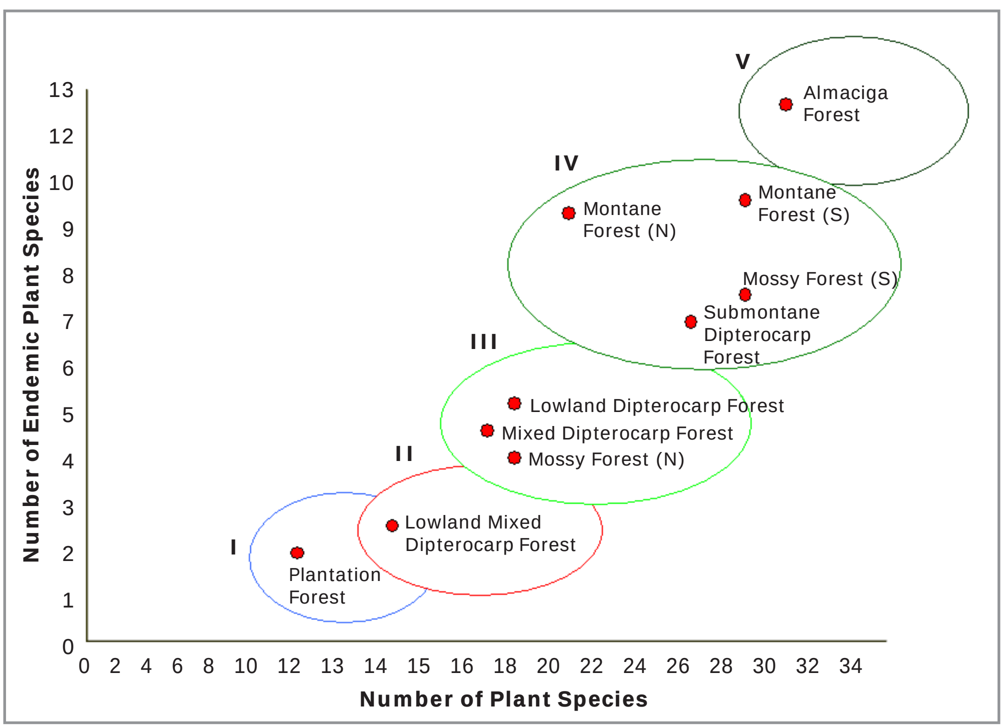

Figure 6. Biodiversity values in the different forest ecosystems.

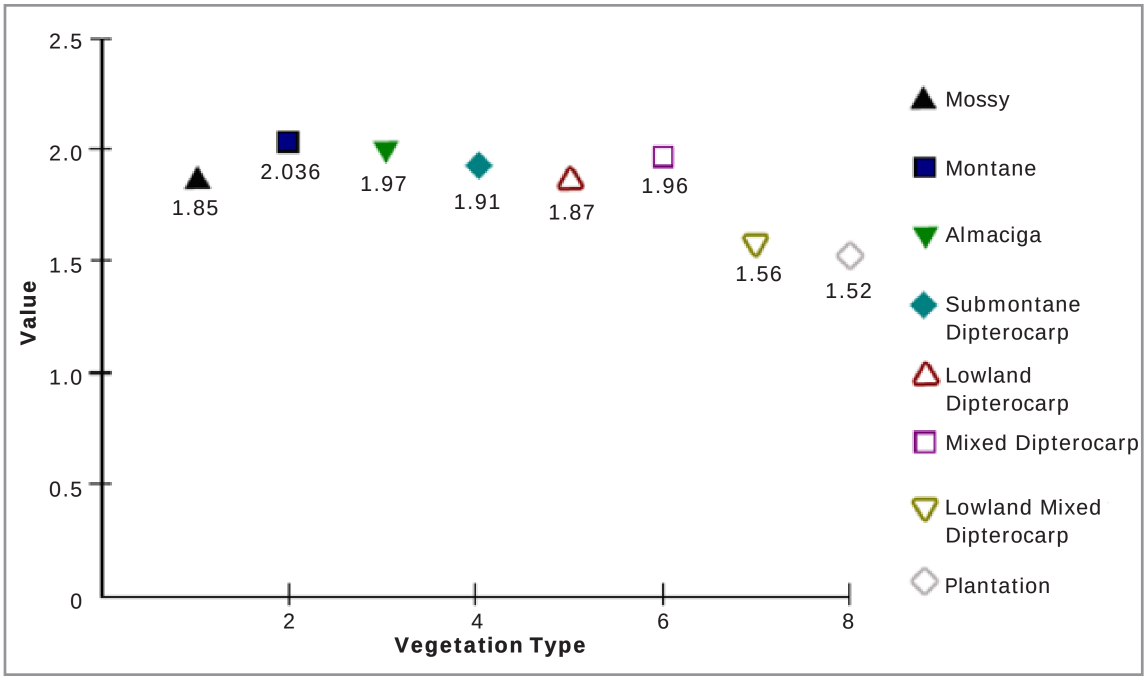

Figure 7. Index of diversity among vegetation types.

Land Use

Only remaining patches of forests were observed on very steep, impracticable slopes. Shifting cultivation and cutting down of trees (for firewood, building materials, and timber) were observed in less steep areas.

Plantation and Degraded Forests

Diagnostic Species

Plantation and degraded forests were characterized by cultivated trees, like *Acacia mangium* and *Cocos nucifera,* and weeds, e.g., *Imperata cylindrica* and *Chromolaena odorata.* This community obtained the lowest species richness (11 per plot) of all forests types (Table 5).

Structure and Vegetation Profile

The plantation forest was characterized by a tree layer of planted species which were 15-20 m tall, covering 75 to 80 percent. The forest floor was covered by *Imperata cylindrica* and *Paspalum conjugatum.*

Floristic Diversity

Plantations had the lowest species richness compared to the other forest types. A total of 61 plant species were recorded in the plots, from which only 30 percent were trees and 50 percent were herbs species. This vegetation type had the lowest plant diversity based on species richness and endemism. Compared with the other vegetation types, it also obtained the lowest diversity value of 1.52 (Figures 6 and 7).

Ecology

Plantation forests were found at an altitude ranging from 120 to 900 masl with low rainfall. The slope was 30° on average. Soil pH was acidic (averaging 4.5).

Distribution

This forest was located in Barangay Peniel, Calamba Misamis Occidental.

Land Use

The estimated area planted with *Acacia mangium* was about 300 to 400 ha. The plantation forest was about five years old, and initiated by the military officials and their personnel as part of their civic action program. The initiative had since been transferred to *barangay* officials. Another major plantation crop was *Cocos nucifera,* a local source of cooking oil.

Agroecosystems

Diagnostic Species

The agroecosystem was typified by seeded or planted vegetables like *Brassica oleracea, Sechium edule,* and *Allium fistulosum* (cabbage, chayote, and green onions) and cereals like *Oryza sativa* and *Zea mays* (rice and corn). For agroforestry, there were *Cocos nucifera* (coconut) and *Lansium domesticum* (lanzones). Grass-dominated fallowed areas (*Cyathea* spp. and *Paspalum conjugatum*) were part of the characteristics of the agroecosystem.

Structure

Crops, like vegetables, cereals, and agroforestry species, dominated the agro/agricultural ecosystems. These agricultural crops were also interspersed by herbs (grasses/weeds/ferns); a few trees/saplings: *Melicope confusa*, *Bischofia javanica*, *Lithocarpus* sp.; and shrubs: *Melastoma malabatricum*, *Saurauia elegans* (endemic), and *S. involucrata* (endemic), which were forest remnant species. The high number of tree saplings and fallen logs were evidence that farmers of Barangay Lake Duminagat recently burned the natural forest.

Floristic Diversity

A total of 73 cultivated crop species were recorded (Tables 9 and 10, Figures 8 and 9): 24 species and 74 varieties were vegetable crops, 23 were fruits crops, seven were plantation crops, five were cereal and grains, eight were ornamentals, and six species were industrial plantation crops. More number of weed species were found at higher elevations (>1,000 masl) than in lower elevations, possibly due to cooler environment and farming practices of multicropping with annual crops. At lower elevations (<1,000 masl), the practice of intensive cultivation resulted to lesser weed diversity. Agroforestry farming systems were also found.

Ecology

The agroecosystems were found at an altitude ranging from 150 to 1,400 masl. At high altitudes, there were lower temperature (20.62°C to 22.75°C) and higher precipitation (8.75 cm/day in Mansawan, Gandawan, Lake Duminagat, Sebucal, and Mialen). Climate was warmer at low altitudes (temperature 26.93°C), with less precipitation (4.09 cm/day in Toliyok, Bunga, Peniel, and Mamalad). The slopes ranged from 5° to 30°. The parent soil material was predominantly sandy loam; the soil-pH was acidic (averaging 5).

Distribution

The agroecosystem was located in all *barangays* covered by the research.

Land Use

Barangays Mansawan, Gandawan, and Lake Duminagat are suitable places to grow vegetables and root crops. Cabbage was the major cash crop, but problems on pest and diseases reduces the yield. Corn was a primary cereal crop raised by the farmers in all *barangays*, while rice was favorably grown in both upland and lowland areas in Oroquieta City, Lopez Jaena, and Calamba. Sebucal, being the innermost and remote *barangay* of Oroquieta City, grow cereals (upland rice, corn), root crops and fruit crops like cassava, *kanaka*, and banana, mainly for subsistence (Figure 8).

Barangays Mialen, Toliyok, and Bunga in Oroquieta City are more advantageous, having favourable soils and climate for growing fruits and cash crops (Figure 8). Different varieties of fruits like lanzones, coconut, *marang*, durian, *rambutan*, and bananas were grown in the *barangays*. Some vegetables were also grown as intercrops (Figure 9). Abaca, which grows well under the coconuts, provided additional income to the farmers who earned money by working as laborers, and by fishing and hunting.

Species Richness/Floristic Diversity

Inventory of the plant species in all research sites (sampling plots and transect walk) revealed a total of 1,284 species, 472 genera, and 187 families. Among the group of plants, 873 species were classified as angiosperms, 20 as gymnosperms, 283 as pteridophytes, 85 as bryophytes, and 26 species as lichens (Table 6). The percentage of angiosperms, gymnosperms, and pteridophytes was comparatively higher than the percentage reported by Tabaranza *et al.* (2001) and Arances *et al.* (2004). For pteridophytes alone, the number of species recorded represented about 44 percent of the 632 species found in Mindanao (Amoroso 2000). On the other hand, Zamora and Co (1986) reported that 33 species of gymnosperms in the Philippines and 20 species (60%) were found in Mt. Malindang. However, at the time this study was conducted, many species still remained unidentified.

The *barangay* with the highest species richness was observed in Lake Duminagat and Sebucal (Table 7). The high species richness had been attributed to the presence of three mountains with two forest types (mossy and montane) in Lake Duminagat, namely, Mt. Ulohan sa

Dapitan, Mt. Guinlajan, and Mt. Tandayan (North Peak), and two forest types in Sebucal (submontane dipterocarp and almaciga forests). Because of diverse habitats, coupled with high altitude, lower temperature, and high rainfall, high diversity of plant species was observed in these two *barangays*.

As shown in Table 15, tree species richness decreased with increasing altitude (1,400-2,185 masl). This fact supports the contention of various ecologists that the number of species at higher altitudes is lower as a response to increasing environmental stress, like wind pressure, steep slopes, thin soil substrates, etc. (Perez 2004). However, an opposite trend was observed in the group of pteridophytes since an increasing number of ferns species was recorded with increasing altitude. This trend was expected since ferns prefer cooler temperature and moist and shaded habitat.

As for vegetation types, the montane and mossy forests had the highest species richness (263 and 256 species, respectively), followed by submontane and mixed dipterocarp forests with 219 and 181 species, respectively. Low species richness was noted in mixed lowland dipterocarp and plantation forests (97 and 61 species, respectively) (Table 8 and Figure 10). The high species richness in the aforementioned forest types was partly due to the more diverse habitats and more sampling areas (12-21 plots/site). On the other hand, 157 species were found in the almaciga forest, which occupied only a small area (only six plots) compared to the other forest types. It had the highest species richness at 32 species per plot, which translates into extremely high diversity. This was followed by mossy, montane, and submontane dipterocarp forests (30, 29, and 28 species/plot, respectively) with very high plant diversity (Table 5 and Figure 7). The high species richness or diversity values in these areas may be attributed to the presence of intact forests.

Trees and shrubs associated with the agroecosystems in the *barangays* of Don Victoriano were also recorded. A total of 38 species in 26 families were documented. Lake Duminagat had the highest number of remnant tree and shrub species (31 species) in the cultivated areas planted with vegetable crops (compared with Mansawan, which had 9 remnant species and Gandawan, which had 3 remnant species). The high number of forest remnant species (trees/saplings) and fallen logs was a strong indication that farmers of Barangay Lake Duminagat recently burned the natural forest. The *barangay* was surrounded with a huge area of natural forest that promoted diversity of trees and shrubs in the agroecosystem. If *kaingineros* could be

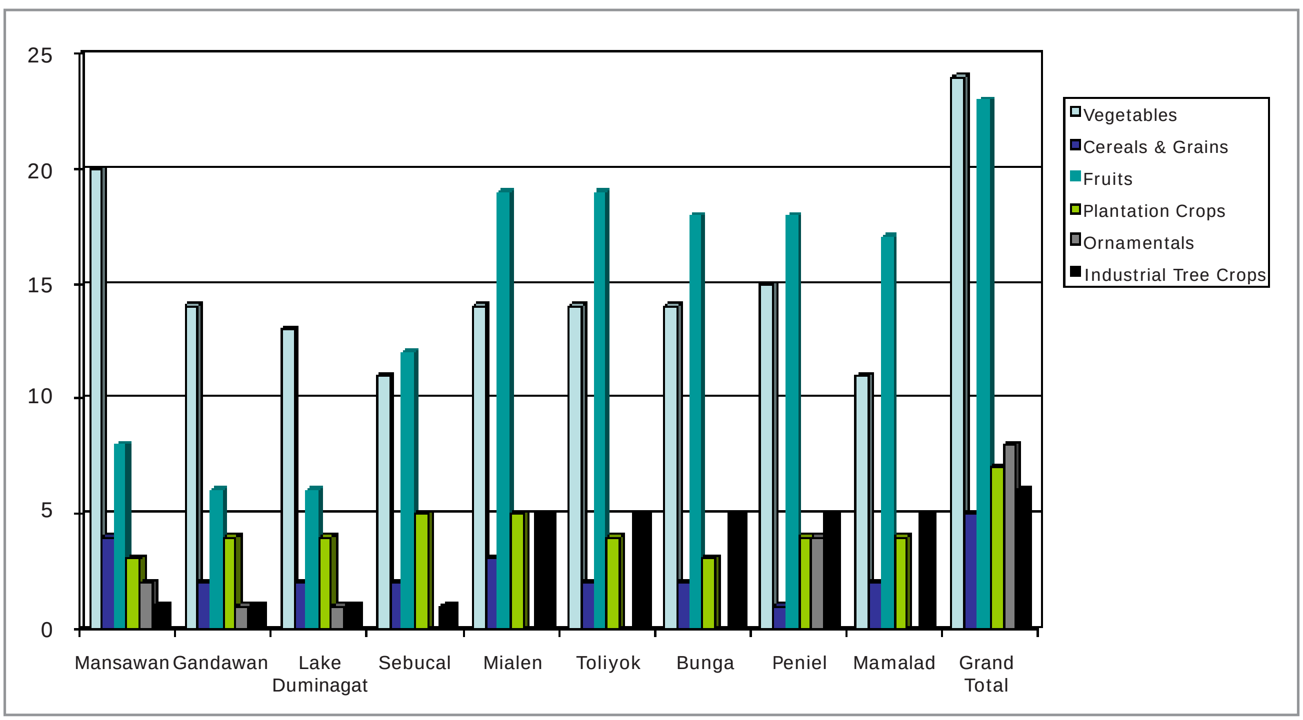

Figure 8. Plant species richness according to plant groups in agroecosystem in nine *barangays* within the Mt. Malindang Range Natural Park.

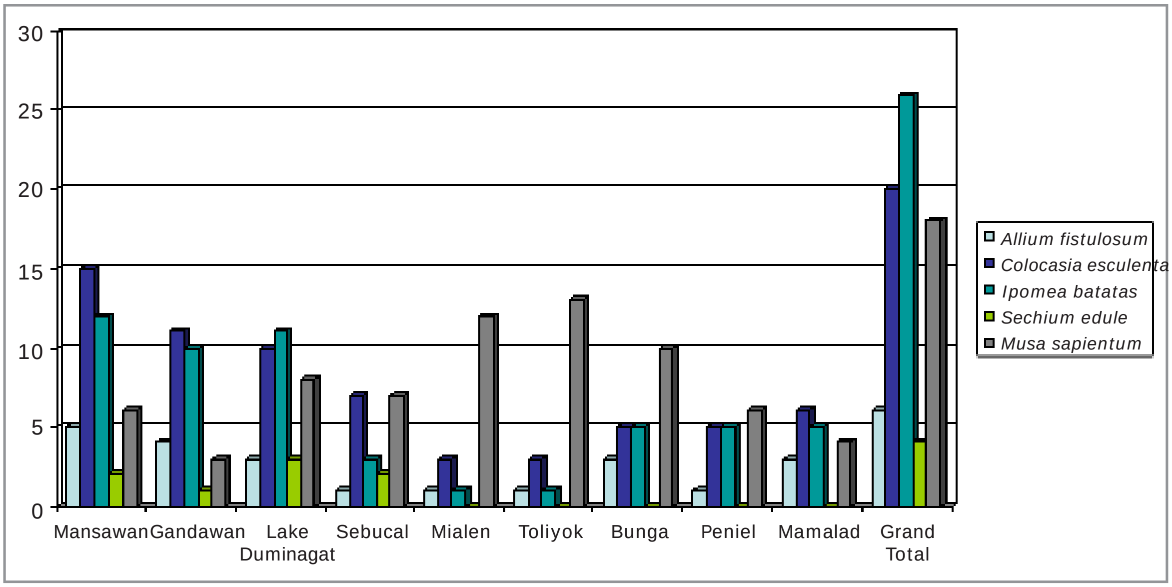

Figure 9. Plant varietal richness of agroecosystem in nine *barangays* of Mt. Malindang Range Natural Park.

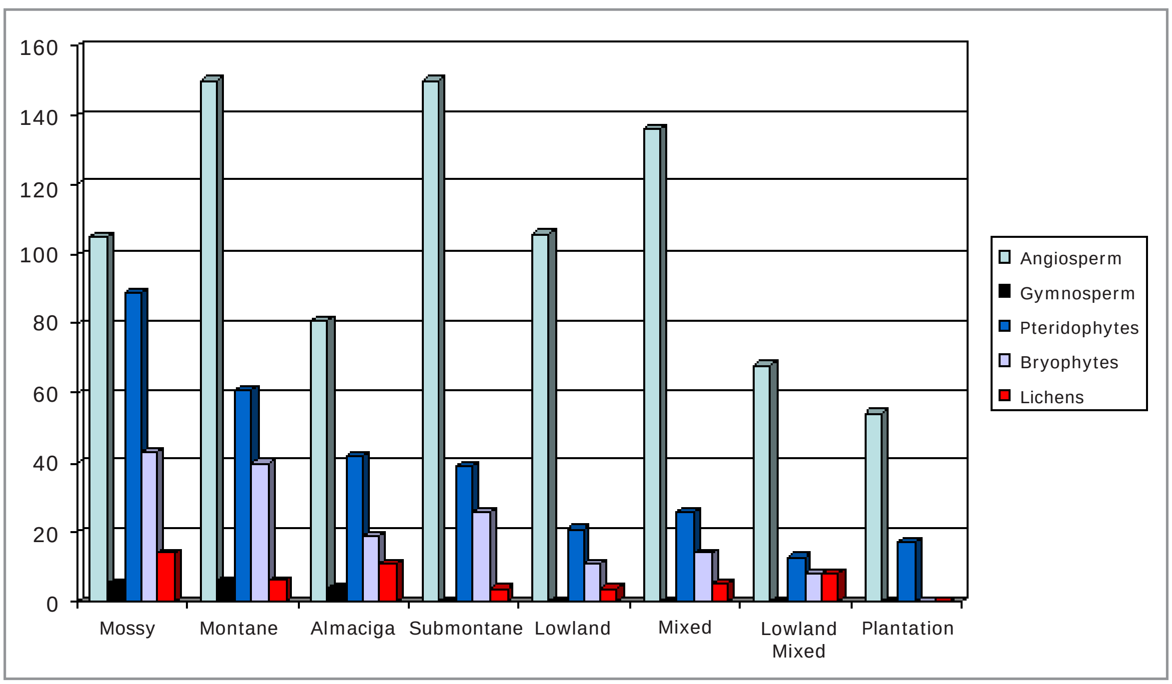

Figure 10. Plant species richness according to plant groups in the various vegetation types in Mt. Malindang Range Natural Park.

Table 6. Plant species richness in Mt. Malindang Range Natural Park based on transect walk and sampling plots.

Plant Groups	Total Number of		
	Family	Genera	Species
Angiosperms	114 (8*)	307 (24*)	873 (89*)
Gymnosperms	4	7	20
Pteridophytes	32	96	283
Bryophytes	32	55	85
Lichens	5	7	26
Total	**187**	**472**	**1,284**

*Confined only to agroecosystem

Table 7. Plant species richness in the nine *barangays within the Mt. Malindang Range Natural Park.**

Plant Groups	*Barangay*								
	Mansawan	Gandawan	Lake	Sebucal	Mialen	Toliyok	Bunga	Peniel	Mamalad
Angiosperms	199	108	332	341	267	252	242	224	226
Gymnosperms	6	5	13	5	0	1	3	5	0
Pteridophytes	86	76	191	95	94	65	83	101	86
Bryophytes	37	45	67	31	20	9	2	24	18
Lichens	14	17	20	16	18	10	4	15	7
Total	**342**	**251**	**623**	**488**	**399**	**337**	**334**	**369**	**337**

* Transect walk and sampling plots

Table 8. Plant species richness according to plant groups in the various vegetation types in Mt. Malindang Range Natural Park.

Plant Group	Number of Species in Forest Vegetation Types							
	Mossy	Montane	Almaciga	Submontane Dipterocarp	Lowland Dipterocarp	Mixed Dipterocarp	Mixed Lowland Dipterocarp	Plantation
Angiosperms	105	150	81	150	106	136	68	54
Trees	51	99	49	93	68	97	47	38
Shrubs	23	21	10	22	12	13	9	3
Herbs	16	16	11	15	15	12	7	9
Vines	15	14	11	20	11	14	5	4
Gymnosperms	5	6	4	0	0	0	0	0
Pteridophytes	89	61	42	39	21	26	13	7
Bryophytes	43	40	19	26	11	14	8	0
Lichens	14	6	11	4	4	5	8	0
Total	**256**	**263**	**157**	**219**	**144**	**181**	**97**	**61**

Table 9. Plant species richness according to plant groups in the agroecosystem in nine *barangays* within the Mt. Malindang Range Natural Park.

Plant Group	Number of Species per *Barangay*									Grand Total of Species / Plant Group
	Mansawan	Gandawan	Lake Duminagat	Sebucal	Mialen	Toliyok	Bunga	Peniel	Mamalad	
Vegetables	20	14	13	11	14	14	14	15	11	**24**
Cereals and grains	4	2	2	2	3	2	2	1	2	**5**
Fruits	8	6	6	12	19	19	18	18	17	**23**
Plantation crops	3	4	4	5	5	4	3	4	4	**7**
Ornamentals	2	1	6	0	0	0	0	4	0	**8**
Industrial tree crops	1	1	1	1	5	5	5	5	5	**6**
Total	**38**	**28**	**27**	**31**	**47**	**44**	**43**	**46**	**34**	**73**

Table 10. Plant varietal richness of agroecosystem in nine *barangays* of the Mt. Malindang Range Natural Park.

Species	Number of Varieties per Barangay									Grand Total of Varieties
	Mansawan	Gandawan	Lake Duminagat	Sebucal	Mialen	Toliyok	Bunga	Peniel	Mamalad	
Allium fistulosum	5	4	3	1	1	1	3	1	3	6
Colocasia esculenta	15	11	10	7	3	3	5	5	6	20
Ipomea batatas	12	10	11	3	1	1	5	5	5	26
Sechium edule	2	1	3	2	0	0	0	0	0	4
Musa sapientum	6	3	8	7	12	13	10	6	4	18
Total	**40**	**29**	**35**	**20**	**17**	**18**	**23**	**17**	**18**	**74**

stopped from expanding cultivation, and the area could be fallowed for a longer period, secondary forest development would be possible. The influx of forest dwellers and increasing population led to a further reduction of the natural forest as people try to find ways to survive by using the forest resources as their livelihood.

Similarity Indices of Plant Species Across the Malindang Landscape

Using the statistical tool Biodiversity Professional, the similarity and degree of correlation of the plant species and varieties found across the Mt. Malindang landscape were evaluated. Similarity indices and correlation analysis were computed for the forest ecosystems and the *barangay* agroecosystem.

Species Similarity Index of Forest Vegetation Types

Similarity indices showed the decreasing values from mossy forests to montane forests (29.55%), to submontane dipterocarp forests (8.79%), to almaciga forests (5.61%), to mixed dipterocarp forests (4.62%), to lowland dipterocarp forests (3.21%), to lowland mixed dipterocarp forests (3.03%), and to plantation forests (2.07%) (Table 11). Similar trends existed in other vegetation types. Species similarity among vegetation types showed that plant species in mossy forests had more similarity to montane forests (29.55%) and least to other vegetation types (Table 11). The same was true for lowland dipterocarp forests to lowland mixed dipterocarp forests (30.60%); submontane dipterocarp to lowland dipterocarp forests (26.12%); submontane dipterocarp to almaciga forests (25.32%); and mixed dipterocarp to plantation forests (25.49%). The degree of similarity among vegetation types was not significant, except between the plantation forests to lowland mixed dipterocarp forests (Table 12).

The vegetation types also represented the various elevation gradients across the landscape. These similarity values were low, indicating wide disparity among plant species contained in the various forest vegetation types. These findings showed dissimilarity among plant species across the landscape due to the influence of climate, altitude, aspect, soil, use of the forest, and other factors.

Species Similarity Index of Agricultural Crops in the Agroecosystem

The similarity and degree of correlation of the plant species and varieties found across the Malindang landscape showed a higher degree of association in *barangays* found at higher elevations such as Lake Duminagat, Mansawan, and Gandawan. The similarity index values ranged from 74.82 to 80.85 percent (Table 13). The high correlation coefficient that ranged from 0.895 to 0.9634 (Table 14) supported the likeness of the plant species and varieties planted. These *barangays* have been classified as vegetable-growing communities.

Barangays at lower elevations practicing agroforestry were dominated by coconut intercropped with other fruits, such as *Lansium domesticum* (lanzones), *Nephelium lappaceum* (*rambutan*), and *Durio zibethinus* (durian). Similarity values of the associated crops among the *barangays* ranged from 62.06 to 94.26 percent (Table 13). However, Barangay Mamalad showed lower correlation values when compared with other *barangays*, except with Sebucal (Table 14).

With respect to the general landscape of Mt. Malindang, *Oryza sativa* (rice), *Ipomoea batatas* (*kamote*), and *Colocasia esculenta* (*gabi*) were dominantly cultivated, either as sole crop or as a component crop, with chi square values of 36.0909, 23.5849, and 18.5714, respectively, based on aggregated analysis. They also served as staple food and cash crops of the Subanen and other tribes living across the Malindang Range.

Assessment of Status

An assessment of the status of the different plant species was carried out to establish a foundation for their protection, conservation, and monitoring. Assessment of the status of each species revealed 56 threatened species both locally and nationally, 138 endemic species, and 289 species of economic value (Table 15). Of the 56 threatened species, 10 were critically endangered, nine endangered, 14 vulnerable, and 21 were locally threatened. Twenty-nine species were endemic to the Philippines and 20 species threatened for extinction in the wild (Table 16).

Seven endangered species were seen only on the transect walk and not found inside the sampling plots. These were *Dawsonia superba*, *Bryum russulum, Alocasia sanderiana*, *A. zebrina*, *Lycopodium magnusianum*, *Dracontomelon dao,* and *Salacca clemensiana,* while only five endangered species were found inside the plots, namely, *Tmesipteris lanceolata*, *Dillenia philippinensis*, *Calamus merrillii, Podocarpus lophatus,* and *Agathis philippinensis*.

Furthermore, *Oleandra nitida* was found in the transect walk, as well as inside the sampling plots. This species was reported by Zamora and Co (1986) as endemic and may become extinct if no conservation measures are adopted. Other species of dipterocarps reported as critically endangered were *Anisoptera thurifera*, *Diptorocarpus grandiflorus*, *D. validus*, *Hopea acuminate, Shorea* *contorta*, *S. palosapis,* and *S. polysperma* (Statistics on Philippine Protected Areas and Wildlife Resources 2000).

Among the plant groups, the trees and gymnosperms obtained the highest percentage of endemism with 41 percent and 27 percent, respectively, while angiosperms showed 24 percent endemism, and pteridophytes 11 percent (Table 17). Of the total 59 endemic pteridophyte species found in Mindanao, 28 species (47%) were from Mt. Malindang (Amoroso 2000).

One species was site endemic (*Medinilla malindangensis)*, while 10 species were Mindanao island endemics. The latter included *Saurauia involucrata, Saurauia fasciculiflora, Saurauia glabrifolia, and Cinnamomum mindanaense*. Fourteen plant species were widespread Philippine endemics (Table 18). Luzon endemics, like *Begonia cumingii, Vaccinium jagori,* and *Saurauia fasciculiflora,* had been recently reported in Mindanao. Some of these endemic species were also observed in the two 1-ha plots in the first generation research of Arances *et al.* (2004). Since some of the endemic species had been already reported as threatened, high priority should be given to the protection of these species.

One of the Mindanao endemic species in Mt. Malindang was *Salacca clemensiana*, previously found only in certain parts of Mindanao such as Lanao, Zamboanga, and Davao (de Guzman *et al.* 1986). The recent discovery of *S. clemensiana* in the Mt. Malindang Range represented a new distribution record. Previous assessment of its conservation status classified it as rare but the study showed that this species was quite common in the headwater portion and along the banks of Layawan River. Gruezo and Amoroso (2004) described the taxonomy, ecology, phenology, population size, and reproductive behavior of *S. clemensiana* and further indicated that this was a Mindanao endemic palm with high commercial, landscape, and ornamental value. The fresh mature leaves were being used by the native people as thatch material for small houses. The ripe fruits were eaten by the residents and by certain wildlife such as palm civet cat, macaque,and cloud rats.

Two hundred and fifty species in the park had economic importance, such as food, medicine, ornament, building material, handicraft, and forage (Timada 2003, Arances *et al.* 2004). These resources could provide sustainable livelihood to the local people if properly managed and utilized. These sustainable products, which were characterized as NTFPs, were locally threatened due to overutilization and conversion of the forestland into agricultural land and human settlements.

Threatened Plant Resources

The highest number of threatened species were found in almaciga (6 species per plot), submontane dipterocarp (6 species per plot), and lowland dipterocarp (4 species per plot) forests (Table 5). Other forest types had lower number of threatened species (1-2 species per plot). The high number of threatened species in the three forest types may be correlated with the higher diversity and occurrence of dipterocarp species and species valued as timber for housing materials and firewood. In addition, these forest types were located in accessible areas, i.e., near human settlements, and therefore more prone to disturbance and resource utilization.

The 56 locally- and nationally-threatened species were found in nine particular *barangays* encompassed by the Mt. Malindang Range Natural Park (Table 16). Barangay Sebucal had the highest number of threatened species (31), followed by Lake Duminagat (29), while Barangay Gandawan had the lowest number (11). The high number of threatened species in Sebucal came from the intact almaciga forest and submontane dipterocarp forests, while in Lake Duminagat, from the relatively virgin montane and mossy forests. In Barangay Gandawan, only small remnants of intact forests could be encountered, hence the low number of species. The presence of the nearby settlements also explained the higher number of threatened species in Barangays Sebucal and Lake Duminagat. Overutilization of the forest resources and conversion of the forest into agricultural lands had endangered some of the plant species.

The use of *Lithocarpus* spp., Syzygium spp., and *Veburnum odoratissimum* for firewood caused the depletion of the population of the tree species; they were recently considered as locally threatened. The data gathered by the SECS team indicated that the average extraction rate per week per household was roughly 0.192 m^3 or 2.20 trees (15-20 DBH and 5 m high). This extraction rate, coupled with the increase of the local population and lack of reforestation, may lead to the conclusion that these tree species, presently being used for firewood, may be extinct in the near future. Tree planting of these species around farms had been encouraged to avert depletion of the population. These conclusions are underpinned by the stand table per hectare of the threatened species (Table 17).

Almaciga trees (*Agathis philippinensis*) are protected by the DENR, and almaciga resin tapping is permitted only under license. However, local communities in Sebucal and Lake Duminagat illegally tapped almaciga resin for household use as illuminant. In Samar, the San Jose

Table 11. Plant species similarity indices between forest types in Mt. Malindang Range Natural Park.

Forest Type	Mossy	Montane	Almaciga	Sub-montane	Lowland Dipterocarp	Mixed Dipterocarp	Lowland Mixed	Plantation
Mossy	*	29.55	5.61	8.79	3.21	4.62	3.03	2.07
Montane	*	*	12.02	15.77	6.94	9.89	4.96	8.10
Almaciga	*	*	*	25.32	15.21	22.77	9.06	7.73
Submontane dipterocarp	*	*	*	*	26.12	14.95	14.39	8.08
Lowland dipterocarp	*	*	*	*	*	23.55	30.60	13.87
Mixed dipterocarp	*	*	*	*	*	*	22.02	25.49
Lowland mixed dipterocarp	*	*	*	*	*	*	*	22.82
Plantation	*	*	*	*	*	*	*	*

Table 12. Species correlation matrix of plants among forest types.

Forest Type	Mossy	Montane	Almaciga	Sub-montane	Lowland Dipterocarp	Mixed Dipterocarp	Lowland Mixed	Plantation
Mossy	1	*	*	*	*	*	*	*
Montane	0.5669	1	*	*	*	*	*	*
Almaciga	0.2997	0.3551	1	*	*	*	*	*
Submontane dipterocarp	0.3369	0.3985	0.5478	1	*	*	*	*
Lowland dipterocarp	0.3089	0.3383	0.4529	0.4968	1	*	*	*
Mixed dipterocarp	0.2298	0.2746	0.4632	0.3931	0.5243	1	*	*
Lowland mixed dipterocarp	0.4142	0.4285	0.5335	0.5295	0.6634	0.5861	1	*
Plantation	0.435	0.4787	0.5435	0.5332	0.6463	0.6352	0.7436	1

Table 13. Species similarity index of agricultural crops in the agroecosystem.

Barangay	Lake	Gandawan	Mansawan	Sebucal	Peniel	Mialen	Toliyok	Mamalad	Bunga
Lake	*	78.12	74.82	54.92	53.79	42.75	43.83	43.60	47.88
Gandawan	*	*	80.85	44.11	53.23	31.65	34.28	45.66	41.17
Mansawan	*	*	*	43.87	55.69	39.24	38.99	45.20	43.87
Sebucal	*	*	*	*	61.43	66.66	64.93	62.41	64.00
Peniel	*	*	*	*	*	71.79	73.88	68.05	79.73
Mialen	*	*	*	*	*	*	94.26	62.50	84.96
Toliyok	*	*	*	*	*	*	*	62.06	85.71
Mamalad	*	*	*	*	*	*	*	*	73.75
Bunga	*	*	*	*	*	*	*	*	*

Table 14. Species correlation matrix of agricultural crops in the agroecosystem.

Barangay	Lake	Gandawan	Mansawan	Sebucal	Peniel	Mialen	Toliyok	Mamalad	Bunga
Lake	1	*	*	*	*	*	*	*	*
Gandawan	0.895	1	*	*	*	*	*	*	*
Mansawan	0.9091	0.9634	1	*	*	*	*	*	*
Sebucal	0.5362	0.4662	0.4757	1	*	*	*	*	*
Peniel	0.6699	0.6132	0.6383	0.5477	1	*	*	*	*
Mialen	0.4513	0.2284	0.3103	0.6463	0.7042	1	*	*	*
Toliyok	0.464	0.2345	0.3111	0.6349	0.7118	0.9806	1	*	*
Mamalad	0.5821	0.583	0.6027	0.7819	0.5904	0.5039	0.5021	1	*
Bunga	0.6377	0.4901	0.5408	0.6481	0.8479	0.8862	0.8881	0.6929	1

Table 15. Status of flora species in Malindang Range, Don Victoriano, Misamis Occidental.

Plant Group	Number of Species				
	Threatened	Endemic	Economic	NRP	Possibly NS or NRP
Angiosperms	45 (36*)	107	223	0	34
Gymnosperms	5 (3*)	3	9	0	0
Pteridophytes	4 (1*)	28	55	1	0
Bryophytes	2*	0	0	3	11
Lichens	0	0	2	0	2
Total	**56 (42*)**	**138**	**289**	**4**	**45**

*nationally-threatened species
NRP - new record in the Philippines; NS - new to science

Table 16. Threatened species in nine *barangays* of Mt Malindang Range Natural Park.

Species	Local Name	Uses	Barangay								
			Mansawan	Gandawan	Lake Duminagat	Sebucal	Mialen	Toliyok	Bunga	Peniel	Mamalad
Nationally-threatened species											
Critically endangered											
1. *Oleandra nitida*				+	+	+	-	-	-	+	+
2. *Anisoptera thurifera* spp. *thurifea* **	*Tomating*	Lumber	-	-	-	+	-	-	-	-	+
3. *Dipterocarpus grandiflorus** *	*Balaw-balaw*	Lumber	-	-	-	-	-	-	+	-	-
4. *D. confertus***		Lumber	-	-	-	-	-	-	+	-	-
5. *D. validus** *	*Apitong*	Lumber	-	-	-	-	-	-	-	+	-
6. *Hopea acuminata*/**/****	*Magasusu*	Lumber	-	-	-	-	+	+	+	+	+
7. *Shorea contorta*/* */****	*Danlugan/ Lauan*	Lumber	-	-	-	+	+	+	-	-	+
8. *S. mindanensis*/****	*Danlugan*	Lumber	-	-	-	+	+	+	-	-	+
9. *S. palosapis*/* */****	*Kalayan*	Lumber	-	-	-	+	+	+	+	+	+
10. *S. polysperma*/* **	*Balabaan*	Lumber	-	-	-	+	-	-	-	+	+
Endangered species											
11. *Dawsonia superba*			-	-	+	-	-	-	-	-	-
12. *Tmesipteris lanceolata*			-	-	+	+	-	-	-	-	-
13. *Lycopodium magnusianum*/***		Ornamental	-	-	-	-	-	-	+	+	-
14. *Alocasia sanderiana*/***		Ornamental	-	-	+	-	-	-	-	-	-
15. *A. zebrina* */***		Ornamental	-	-	+	-	-	-	-	-	-
16. *Dracontomelon dao***	*Luyaw*	Lumber	-	-	-	-	-	+	+	-	-
17. *Calamus merrillii*/***	*Tomalum*	Handicraft	-	-	-	+	-	-	-	+	-
18. *Salacca clemensiana*/****	*Kalubi*	Handicraft	-	-	-	+	+	+	+	+	+
19. *Freycinetia multiflora**	*Baraas*		+	-	+	+	+	+	-	-	-
Vulnerable species											
20. *Dillenia philippinensis* *	*Katmon*	Lumber, food	-	-	-	+	+	+	+	+	+
21. *Elaoecarpus calomala*	*Babate*	Wood timber	-	-	-	-	+	+	+	+	+
22. *Macaranga grandifolia**	*Labulag*	Lumber, firewood	+	-	+	+	-	-	-	+	-
23. *Lithocarpus ovalis*/***	*Gulayan kulasit*	Wood timber	+	+	+	-	-	-	-	-	-
24. *Pterocarpus indicus***	Narra	Lumber	-	-	-	-	+	+	+	+	+
25. *Cinnamomum mercadoi*/** /****	*Kalingag*	Medicinal	+	-	+	+	+	+	+	+	+
26. *C. mindanaensis**	*Mana-mana*	Lumber, wood timber	+	-	+	+	+	+	+	-	-
27. *Neolitsea vidalli* *	*Magamatong*	Wood timber firewood	+	-	+	+	-	-	-	-	-
28. *Artocarpus blancoi*	*Kapulot*	Food	-	-	-	-	+	+	+	+	+
29. *Palaquium luzoniense**	*Nato*	Lumber	-	-	-	+	+	+	+	-	+
30. *P. philippinense**	*Lucos*	Lumber	-	-	-	+	+	+	+	+	-
31. *Diplodiscus paniculatus* /****	*Barobo*	Wood timber	-	-	-	+	+	+	+	+	+
32. *Agathis philippinensis* **	Almaciga	Lumber	+	+	+	+	-	-	-	-	+
33. *Podocarpus lophatus**	*Subing*		-	-	+	-	-	-	-	-	-
Data deficient / Indeterminate											
34. *Toona calantas***	*Dyak*	Lumber	-	-	-	-	+	-	-	-	-
35. *Caryota rumphiana* var. *philippinensis**	*Takipan*	Young shoot for food	-	-	-	+	+	+	+	+	-

*endemic species **locally-threatened species ***locally abundant species

Table 16. Continuation...

Species	Local Name	Uses	Barangay: Mansawan	Gandawan	Lake Duminaga	Sebucal	Mialen	Toliyok	Bunga	Peniel	Mamalad
Locally-threatened species											
36. *Medinilla malindangensis**	*Latepo*		-	-	+	-	-	-	-	-	-
37. *Polyosma philippinensis**	*Babasa*	Lumber	+	-	+	+	-	-	-	-	-
38. *Dacrycarpus cumingii*	Pine tree	Lumber	+	+	+	+	-	-	-	-	-
39. *Viburnum odoratissimum*	*Baho-baho*	Wood timber	+	+	+	-	-	-	-	-	-
40. *Lithocarpus* spp.	*Gulayan*	Lumber, firewood	+	-	+	+	+	+	+	-	-
41. *Caldcluvia celebica*	*Malabago*	Lumber	+	+	+	-	-	-	-	-	-
42. *Podocarpus rumpii*	*Malakawayan*	Lumber	+	-	+	-	-	-	-	-	-
43. *Phyllocladus hyphophyllus*	*Magaringan*	Lumber	+	+	+	+	-	-	-	-	-
44. *Cyathea contaminans*	*Gantaw*	Potting medium, firewood	+	+	+	+	+	+	+	+	+
45. *Syzygium* spp.	*Polayo*	Wood timber, firewood	-	-	+	+	+	+	+	+	-
46. *Chionanthus* sp.	*Tulan Manok*	Firewood	+	+	+	-	-	-	-	-	+
47. *Magnolia philippinensis**	*Ngilo*	Lumber	+	-	+	-	-	-	-	-	-
48. *Bischofia javanica*	*Guilon*	Lumber, food	-	+	+	+	+	+	+	+	+
49. *Gordonia luzonica**	*Sabon-sabon*	Lumber	+	-	+	+	-	-	-	+	-
50. *Mastixia premnoides**	*Magatalo*	Lumber	+	+	+	+	+	+	-	-	-
51. *Calophyllum blancoi**	*Palomaria*	Lumber	+	-	+	+	+	+	+	+	+
52. *Myristica philippinensis**	*Duguan*	Medicinal	-	-	-	-	+	+	+	-	-
53. *Psilotum complanatum*			-	-	-	+	+	-	-	+	-
54. P. nodum			-	-	-	-	-	+	-	-	-
55. *Christensenia aesculifolia***			-	-	-	-	-	-	-	+	+
56. *Helmintostachys zeylanica***	*Tungkod langit*		-	-	-	-	-	-	-	-	+
Total			**20**	**11**	**29**	**31**	**25**	**25**	**23**	**24**	**22**

*endemic species **locally-threatened species ***locally abundant species

Table 17. Total number and percentage of endemic species in the Mt. Malindang Range Natural Park.

Plant Group	Total Number and Percentage of Endemic Species: Philippines		Mindanao		Malindang	
	Species	Endemism	Species	Endemism	Species	Endemism
Angiosperms	8,000+	3,200	No data	No data	871 (450*)	107 (24%)
Trees	No data	No data	No data	No data	225 (129*)	53 (41%)
Gymnosperms	33	6 (18%)	No data	3	20 (11*)	3 (27%)
Pteridophytes	1,027	351 (37%)	632	183	280 (246*)	28 (11%)

*based solely on the specimens identified up to species level

Table 18. List of Malindang, Mindanao, and Philippine endemic species and their distribution.

Family / Species	*Barangay*	Distribution
A. Malindang endemic		
1. *Medinilla malindangensis (Latipo)**	Lake Duminagat	Mindanao (Mt. Malindang)
B. Mindanao endemic		
1. *Radermachera whitfordii (Magasili)*	Mansawan, Gandawan, Lake Duminagat, and Sebucal	Mindanao (Bukidnon, Davao, Cotabato, Lanao, Zamboanga)
2. *Mastixia premnoides (Magatalo)**	Mansawan to Mialen	Mindanao (Davao, Bukidnon, Lanao)
3. *Cinnamomum mindanaense (Mana-mana)**	Mansawan, Lake Duminagat, Sebucal, Mialen, and Toliyok	Mindanao (Surigao, Davao, Zamboanga)
4. *Talauma candolie (Bunot-bunot)*	Mansawan to Toliyok, Peniel and Mamalad	Mindanao (Surigao)
5. *Wendlandia williamsii (Malatakway)*	Mansawan, Gandawan, and Lake Duminagat	Mindanao (Zamboanga)
6. *Neonauclea media (Labalod)*	Lake Duminagat	Mindanao
7. *Saurauia fasciculiflora (Balangog-lagwis)*	Mansawan, Gandawan, and Lake Duminagat	Mindanao (Surigao)
8. *Saurauia glabrifolia (Balangog-dibahiboon)*	Mansawan, Gandawan, and Lake Duminagat	Mindanao (Davao)
9. *Syzygium huchinsonii (Magatambis)*	Lake Duminagat	Mindanao (Basilan)
10. *Salacca clemensiana (Kalube)**	Sebucal, Mialen, Toliyok, Bunga, Peniel, and Mamalad	Mindanao
11. *Schefflera alvarezii (Tagima)*	Mansawan	Mindanao
12. *Schefflera multiracemosa (Tagima)*	Mansawan, Gandawan, Lake Duminagat, and Sebucal	Mindanao (widespread)
C. Philippine endemic		
1. *Elaeocarpus calomala (Babate)**	Mialen and Mamalad	Luzon
2. *Ficus cardinalicarpa (Kalangkaeng)*	Mansawan, Gandawan, and Lake Duminagat	Palawan
3. *Saurauia latiflora (Balangog)*	Lake Duminagat and Sebucal	Luzon
4. *Vaccinium jagori (Gamaw)*	Mansawan and Lake Dumingat	Luzon
5. *Cyrtandra umbellifera (Lalago-pino)*	Mansawan, Gandawan, Lake Duminagat, and Sebucal	Luzon
6. *Impatiens montalbanica (Silangka)*	Mansawan, Gandawan, Lake Duminagat, and Sebucal	Luzon
7. *Podocarpus lophatus (Subing)**	Lake Duminagat	Zambales (Mt. Tapulao)
8. *Saurauia involucrata (Balangog-balhiboon)*	Mansawan, Gandawan, and Lake Duminagat	Luzon, Polillo, Mindoro, Cebu
9. *Ficus septica (Lagnob)*	All *barangays*	Samar, Mindanao (Bukidnon)
10. *Begonia cumingii (Mamangpang)*	Mansawan, Gandawan, and Lake Duminagat	Luzon, Mt. Banahao, Mt. Makiling
11. *Begonia copelandii (Mamangpang)*	Mansawan, Gandawan, and Lake Duminagat	Luzon, Panay, Mindanao (Davao)
12. *Freycinetia negrosensis (Baraas)**	Mansawan, Gandawan, and Lake Duminagat	Luzon, Negros, Mindanao
13. *Dischidia lancifolia* (Christmas tree)	Mansawan, Gandawan, and Lake Duminagat	Luzon, Mindanao (Bukidnon)
14. *Elastostema pulchellum*	Lake Duminagat and Sebucal	Luzon, Mindanao

*threatened species

Table 19. Standing trees / hectare of threatened tree species among vegetation types of Mt. Malindang Range Natural Park.

Species	Local Name	Number of Individuals by Vegetation									
		Mossy		Montane		Dipterocarp		Almaciga		Mixed Dipterocarp	
		Ind.	Ha.	Ind.	Ha.	Ind.	Ha.	Ind.	Ha.	Ind.	Ha.
1. *Agathis philippinensis*	Almaciga			1	1.19			17	70.83		
2. *Anisoptera thurifera* ssp. *thurifera*	*Tomating/Ganon*					18	37.50			4	3.33
3. *Bischofia javanica*	*Gilon*					5	10.42				
4. *Caldcluvia celebica* (Bl.) Hoogl.	*Malabago*	4	6.67	9	10.71						
5. *Calophyllum blancoi*	*Bintangol*							3	12.50		
6. *Chionanthus* sp.	*Tulanmanok*	17	28.33	3	3.57						
7. *Cinnamomum mercadoi*	*Kaligag*			4	4.76	1	2.08	9	37.50		
8. *Cinnamomum mindanaense*	*Kalingag*							2	8.33	2	1.67
9. *Dacrycarpus cumingii*	*Igem*	3	5.00	2	2.38			3	12.50		
10. *Dillenia philippinensis*	*Katmon*							4	16.67		
11. *Diplodiscus paniculatus*	*Balobo*									4	3.33
12. *Dipterocarpus validus* Blume	*Apitong*									1	0.83
13. *Dipterocarpus confertus* V. Sloot	Round leaf/ *Apitong*									2	1.67
14. *Elaeocarpus calomala* (Bl.) Merr.	*Babate*	28	46.67	11	13.10						
15. *Gordonia luzonica*	*Sabon-sabon*	2	3.33	20	23.81	3	6.25				
16. *Hopea acuminata*	*Mangachapoi*									1	0.83
17. *Lithocarpus* spp.	*Gulayan*	34	56.67	73	86.90	5	10.42	2	8.33	65	54.17
18. *Macaranga grandifolia*	*Hamindang*									4	3.33
19. *Magnolia philippinensis*	*Ngilo*			2	2.38						
20. *Mastixia premnoides*	*Magatalo*	23	38.33	19	22.62			6	25.00	2	1.67
21. *Neolitsea vidalli* Merr.	*Magamatong*	7	11.67								
22. *Palaquium luzoniense*	*Nato*					9	18.75	1	4.17	1	0.83
23. *Palaquium philippense*	*Lucos*					6	12.50			2	1.67
24. *Phyllocladus hypophyllus* Hook. f.	*Magaringan*	12	20.00	1	1.19						
25. *Polyosma philippinensis* Merr.	*Babasa*	15	25.00	33	39.29						
26. *Pterocarpus indicus*	Narra									1	0.83
27. *Shorea contorta*	*Danlugan*					5	10.42			20	16.67
28. *Shorea mindanaense*	*Danlugan*					35	72.92	2	8.33	18	15.00
29. *Shorea palosapis*	*Kalayaan*					1	2.08			26	21.67
30. *Shorea polysperma*	*Balâbaan*					26	54.17			20	16.67
31. *Shorea* sp. 1	*Tobongon*									11	9.17
32. *Shorea* sp. 2	*Gisok labaw*									5	4.17
33. *Shorea* sp. 3	*Ganon*									5	4.17
34. *Syzygium* spp.	*Polayo puti*	11	18.33	11	13.10	7	14.58	39	162.50	11	9.17
35. *Toona calantas*	*Luyaw*					1	2.08			2	1.67
36. *Viburnum* sp.	*Baho-baho*	1	1.67	7	8.33						
Total		**157**	**262**	**196**	**233.3**	**122**	**254.2**	**88**	**366.7**	**207**	**172.5**

Timber Corporation processed the resins into local varnish and paint for furniture and handicraft industries (FRRDI 2000). The people in the community had crude and old-fashioned extraction practices, with no restrictions to diameters of trees to tap, and used horizontal cutting without definite thickness prescription. Unless such methods of resin extraction are corrected, the almaciga trees in Sebucal could become extremely threatened.

Rattan (*Calamus* spp.) or "climbing palms" were found abundantly in Barangay Sebucal, and fairly in Peniel, Lopez Jaena, and Toliyok in Oroquieta City. It was used for making basket strips and tying materials. In Sebucal, rattan was collected from the nearby almaciga forest and dipterocarp forest by pulling down the whole cane, thereby killing the plant in the process. Since there was no local experience with asexual reproduction, the high frequency of observed wildlings was a result solely of high seed germination. However, since it takes about 15 to 20 years for rattan to mature enough to be harvested (Palaypayon and Cadiz 1988), local people resorted to collecting the young and immature canes, which contributed to the fast dwindling of rattan in Peniel, Toliyok, and other places in the park. Sustainable rattan industry in Sebucal and other parts of the natural park may only be achieved through establishment of rattan plantations.

Indigenous Knowledge System (IKS) on Conservation

Indigenous agroforestry practices are land use forms, which are products of experiences, intelligent analysis of problems, and their solutions, refined through time (Cardenas 2003). In the three *barangays* of Don Victoriano (Mansawan, Gandawan and Lake Duminagat), in four *barangays* of Oroquieta City (Sebucal, Mialen, Toliyok, and Bunga), as well as in Peniel, Lopez Jaena, and Mamalad, Calamba, Misamis Occidental, the indigenous agroforestry practices of the Subanens and other tribal groups had most likely evolved as a strategy to cope with the existing biophysical and socioeconomic conditions in the upland ecosystem. Key informants said that whenever a new crop was introduced and the locals found it productive, many others adopted it. This implied open-mindedness of the farmers and their eagerness to embrace technological improvement.

Farmers in the different *barangays* were found to trust their own indigenous knowledge and beliefs (Table 20). Farmers in settlements at higher altitudes in Mt. Malindang used the slash and burn farming method (*kaingin*) to raise crops. They cleared the areas to be farmed by cutting down the trees and burning the remains. This practice was done in logged-over or fallowed areas at higher elevations, like in Don Victoriano and Lopez Jaena, Misamis Occidental. It was observed that most of the *kaingins* were done in sloping areas, which are very prone to surface runoff and erosion. Subanen farmers in the higher zones preferred to cultivate in the rolling areas because they found it easier to work standing across the slope than on flat land where they had to stoop or seat while working. This was aggravated by the clean monoculture practice of most farmers: planting cabbage and onions on newly opened sites. As soil fertility declined, other crops, such as sweet potato and *gabi*, were usually promoted. This practice of the Subanen farmers was similar to the practices of other ethnic groups in the Philippines (Denevan and Padock 1988, Cardenas 2003). The Subanen farmers, however, observed a longer fallow period (3-4 years) to restore the soil fertility.

Some farmers, being aware of the problematic situation of their farms, adopted innovations to improve production. Some of their innovations were: the application of fertilizers to their cash crops, such as cabbage and green onions; construction of diversion ditches or dikes; construction of rock walls or *balabag* system using decomposing logs; retention of uprooted weeds; and multiple cropping with sweet potato planted at the lower portion to trap eroded soil. However, in areas below 1,000 masl, farmers resorted to the planting of permanent crops, such as coconut and other fruit trees, resulting in an agroforestry farming system.

Coconut farmers also practiced girdling of the coconut stem on the first one meter above the ground to remove the dead roots. They believed that by doing so, the fruiting of the coconut could be induced. This belief corresponded with scientific findings that tapping or creating bark injuries would induce the release of the stress hormone ethylene. Ethylene is developed within the plant system and can induce maturity and fruiting when it enters the plant stomata. They also wrapped coconut stem with galvanized iron (GI) and plastic floor mats to restrict the rats from climbing the trees and eating young coconut fruits.

Farmers also believed that the opening of the orchid *ting-ulan* indicates the coming of rain. They also believed that the flowering and fruiting of *Lithocarpus* spp. signal the right time to hunt for wild pigs. But the most significant practice of the Subanen farmers was the conduct of rituals to ask permission from the mountain spirits to use the lands, for they believed that the spirits owns the lands. It was found, however, that Christianized Subanens no longer followed such practices.

Some of the documented Subanen farmers' IKS on conservation and protection of Mt. Malindang were scientific in nature. They were also found to contribute to

Table 20. Indigenous farming practices and innovations of farmers in agroecosystem of Mt. Malindang Range Natural Park.

		Barangay								
	Practices	Mansawan	Gandawan	Lake Duminagat	Sebucal	Mialen	Toliyok	Bunga	Peniel	Mamalad
1.	Conduct of rituals									
	a. Before planting (*pailis*)	+	+	+	+					
	b. After planting (*paggasa/liso-batong*)	+	+	+	+					
	c. Harvesting (*pagsuko*)	+	+	+	+					
2.	Practice of beliefs (*palihi*)									
	a. Planting of sweet potato/root crops during dawn or a full moon	+	+	+	+					
	b. Planting at low tide	+	+	+	+					
	c. Spitting saliva on planting hole	+	+	+	+					
	d. Stones near first planting hole	+	+	+	+					
	e. Burying mat or *babasig* leaf	+	+	+	+					
	f. Putting ash and egg shell in planting hole	+	+	+	+					
	g. Burying succulent herbs	+	+	+	+					
	h. Burying high yielding flower plants or fruit trees	+	+	+	+					
3.	Slash and burn farming	+	+	+	+	+	+	+	+	
4.	Fallowing (*paanuton*)	+	+	+	+					
5.	Crop rotation (*sal-ang sal-ang*)	+	+	+	+					
6.	Farm orientation facing the east			+						
7.	Use of organic pesticides			+						
8.	Non-burning of crop residues	+	+	+	+	+	+	+	+	
9.	Diversion ditches/dikes construction	+	+	+		+		+		
10.	Establishment of rock wall	+	+	+						
11.	*Balabag* using logs	+	+	+						
12.	Multiple cropping of annual crops	+	+	+	+	+	+	+	+	+
13.	Agroforestry					+	+	+		
14.	Girdling of coconut stems					+	+	+		
15.	Wrapping coconut stems with GI sheets/floor mat					+	+	+		
16.	Rice paddy terracing					+		+		
17.	Inorganic fertilizer application	+	+	+						
18.	Organic fertilizer application	+	+	+					+	
19.	Planting/cultivation on rolling area preferred more than flat/plain areas – cultural/inherited		+	+						
20.	Pastor Villamino to open new *kaingin* area in Barangay Lake Duminagat			+						
21.	Flowering of *Lithocarpus* or *gulayan* means hunting season of wild pig				+					
22.	Flower opening of an orchid *ting-ulan* means rain is coming	+	+	+						
23.	Rituals asking permission from spirits of the forest to keep their wild animals/dangerous animals/poisonous pets to ensure safety of the visitors	+	+	+	+					

the increase of productivity in the agroecosystem. The Subanen's *balabag* system, for example, promotes soil conservation and minimizes soil erosion. Their fertilization through both organic and inorganic fertilizers had been proven scientifically to manage soil fertility.

It was observed that there were more indigenous farming practices in the *barangays* located in higher elevation than those in the lower elevation. Perhaps, differences in exposure to modern farming practices could account for this. The *barangays* in the lower elevation had more exposure and access to modern farming technologies coming from the lowlands.

Development of Biodiversity Monitoring and Conservation Instrument

The community monitoring teams used an instrument developed by the Central Mindanao University and Bukidnon Resource Foundation to monitor, evaluate, and conserve biodiversity. The instrument was used during the training conducted in December 2004, where 54 participants from Mansawan, New Liboron, Gandawan, and Lake Duminagat attended. As suggested by the participants, two community monitoring teams (CMT), namely, Mansawan-New Liboron CMT and Gandawan-Lake Duminagat CMT, were organized. The *barangay* captain headed each community team and the *Bantay Lasang* (forest guards) were the members.

During the training, the researchers from the study and from the Bukidnon Resource Foundation acted as resource persons. The selection and installation of the Biodiversity Monitoring and Evaluation (BIOME) sites were demonstrated. The participants decided to install the BIOME sites in the two 1-ha plots in Palo 6, Barangay Mansawan and in Mt. Guinanlajan, Barangay Lake Duminagat.

To make biodiversity monitoring and evaluation sustainable even beyond BRP, the CMTs were empowered by teaching them the tools for biodiversity monitoring. These were: transect walk (TW), photo documentation (PD), field diary (FD), and focus group discussion (FGD). Hands-on activities followed the lecture/demo and they were asked to gather initial data from the 1-ha plots. The CMTs were then taught how to organize, analyze, and interpret the data collected from the field. Ultimately, they were given tips on how to present the results of the BIOME activities. On the last day, the participants became involved in action planning and preparation of the proposals to continue the BIOME activities and nursery project even after BRP ends. The proposals were submitted to the park superintendent for discussion during the meeting of the Protected Area Management Board (PAMB) and officials of the local government units (LGUs).

The TEMP flora researchers were designated to continue the activities of the CMTs so that trends in species biodiversity (whether increasing or decreasing) could be determined and changes in the landscape could be recorded. The results of the BIOME activities could be useful for the policy and ordinance formulation of the PAMB or other local government units in the conservation of the remaining biodiversity in Mt. Malindang Natural Park. The BIOME was not only expected to build the capabilities of the CMT and communities in determining changes in the biological and economic resources that they manage, but also to identify and formulate timely and appropriate conservation management interventions based on the gathered data.

Information, education, and communication (IEC) materials, such as flyers, of threatened and endemic plant species were prepared to enhance awareness regarding the biodiversity status of the park.

SUMMARY AND CONCLUSIONS

The forest/vegetation types present were: (1) mossy forests, (2) montane forests, (3) almaciga forests, (4) submontane dipterocarp forests, (5) lowland dipterocarp forests, (6) mixed dipterocarp forests, (7) lowland mixed dipterocarp forests, (8) plantation forests, and (9) agroecosystems. Each vegetation type was characterized by a dominant and distinct floral species, which was used in naming each community.

Inventory of flora in the two 1-ha plots and 220 nested plots of 20 x 20 m revealed a total of 1,284 species distributed among 307 genera and 114 families. Of these, 873 were angiosperms, 20 were gymnosperms, 283 were pteridophytes, 85 were bryophytes, and 26 species were lichens.

Of the nine *barangays* studied, Lake Duminagat and Sebucal showed the highest species richness with 623 and 488 species each, respectively. In terms of vegetation type, very high to extremely high biodiversity values were obtained in almaciga, mossy, montane, and submontane dipterocarp forests; low to moderate biodiversity values were recorded in plantation and lowland mixed dipterocarp forests.

Assessment of floral resources revealed 56 threatened species. Of these, 36 were nationally threatened and 18 were locally threatened due to overutilization and land conversion. Seven species were locally abundant: C*innamomum mercadoi, Shorea contorta, S. mindanensis, S. palosapis, Hopea acuminata, Salacca clemensiana,* and *Diplodiscus paniculatus.*

Percent endemism of the park ranged from 11 to 27 percent. There were 107 endemic species of angiosperms, three species of gymnosperms, and 28 endemic species of pteridophytes. Some of these endemic species were also threatened species.

The agroecosystem had four communities. These included the vegetable communities which dominated the *barangays* of Don Victoriano; cereal communities in *barangays* of Oroquieta, Lopez Jaena, and Calamba, Misamis Occidental; agroforestry communities in Oroquieta, Lopez Jaena, and Calamba; and grass-dominated fallowed areas that developed after a long fallow period of the Subanen farmers across the Malindang landscape.

A total of 73 cultivated species had been documented in the agroecosystem. Of these, 24 species were vegetable crops, 23 species were fruits crops, seven species were plantation crops, five species were cereal and grains, eight species were ornamental plants, and six species were industrial tree crops.

Among the vegetables, sweet potato exhibited the most number (26) of local varieties. Most of these varieties were dominantly found in Don Victoriano, but were not found in the lower *barangays* of Mt. Malindang. In addition, among other root crops, *kanaka* (*Colocasia* sp.) served as the cash crop, particularly in Barangay Sebucal.

The similarities in the varieties planted by the Subanens were found to be influenced by the market demand. The proximity of farms to the market centers also greatly influenced the species being planted. Because of the high cost of production and transport, high yield and profitability were topmost considerations in the choice of crop species planted.

Conclusions

The vegetation of Mt. Malindang Natural Park was a combination of nine different vegetation/forest types. The difference in forest physiognomy was attributed to the inherent effects of soil types, variations in altitude, temperature, and amount of rainfall.

Among the habitats for conservation, the most important were the montane forest in Barangay Lake Duminagat, and the almaciga and dipterocarp forests in Barangay Sebucal. Due to the presence of 14 endangered species, very high percent endemism, and prevalence of destructive farming activities, these habitats should be given utmost priority.

The forests of Mt. Malindang Natural Park, important resources for both *in situ* and *ex situ* conservation, were still rich in biodiversity. In particular, the almaciga, montane, mossy, and submontane dipterocarp forests had high species richness, diversity values, and endemism. However, the number of threatened species was likewise high due to the fast rate of land conversion and resource utilization.

As the altitude increased from 1,400 to 2,185 masl, the number of tree species decreased. However, in the case of pteridophytes, there was increased species richness as altitude increased.

RECOMMENDATIONS

Capacity Building

A sustainable approach is to build the capacity of the people in the preparation and implementation of individual household farm plans. This incorporates schemes of increasing and sustaining crop production in their current occupancy by way of correct site-crops matching, establishment of small woodlots within fallowed areas to address the need for firewood, house construction materials, and rattan for alternative livelihood and alternative ways of conserving and ameliorating soil productivity. This scheme would retain people in their present occupancy, minimizing shifting cultivation and dependence on the natural resource base.

Forest Resources Replenishment

Using seedlings from the BRP nursery study, planting of trees in forests of denuded mountains should be conducted to replenish diminishing forest resources. In line with this, forest nurseries in other *barangays* surrounding Mt. Malindang should be established to ensure the continued availability of materials for reforestation. Potential funding donors are LGUs, DENR, and NGOs concerned with the conservation of biodiversity resources of Mt. Malindang.

BIOME and CMT

BIOME activities should be continued with funding from the LGU to build the capabilities of the communities in determining changes and trend in biological diversity, and to formulate appropriate conservation management interventions. The recognition by the PAMB of the CMT in

Mansawan-New Liboron and Gandawan-Lake Duminagat is highly recommended.

Appropriate Soil Conservation Measures

Except for the *barangays* practicing agroforestry, only Barangay Lake Duminagat had shown initial evidence of soil conservation by using the *balabag* system. Most of the farmers still practiced the *kaingin* system, a farming method that strips the forest soils of nutrients for a long period of time, leaving big portions of lands unproductive. Thus, more appropriate soil conservation measures should be introduced to the local farmers to achieve sustainable production.

Regulated Harvesting

A temporary but immediate course of action is to regulate the cutting down and harvesting of trees for firewood and house construction. Harvesting of favored species should be restricted according to its abundance and location of mature individuals, as well as its rate of regeneration. Harvesting in areas with very few stands per hectare should be prohibited. This includes regulations to control the harvest of rattan, especially the immature plants, and the tapping of almaciga exudates in Barangays Sebucal and Lake Duminagat.

Trainings and Information Campaigns

The absence of site crop matching had been noted, where farmers failed to evaluate their soil characteristics and climate to fit the crop requirements. In effect, crop yield was not maximized. With the help of the Department of Agriculture, trainings on soil and climatic requirements of crops could be conducted to help farmers maximize production.

To avert the status of almaciga and to make almaciga extraction a potential livelihood opportunity, there is a need to inform and train the community on the right and sustainable tapping procedure.

To increase awareness level among the people on critical flora resources and plant diversity, there is a need to produce and distribute IEC materials, like flyers, leaflets, and the like, written in the local dialects.

Further Studies

To expand knowledge of ecosystems, further exploration and establishment of more sampling plots in the other parts of the Mt. Malindang Range Natural Park should be conducted to underpin these preliminary results.

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MORE VEGETABLES IN THE MOUNTAIN!? THE CASE OF THE BRP ARTHROPOD STUDY IN CABBAGE-GROWING AREAS IN MT. MALINDANG[1]

Mariliza V. Ticsay[2]

The Arthropod Diversity Study in Cabbage-Growing Areas on Mt. Malindang was one of the open research projects under the Philippines-Netherlands Biodiversity Research Programme (BRP) for Development in Mindanao: Focus on Mt. Malindang and its Environs. Open researches or "action researches" were implemented in order to fill in gaps in understanding the landscape not covered by the master projects (i.e., Terrestrial Ecosystem Master Project [TEMP], Aquatic Ecosystem Master Project [AMP], and Socioeconomic and Cultural Studies [SECS] Master Project). These studies were more specific and placed increasing emphasis on social and policy researches, including people/migration, information, labor, and matter (products and sediments); policy and eco-governance; and identification of sustainable livelihood strategies.

The Arthropod Diversity Study was conducted by a research team from the Mindanao State University (MSU)-Marawi, Municipal Agricultural Office (MAO) of the Department of Agriculture (DA), and farmer-residents of three upland *barangays* in the Municipality of Don Victoriano, Misamis Occidental, which also sits right on the Mt. Malindang Range Natural Park (MMRNP) – a protected area.

Vegetables were important sources of income for upland farmers, and the upland communities of Mt. Malindang were important producers and suppliers of vegetable and root crops in the four provinces of Misamis Occidental, Zamboanga del Sur, Zamboanga de Sibuguey, and Zamboanga del Norte. Cabbage (*Brasicca* sp.) was the main cash crop because of its high economic return, great market demand, and ease of production provided by the favorable climate in Mt. Malindang. Next to cabbage were onions, sweet peppers, snap beans, potato, pechay, and chayote – the latter was the most profitable because it does not require fertilizer or pesticide inputs.

Intensification of vegetable production in these upland communities had led to heavy reliance on fertilizers and pesticides to obtain high yields and control insect pests. Upland farmers may earn little, as the cost of chemical inputs takes a significant portion of their sales.

Cabbage farmers realized that cabbage is prone to pests if repeatedly planted in the same area/location. Farmers who could not afford to buy these inputs simply avoided the pests by moving on to new areas, thereby opening new plots – akin to shifting cultivation or swidden agriculture. More significantly, Mt. Malindang cabbage farmers also observed that cultivating newly opened steep areas along forest margins was a more effective strategy of pest avoidance. This had "evolved" into an indigenous knowledge system (Figure 1).

The Arthropod Diversity Study was originally implemented to assess the diversity of insects and other economically important arthropods in the upland vegetable-growing areas of Mt. Malindang (i.e., an inventory), with the specific objective of identifying the major insect pests attacking cabbage and the pest's natural enemies.

The inventory indicated the presence of four arthropod classes: Crustacea (sow bugs and scuds), Arachnida (spiders and mites), Diplopoda (millepedes), and Insecta (insects). The diamond-back moth (DBM) [*Plutella xylostella* (Linn.)] was identified to be the primary pest of crucifers like cabbage (Figure 2). Minor pests were also identified - common cutworm *(Spodoptera litura)*, black cutworm *(Agrotis ypsilon)*, green peach aphid *(Myzus persicae)*, and otiorrhynchine weevil.

Focus group discussions (FGDs) also confirmed the earlier reports that cabbage farmers had abandoned the flat and low-lying areas in their villages in favor of the steeper (20°-40°) slopes along forest margins.

[1] Paper presented during the Executive Training Course on Natural Resource Management in a Globalizing Asia. 8-12 May 2006, SEARCA, Los Baños, Laguna.

[2] Programme Coordinator, National Support Secretariat, Biodiversity Research Programme for Development in Mindanao: Focus on Mt. Malindang and its Environs. SEARCA, College, Laguna.

Figure 1. Cabbage plots in sloping areas.

Figure 2. The diamond-back moth.

With these initial research results, the lead researchers moved to investigate further this indigenous pest management practice of planting on steep slopes near the forests to minimize pest damage. The ultimate goal was to identify possible solutions to the pest problem with minimal use of chemical inputs (e.g., Integrated Pest Management, preferably indigenous IPM) to help the farmers improve their income, and of course, forest conservation by minimizing the adverse effects of swidden agriculture and further encroachment of mountain slopes and the remaining natural forests in the area.

A detailed analysis of the inventory (species composition and richness) indicated that although arthropod populations from the three sites did not differ significantly, spiders dominated the predatory guild. Field trials (i.e., in cabbage farms) using different pesticide treatments also indicated that farms near the forests harbored significantly more spiders than the sprayed and unsprayed cabbage farms. Moreover, results indicated that the average cabbage yield was also correlated with spider number.

It seemed like, without really knowing why (i.e., that farms near the forest would have higher arthropod diversity and abundance, particularly of parasites and predators, compared to those farther away), cabbage farmers made use of certain basic observations and knowledge to their advantage, calling it an indigenous pest management tactic.

At any rate, further study in the field by the lead researchers yielded various recommendations including technologies and new practices like conserving beneficial organisms such as spiders, the bagging of cabbage seedlings for increase survival during transplanting, and the use of chicken dung as fertilizer supplement.

ISSUES FOR FURTHER DISCUSSIONS

With these research results and recommendations, there could at least be two scenarios if farmers opt to use the information:

(1) More farmers will produce cabbage in the low/flat areas (with IPM), perhaps even converting more areas for cabbage production.

(2) If there is not enough, more slopes on forest fringes (which have been proven to have less pest occurrence) will be opened, too.

The research results may be helping the farmers lower their production costs and increase their income by launching IPM in the area, but have the same results of well-meaning researchers and development workers stopped forest encroachment?

We might just end up having more cabbage than trees, more vegetable farms than forests, on the Mt. Malindang Range Natural Park after the BRP has ended. But then again, we can also hope that farmers may just opt to cultivate the low flat areas. After all, steep slopes are harder to climb!

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EX SITU CONSERVATION OF SOME ECONOMICALLY IMPORTANT, RARE, AND ENDANGERED PTERIDOPHYTES[1]

Cecilia B. Amoroso[2]

Introduction

The Philippines, known for its high floral diversity, has about 1,907 species of pteridophytes (Amoroso 2000). Some of these plants are endemic, rare, endangered, and most are economically important species.

Uses of pteridophytes
a. as ornamental plants
b. source of medicine
c. some as sources of food
d. building materials
e. potting medium
f. some as raw materials for handicraft manufacture

The economically important species can be managedd to contribute, in a way, to socioeconomic progress of the country, especially in the rural areas, through the development of 1) pteridofarms for ferns as cash crops; 2) cottage industry for ferns with handicraft potentials for export; 3) plantations for medicinal ferns; and 4) commercial gardens for ornamental plants (Amoroso 1998).

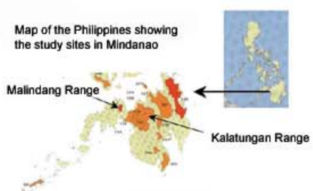
These species are threatened due to overharvesting and continuous destruction of their natural habitats. There are strategies for *ex situ* conservation of these plants: propagation in the greenhouse and through *in vitro* culture (Ramanatha Rao and Arora 1999).

Objective

The research study was conducted for the *ex situ* conservation of some economically important, rare, and endangered pteridophytes found in selected fprests of Mindanao through *in vitro* culture and their propagation in the greenhouse.

Methodology

A. Representatives of some economically important, rare, and endangered pteridophytes were collected from selected forests of Mindanao, Philippines.



Kalatungan Range Natural Park
Pangantungan, Bukidnon

Altitude: 2,824 masl
Area: 21,31.34 ha
Lowland dipterocarp forest, lower and upper montane forests
Inhabited by Manobos and Talaandigs

Kalatungan Range showing research sites (*)

Malindang Range showing research sites

Malindang Range, Don Victoriano,
Misamis Occidental

Highest elevation: 2,424 masl
Area: 53,262 ha
With crater lake and rivers, agroecosystem, lower and upper montane forests
Inhabited by Subanens

B. Flow Chart (*In Vitro* Cuture)

Collect spores
↓
Air dry
↓
Sterilize spores with 10% sodium hypochlorite (3 min.)
↓
Rinse in distilled water 3x
↓
Inoculate in:
↓
T_0 - spore culture medium only
↓
T_1 - spore culture medium + 2% glucose
↓
Monitor cultures once a week

Abstract

In Mindanao, Philippines the remaining known forests are continuously threatened by their conversion into agricultural farms, human settlement areas, and overharvesting of minor forest products (wild ornamentals, medicinal plants, etc.). Some of these plants are economically important, rare, and endangered. Thus, there is a need to conserve them before they are totally wiped out. This study aimed for the *ex situ* conservation of some economically important, rare, and endangered pteridophytes by propagating them in the greenhouse and through *in vitro* culture.

Some economically important, rare, and endangered pteridophytes were collected from selected forests in Mindanao (Mt. Malindang, Misamis Occidental; Mt. Kalatungan, Pangantucan, Bukidnon; and Mt. Calo-calo, Lourdes, Kalatungan Range, Bukidnon). Those which have been successfully propagated in the greenhouse of the Department of Biology, Central Mindanao University, Musuan, Bukidnon are: *Ophioglossum petiolatum* Linn. (rare, ornamental), *Ophioglossum pendulum* Linn. (ornamental), *Ophioglossum reticulatum* Linn. (medicinal), *Botrychium daucifolium* Wall (rare, ornamental), *Lycopodium magnusianum* Hert. (rare, endangered, endemic, ornamental), *Lycopodium phlegmaria* Linn. (rare, ornamental), *Lycopodium nummularifolium* Blume (ornamental), *Tmesipteris lanceolata* Dang (endngered), *Lycopodium clavatum* Linn. (ornamental), *Lycopodium cernuum* Linn. (ornamental), and *Huperzia serrata* Thunb. (medicinal, ornamental).

In vitro cultured spores of *Lycopodium clavatum* in T1 (spore culture medium + 2% glucose) formed gametophytes and eventually sporophytes. Likewise, *in vitro* cultured *Lycopodium cernuum* in T1 also formed sporophytes.

The results showed that propagation in the greenhouse and through in vitro cultures are two strategies for the ex situ conservation of some economically important, rare, and endangered pteridophytes.

Direct Planting of Some Pteridophytes to Various Potting Media in the Greenhouse/Femery of the Department of Biology, Central Mindanao University, Musuan, Bukidnon, Philippines

Species	Potting Medium Used
A. Fern Allies	
Lycopodium clavatum Linn. and *Huperzia serrata* (Thunb.) *Trevisan*	Garden soil, soil from its natural habitat (1:1) mixed thoroughly
Lycopodium magnusianum Hert. and *Lycopodium phlegmaria* Linn.	Advantitious roots of *Cyathea* and sawdust (1:1)
Lycopodium nummularifolium Bl.	Sawdust
Tmesipteris lanceolata Dang	Adventitious roots of *Cyathea*
B. Ferns	
Epiphytic ferns (*Platycerium grande* (Fee) Presl., *Ophioglossum pendulum* Linn., and others)	Adventitious roots of *Cyathea*
Terrestrial ferns (*Botrychium daucifolium* Wall., *Ophioglossum petiolatum* Linn., *Ophioglossum reticulatum* Linn., and others)	Garden soil

Results and Observations

A. In Vitro Culture

Sporophytes (plantlets) arising from *in vitro* cultured spores of *Lycopodium cernuum* Linn.

Sporophytes (plantlets) arising from *in vitro* cultured spores of *Lycopodium clavatum* Linn.

Sporophytes (plantlets) arising from *in vitro* cultured spores of *Platycerium grande* (Fee) Presl.

Plantlets of *Platycerium grande* (Fee) Presl. transferred to potting medium

Plantlets of *Lycopodium cernuum* Linn. in (a) sawduct and (b) graden soil

B. Some Pteridophytes Propagated in the Greenhouse/Fernery

List of Some Pteridophytes in the Greenhouse/Fernery Showing their Place of Collection and Status

Family	Species	Place of Collection	Status
Fern Allies: Psilotaceae	*Tmesipteris lanceolata* Dang	Mt. Kalatungan, Pangantungan, Bukidnon, and Mt. Malindang, Don Victoriano, Misamis Occ.	Endangered, economically important
Lycopodiaceae	*Lycopodium magnusuanum* Hert.	Mt. Malindang	Rare, endemic, economically important
	Lycopodium nummularifolium Bl.	Mt. Malindang; Mt. Calo-calo; Kalatungan Range, Bukidnon	Economically important
	Lycopodium phlegmaria Linn.	Mt. Malindang; Mt. Kalatungan	Rare, economically important
	Lycopodium clavatum Linn.	Mt. Malindang	Common, economically important
	Lycopodium cernuum Linn.	Mt. Malindang	Common, economically important
Ferns: Cyatheaceae	*Cyathea contaminans* (Hook) Copel.	Mt. Malindang; Mt. Kalatungan	Common, economically important
Marattiaceae	*Angiopteris palmiformis* (Cav.) Chr.	Mt. Malindang; Mt. Kalatungan	Common, economically important
Ophioglossaceae	*Ophioglossum petiolatum* Linn.	Mt. Malindang	Rare, economically important
	Ophioglossum pendulum Linn.	Mt. Malindang; Mt. Kalatungan	Common, economically important
	Ophioglossum reticulatum Linn.	Mt. Malindang	Common, economically important
Polypodiaceae	*Platycerium grande* (Fee) Presl.	Mt. Malindang	Endemic, economically important

Tmesipteris lanceolata Dang
Endangered

Lycopodium magnusianum Hert.
Rare, endangered, endemic, ornamental

Lycopodium nummularifolium Bl.
Ornamental

Lycopodium phlegmaria Linn.
Rare, ornamental

Cyathea contaminans (Hook.) Copel.
Ornamental

Huperzia serrata (Thunb.) Trevisan
Medicinal, ornamental

Lycopodium clavatum Linn.
Ornamental

Angiopteris palmiformis (Cav.) Christen.
Edible, ornamental

Ophioglossum petiolatum Linn.
Rare, ornamental

Ophioglossum pendulum Linn.
Ornamental

Ophioglossum reticulatum Linn.
Medicinal

Botrychium daucifolium Wall.
Rare, ornamental

Platycerium grande (Fee) Presl.
Endemic, ornamental

Summary and Conclusion

It has been observed that these economically important, rare, and endangered pteridophytes could grow well outside of their natural habitats and easily propagated either through *in vitro* culture and through their propagation in the greenhouse/femery as *ex situ* conservation strategies.

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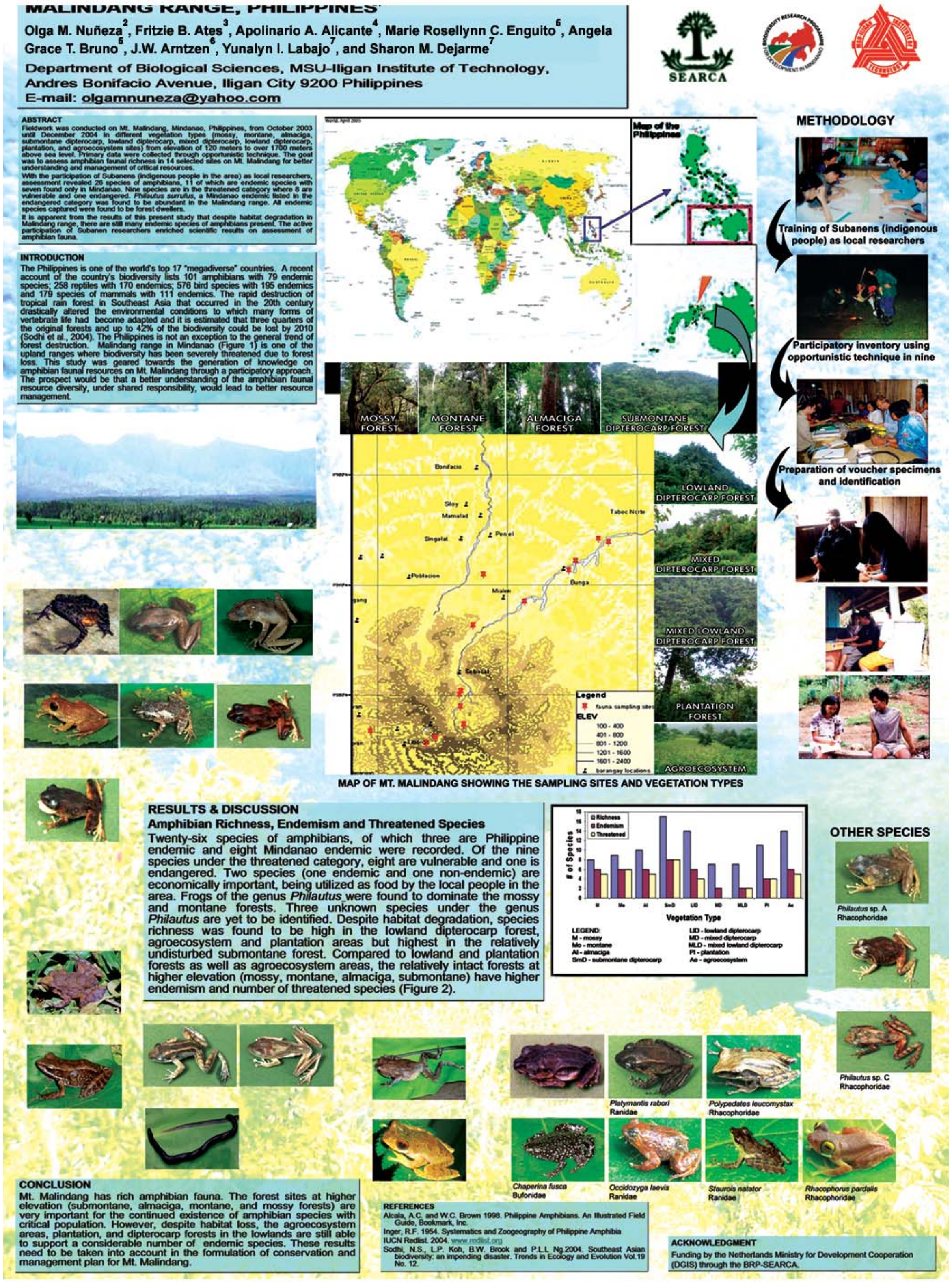

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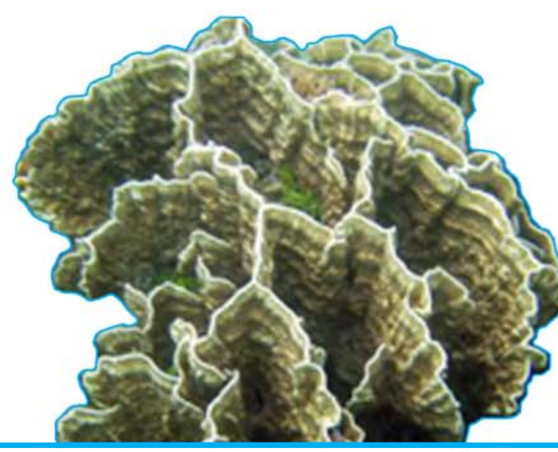
Water



A LIMNOLOGICAL SURVEY OF LAKE DUMINAGAT, MT. MALINDANG NATURAL PARK, MISAMIS OCCIDENTAL[1]

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Lake Duminagat is a crater lake located in Mt. Malindang Natural Park, which is one of the Protected Areas in the Philippines. Two communities are adjacent to it - Barangays Lake Duminagat and Gandawan, which are both within the Municipality of Don Victoriano, Province of Misamis Occidental. The Municipality of Don Victoriano is wholly circumscribed by the park. The plant and animal species that inhabit the park represent the flora and fauna of the Zamboanga biogeographic zone. This paper focuses on characterizing the limnology of Lake Duminagat - its morphology, its physico-chemical components, and its biota.

The area of study consisted of valleys and mountains, Barangays Gandawan and Lake Duminagat, and the lake basin considered as crater valleys, surrounded by varyingly tall mountains. Being at a high elevation (~1,240 to 1,560 meters above sea level or masl), the climate in the Lake Duminagat area was cooler compared to the lowlands. The area belonged to the region classified as Intermediate B type - no very pronounced maximum rain period and no dry season, with an annual rainfall of 2,099 mm. Lake Duminagat is a small lake, with an area of 8.04 hectare (ha), maximum depth of 20.95 m, water volume of 933,000 m^3, mean depth of 11.6 m, shoreline length of 1,060 m, and shoreline development of 1.054. It was a thermally stratified lake; though whether it undergoes periodic mixing was not determined. The water was low in alkalinity and was very soft. The water at the middle of the lake was potable enough to be used as drinking water at various times of measurement. Its various morphometric and physico-chemical characteristics, such as low surface area to volume ratio, low lake area to watershed area ratio, low alkalinity, and low amount of dissolved solids, all contributed to its low productivity. Its macrophytes (representing one component of primary productivity) and zooplankton (representing secondary productivity) population were thus low in numbers, aside from being limited in number of species. Consequently, the fish population, which is at the top of the aquatic food chain, was also low in kind, number, and biomass. Nonetheless, the lake supported a high diversity of indigenous shoreline fauna and flora. Considering the lake's characteristics and that of its surrounding community, one potential for the Lake Duminagat area was its use for ecotourism, with the local people being the hosts-entrepreneurs.

The project, from which this paper was derived, was one of the projects in the Philippines-Netherlands Biodiversity Research Programme (BRP) for Development: Focus on Mt. Malindang and Environs. It utilized the participatory approach, one aspect of which was the involvement of some people in the local community as local researchers or local partners. It is hoped that involvement in this research gave the local researchers and the community an awareness of the natural and social factors that determine/affect the Lake Duminagat ecosystem. It is also hoped that results of this research would be used and would empower the local communities to come up with a strategy of conserving and sustainably utilizing the lake's biodiversity and resources so as to improve livelihood and cultural opportunities.

INTRODUCTION

Mt. Malindang was declared a National Park and Watershed Reservation in 1971, covering 53,262 ha of the Malindang Range, per Republic Act (RA) 6266. Following the law on the National Integrated Protected Areas System (NIPAS), RA 7586 of 1992, it was declared a Natural Park in 2000. Its boundary was re-surveyed and the park proper was determined now to be 34,464 ha; the remaining area out of the original being proposed as a buffer zone.

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During the pre-implementation phase of the BRP, Lake Duminagat was identified as of great interest among the freshwater ecosystems in Mt. Malindang. It was biologically significant as a water source for flora and fauna, as an area of high species diversity, and, in cultural terms, as a sacred place for the Subanen (BRP 2000). It was a destination site of local tourists, especially during the summer months. The region is one of the last areas representing the flora and fauna of the Zamboanga biogeographic zone (DENR and UNEP 1997).

The high-altitude lacustrine ecosystem of Lake Duminagat was one of those comprising the diversity of ecosystems in Mt. Malindang. Adjacent to the lake were two villages or *barangays*: Barangay Lake Duminagat, where the lake is located, and Barangay Gandawan, both of the Municipality of Don Victoriano, Misamis Occidental. Most of the residents of Barangay Lake Duminagat were settled in the *centro*, about an hour walk from the lake, while the residents beside the lake itself consist of only five households. Almost all of the Barangay Lake Duminagat residents considered themselves to be Subanen. The Subanen is an indigenous group who had lived in parts of the Zamboanga Peninsula starting from pre-Hispanic times, one group of which had lived in the Mt. Malindang area. Although the Subanen had their own traditional customs and practices, they had become more or less enculturated by the influence of Bisayan and western cultures, brought about by Bisayan settlers/businessmen and mass media.

The residents of both villages believed that the lake was important as a water source for domestic use, as well as a source of “healing water”. Many people go to the lake to take water in bottles and use it for healing. Others go to there during Holy Week and take a bath there as treatment for their illnesses. The community agreed that it would be beneficial and informative to have studies done on the lake and its shoreline flora so as to explain its perceived mysteries. They believed that as Subanen natives (most of them had resided in the area since 1960), they inherited the lake discovered by their ancestors. Thus, they were compelled to take care of the lake and conserve it for posterity. They were willing to impart any information they might have on the lake and its surroundings. Likewise, they expressed their desire to obtain information from the research (Cati *et al*. 2002, personal communication).

A new paradigm for resource management is integrated multidisciplinary science, management, and education outreach efforts (Crosby *et al.* 2000). This involves the participation of the academic community to do research to provide new understanding of the structure, ecological processes, and impacts on natural resources upon which the manager bases the policies, and for the agencies to educate the public. Likewise, the local community participates in the research process from problem analysis to designing solutions to achieve sustainable resource use and development. These participatory approaches had been developed for coastal resource management (e.g., IIRR 1998, Crosby *et al.* 2000) and for various development projects, though the results may vary depending on the extent/degree of participation by the community. Following the principle of participatory action development, it is hoped that this research (the diagnosing phase) would lead to the experimenting and sustaining phases, possibly collaborative management of this protected area with the Subanen community.

The overall objective of this project was to determine the biodiversity status and potentials of Lake Duminagat through participatory research methods, focusing on its limnology.

METHODOLOGY

Participatory Methodology

The first step in the involvement of the community was for the researchers to follow the entry protocol. Entry to the community was carried out by making courtesy calls on the mayor of the Municipality of Don Victoriano, the *barangay* captains of Barangays Gandawan and Lake Duminagat, and the *timuay* (Subanen religious leader) of Barangay Lake Duminagat. A community meeting was held to present both the BRP and the Lake Duminagat project.

Appropriate permits were obtained from the Office of the Mayor and from the Department of Environment and Natural Resources Protected Areas Wildlife Bureau (DENR PAWB). Prior informed consent was also obtained from the two *barangays*.

The participatory methodology used may be referred to as Participatory Biodiversity Assessment (Steinmetz 2003). Various participatory tools and techniques were utilized – the participation of local people as local researchers, key informant interviews, focus group discussions, participant observation, Venn diagram, and community meetings for consultation and validation. The local partners were trained on field research and limnological research work, and were involved in studying the lake and its biodiversity.

At the end of the research, the results were presented and discussed to the community.

Lake Characterization

Morphology

A lake's morphology could best be described by a detailed bathymetric map, which is needed for the determination of all other morphometric parameters. A detailed bathymetric map shows the shape of the lake and its bottom contours at various depths. This involved an engineering survey so as to be able to determine the location of various points in the shoreline and the location of various points in the lake at which the depth was measured.

The bathymetric map was drawn to scale with the data gathered by the survey. Radial chords were drawn at 20-m incremental radii, and then the magnetic gradients were drawn on the corresponding chords, the water depth was then recorded on the intersectional points. Lines connecting the same depth were drawn beginning with the shoreline (0 m depth) and at increasing depths in 5-m intervals, producing the 5-m, 10-m, 15-m, and 20-m depth contour lines. The radial chord lines, locations at the shoreline, and the points at which the water depths were measured are shown in Figure 1.

Based on the bathymetric map, the following major morphometric parameters of the lake were measured and/or calculated: area, volume, shoreline length, shoreline development, maximum length, maximum width, maximum depth, mean depth, and relative depth. The formulas came from Lind (1985), Wetzel (1983), and Wetzel and Likens (1978).

The area of the surface and each contour at depth z was determined using a planimeter. The volume of the lake is the integral of the areas of each stratum at successive depths from the surface to the point of maximum depth. This was approximated by calculating and summing the volumes of conical segments (frusta), with upper and lower surfaces delimited by the areas of sequential depth contours. The calculation is then:

$$\text{Lake volume} = \Sigma \text{ Frustum volumes}$$

where:

$$\text{Frustum volume} = h/3\,(A_1 + A_2 + \sqrt{A_1 A_2})$$

h = depth of frustum

A_1 = area of frustum surface

A_2 = area of frustum bottom

The volume of the last stratum was calculated as a cone (cone volume = $1.047\ r^2h$).

In the absence of a cartometer, the shoreline length (S) was measured simply with a string, having predetermined the scale of the bathymetric map.

Shoreline development (SD) is an index of the regularity of the shoreline. It is the ratio of the length of the shoreline to the circumference of a circle with area equal to that of the lake.

$$SD = S/2\sqrt{\pi A}$$

Very circular lakes would approach the minimum shoreline development value of 1.

Maximum length (l) is the longest straight line that may be drawn without intersecting any mainland. This length is the maximum effective length or fetch for wind to interact on the lake without land interruption.

Maximum width or breadth (b) is the maximum distance on the lake surface at a right angle to the line of maximum length.

The mean width is equal to the area divided by the maximum length.

Maximum depth (z_m) is the greatest depth of the lake.

Mean depth ($\bar{z}$) is calculated from the volume divided by its surface area.

Relative depth (z_r) is the ratio of the maximum depth as a percentage of the mean diameter of the lake at the surface, expressed as a percentage.

$$z_r = 50\ z_m \sqrt{\pi}/\sqrt{A}$$

Physico-chemical Characteristics

The physical factors measured in the lake included the following: temperature, visibility (transparency), and turbidity. A vertical temperature profile was obtained by measuring water temperature at various depths at 1-m intervals. When presented as a depth-temperature plot, this would show whether the lake exhibits temperature stratification. Temperature was measured with the use of a dissolved oxygen (DO) meter (Oxi 330/SET, WTW), which also had a sensor for temperature.

Visibility or transparency is a measure of the depth to which one may see into the water. This is commonly measured as Secchi disk visibility/transparency, with the numerical value termed as Secchi depth. The Secchi disk used was improvised, made of wood 20 cm in diameter, with the

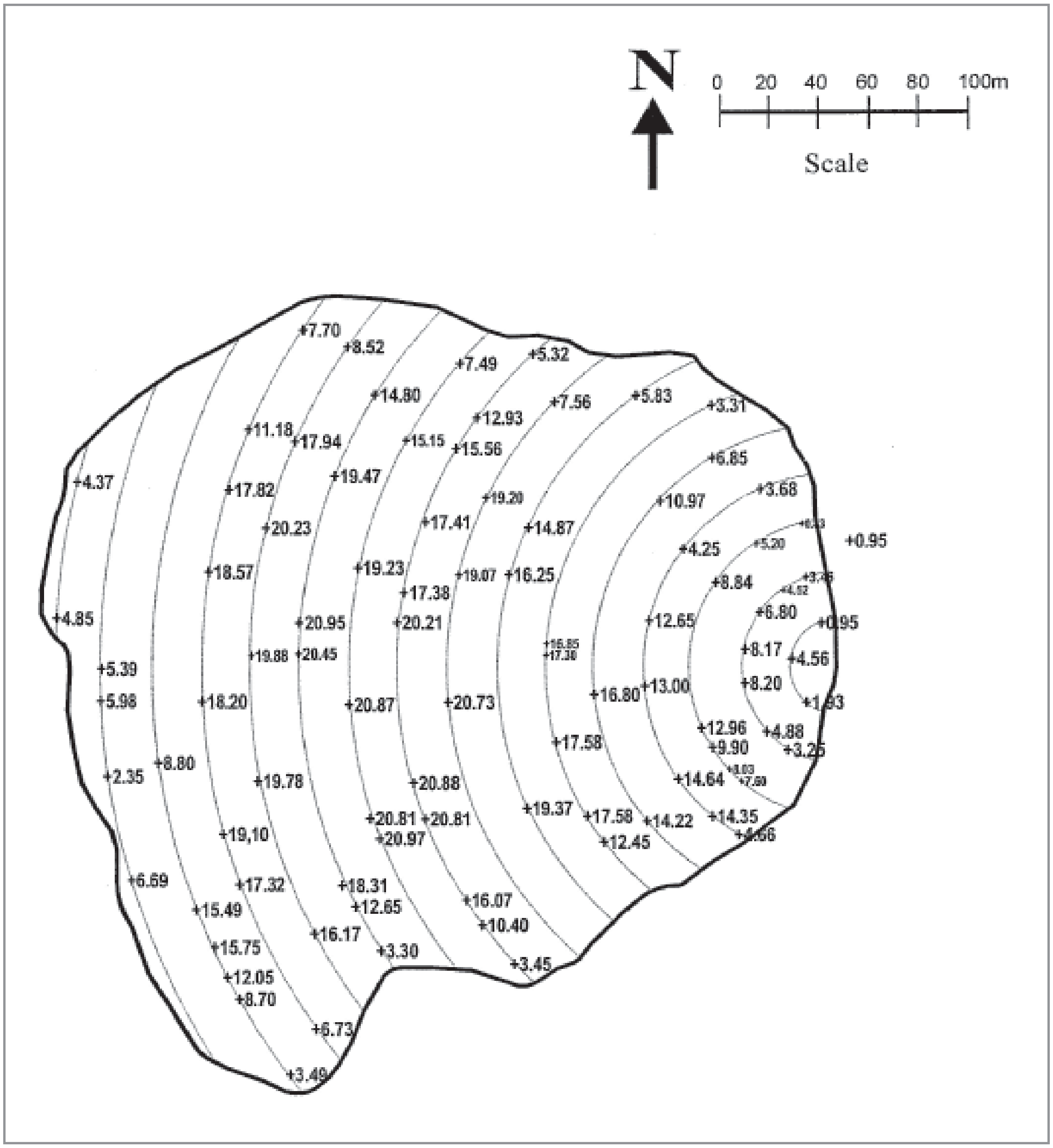

Figure 1. Bathymetric map showing the radial chord lines.

surface painted gloss white and gloss black in opposing quarters. The clearness of the day, position of the sun, time, and the observer were also recorded as these affect the Secchi disk readings.

Water turbidity is affected by the presence of suspended solids, which reduce the transmission of light either through scattering or absorption. Water samples were brought to the Iligan City Waterworks System for turbidity determination, which was expressed in nephelometer turbidity units (NTU).

The chemical characteristics of lake water included the quantification of the following: dissolved oxygen, salinity (if present), pH, total alkalinity, total hardness, nitrate-nitrogen, total phosphorus, total suspended solids (TSS), and total dissolved solids (TDS). Dissolved oxygen and salinity were determined on site. The other factors were analyzed by the Iligan City Waterworks System (pH, total alkalinity, total hardness, and TDS) and by the Department of Science and Technology Regional Office X (DOST-R.O.10) in Cagayan de Oro City (nitrate-nitrogen, total phosphorus, and TSS). Just prior to leaving the research area, water samples for chemical analyses were collected in bottles previously used for distilled drinking water (rinsed first with the water sample). These were placed in a styrofoam container with ice (approximately 4^{o}C) during transport. Upon arrival in Iligan City, they were submitted to the Iligan City Waterworks System for analyses. Other samples were brought further to Cagayan de Oro City and submitted to the DOST-R.O.10 laboratory for analyses.

Dissolved oxygen content of the water obtained at various depths was measured in order to get a vertical dissolved oxygen profile. The water sample was obtained at 1-m intervals with a Kemmerer water sampler, made to flow into a BOD bottle, then its dissolved oxygen measured by a DO meter. Care was taken that the DO content in the water was not changed.

The salinity of inland waters is generally very low in comparison to that of the sea. Salinity was measured using a refractometer (Atago S/Mill-E, Salinity 0~100 ^{o}/oo). The pH of the lakewater should ideally be measured on site. In the absence of a portable pH meter, this was determined on the water samples brought to the Iligan City Waterworks System.

Total alkalinity was determined using titrimetric method, with methyl orange as indicator. It was expressed in terms of mg per liter $CaCO_3$. Total hardness was determined on the water samples brought to the Iligan City Waterworks System.

Inorganic nitrogen in the form of nitrate was measured using Method 53, Spectroquant 118, Merck. Total phosphorus was analyzed using 4500-P D. Stannous chloride method, Standard Methods for the Examination of Water and Wastewater, APHA, AWWA, WEF, 1995 (H_2SO_4-HNO_3 digestion).

TSS was determined using 2540 D. Gravimetric method, Standard Methods for the Examination of Water and Wastewater, APHA, AWWA, WEF, 1995. The method involved filtering a known volume of water (usually 100 ml) through a pre-dried and pre-weighed filter paper (hard-finish filter paper for fine precipitates or 0.45 um membrane filters). The filter paper was dried overnight in an oven at 103^{o}C and weighed. The difference in weight of the filter was taken and expressed as mg per liter. TDS was determined on water samples brought to the Iligan City Waterworks System and was expressed in ppm.

Bacteriological Analyses

The bacteriological analyses of water is mainly done to determine its potability rather than as an inventory of the bacterial population of the water. Bacteriological analyses were done on the surface water samples taken from approximately the middle of the lake where the lakeshore residents get their drinking water. The Iligan City Waterworks System water laboratory did the analyses. Heterotrophic plate counts were determined and the coliform test was performed. The coliform test consisted of three tests: the presumptive test (which made use of the multiple-tube fermentation technique), the confirmed test, and the completed test.

Plankton

An integrated vertical sample of plankton was obtained by lowering a plankton net with a 25-ml bucket (119 mm mesh size; 24.5 cm mouth diameter) to almost the bottom (about 19 m) and hauling it vertically. Mostly zooplankton was obtained. The concentrated plankton sample in the bucket was poured into a bottle (amber) and preserved with Lugol's iodine to make a one percent final concentration (about the color of weak tea). (Zooplankton should preferentially be preserved with 10% neutral formalin to make a final 4-5% concentration [Lind 1985]).

In the laboratory, 1-ml aliquot samples were examined under the microscope using a Sedgwick-Rafter counting cell for the identification and enumeration of the zooplankton species. Total count was made for each species in the 1 ml of water. These data were converted back to the number in the unconcentrated lake water by using the formula as follows:

$$\text{Organisms per liter of lake water} = \frac{\text{Organisms per ml of concentrate x 100}}{\text{Concentration factor}}$$

where

$$\text{Concentration factor} = \frac{\text{Volume of lake water filtered (ml)}}{\text{Volume of concentrate (ml)}}$$

Volume of lake water filtered was obtained by multiplying the mouth area of the plankton net (pr^2) with the actual depth through which the net was towed.

Aquatic Fauna

Lake fishes were collected using the residents' traditional fishing methods, namely, fish traps or *bubu*, and hook and line. A mosquito net was dragged around to catch whatever pelagic organisms were there. For benthos, an Ekman dredge was used to collect sediments from various points of the lake, specifically two replicate samples from the middle of the lake (20.4 m depth) and near the shore. Sampling near the shore proved to be difficult because of the large number of dead trees that had fallen and accumulated at the bottom. Thus, a nearshore sample was not taken. The sediment obtained was sieved successively through sieves of mesh size 4, 8, and 12 (0.203 in, 0.097 in, and 0.060 in, respectively, as marked in the sieves; six-hundredth inch is approximately 1.5 mm). The concern of this study was the macrobenthic invertebrates visible to the naked eye. Collected animal specimens were documented by photographs.

Aquatic Flora

The sampling stations for the aquatic flora, in particular, the submerged macrophytes, were the same as those for the shoreline flora by extending the station to the lake's littoral area. Stations 1 and 2 were near the residential houses in the east, then going on to the other stations in a counter clockwise direction.

At each station, a 1 x 1 m quadrat was laid out in the lake's littoral, and species density counts were determined. Local names and local uses, if any, were recorded for each plant. For plants whose local names were not known to the local researchers, the specimens were referred to key informants. Representative plants were collected, photographed, and prepared into herbarium voucher specimens.

Data Collation and Analysis

Species Diversity

Ratios between the number of species and "importance values" (number, biomass, productivity, etc.) of individuals are called species diversity indices. One index is the Shannon function or H index, which combines the species richness/variety and evenness/equitability components of diversity as one overall index of diversity. The Shannon index of general diversity was calculated using the formula:

$$H = - S\ n_i/N \log n_i/N$$

where: n_i = importance value for each species (e.g., number of individuals)
N = total of importance values

The Shannon index of diversity was calculated for the zooplankton.

Species Identification

Fresh and preserved specimens were used for species identification. Manuals, pictorials, and books were referred to (e.g., Fassett 1957, Hotchkiss 1972, Madulid 2000, Mamaril 1986, and Merrill 1912). Keying out was difficult for some plant specimens because of the absence of reproductive structures. Resource persons in Central Mindanao University working in the biodiversity research of Dr. Victor B. Amoroso and Dr. Jose B. Arances were consulted. The collection of the ITBACS Museum of Central Mindanao University was also utilized as reference.

RESULTS AND DISCUSSION

Lake Characteristics

Morphology

A lake's morphology, which was best described by a detailed bathymetric map, had important effects on nearly all of the physical, chemical, and biological parameters of lakes. The bathymetric map of Lake Duminagat is shown in Figure 2. The measured and calculated morphometric chararacteristics are shown in Table 1.

Lake Duminagat is a small lake with a surface area of only 80,400 m^2 or 8.04 ha (0.0804 km^2). Its maximum depth of 20.95 m was about at the middle of the almost circular lake. Its shoreline development (SD) was 1.054. Shoreline development is an index of the regularity of the shoreline. Thus, very circular lakes would approach the minimum

Table 1. Morphometric characteristics of Lake Duminagat.

8°18'N, 123°37' E		Depth (m)	Area ($m^2 \times 10^3$)	Percent (%)	Stratum (m)	Volume $m^2 \times 10^3$	Volume %
Area	80,400 m^2	0	80.4	100.0	0 - 5	367.73	39.41
Maximum depth	20.95 m	5	66.9	83.2	5 - 10	291.75	31.27
Mean depth	11.6 m	10	50.2	62.4	10 - 15	203.26	21.79
Relative depth	6.5%	15	31.8	39.6	15 - 20	69.63	7.46
Length of shoreline	1,060 m	20	2.0	2.5	20 - 20.95	0.63	0.07
Shoreline development	1.054	20.95	0				
Maximum effective length	345 m						
Maximum effective width	285 m						
Mean width	233 m						
					Total	933.00	100.00

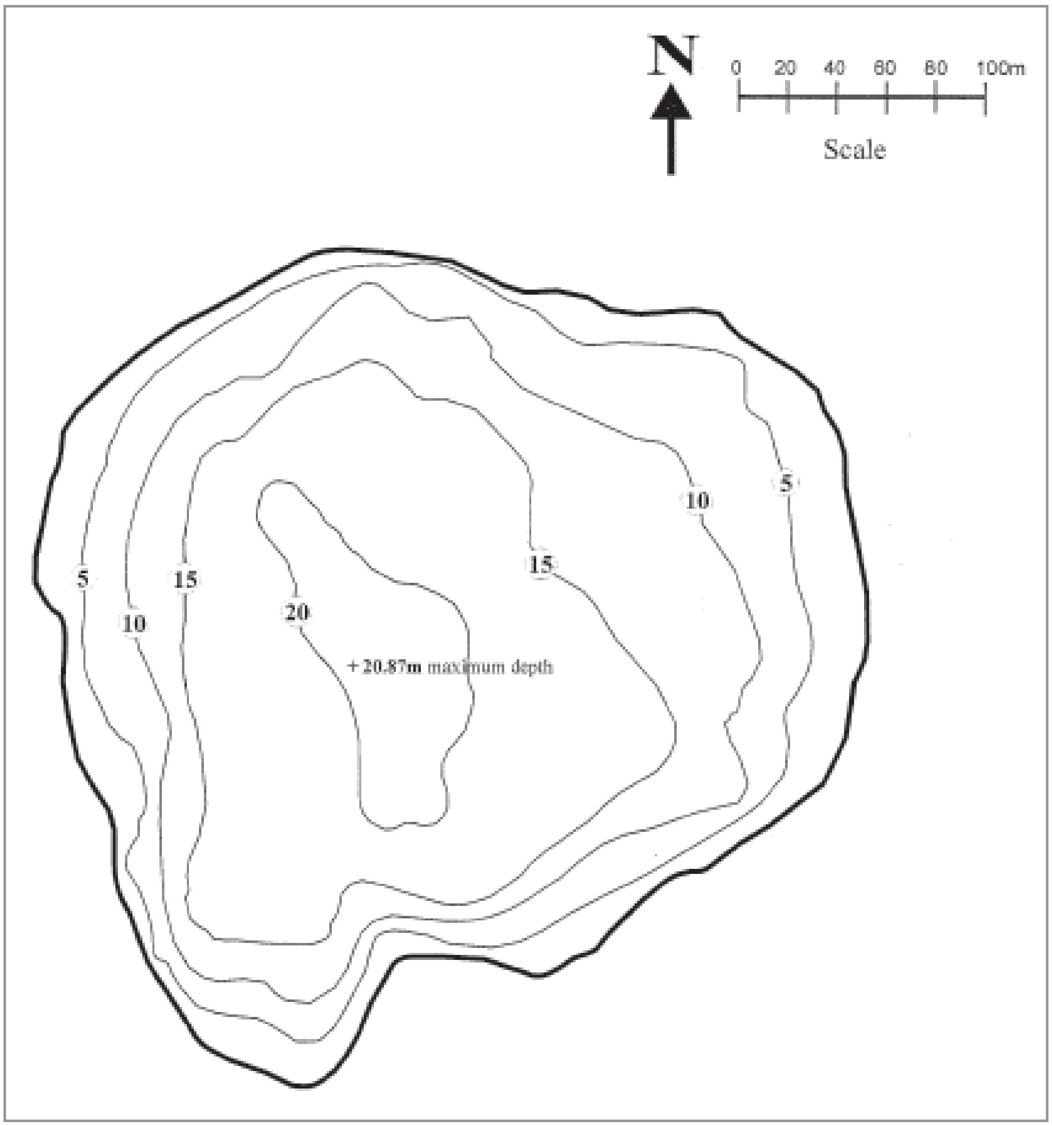

Figure 2. Bathymetric map of Lake Duminagat.

shoreline development value of 1. The SD of Lake Duminagat was very close to unity, showing its almost circular shape and implying the limited extent of its littoral zone. At some places, there was an abrupt increase in depth so that the 5-m depth contour line was quite close to the shore. This was true at the northern side of the lake where the forested perimeter occurs. The limited littoral zone substrate bed was soft and muddy. One would find the substrate/mud up to midshin if one inadvertently stepped on it. The significance of shoreline development was that it reflects the potential for greater development of littoral communities in proportion to the volume of the lake (Wetzel 1983). Because of the small value for shoreline development of Lake Duminagat, the amount of aquatic macrophyte community, as observed, was low.

The lake had a small surface area relative to its volume, thus it had a relatively large value for mean depth (11.6 m). Mean depth is generally considered as a reliable morphometric indicator of trophic conditions with it being inversely related to production (Wetzel 1983). Thus, the large mean depth of Lake Duminagat was another indicator of its low productivity (oligotrophy). When the mean depth was divided by maximum depth, the value for Lake Duminagat was 0.55. Apparently, this value was a reflection of the shape of the lake basin. Likens (1985) cited the value for Mirror Lake (North Hampshire) of 0.52, which was higher than for many kettle lakes and was characteristic of ellipsoid basins.

The larger the surface area relative to its volume, the greater is the amount of gas exchange and mixing due to winds. The relatively small surface area of Lake Duminagat relative to its volume, thus reduced the amount of gas exchange and mixing due to winds. Furthermore, the short maximum length (345 m) resulted into insufficient interaction of the wind on the lake. The lake was also protected from wind action by the surrounding topography. The resulting non-mixing of the deeper layers of lake water promoted the maintenance of the lake's stratification.

Lakes with high relative depths are characterized by a small surface area relative to their maximum depth. The relative depth of Lake Duminagat was 6.5 percent. Most lakes have a relative depth of less than two percent, whereas deep lakes with a small surface area usually have a z_r greater than four percent (Wetzel 1983).

The volume of the lake was 933 x 10^3 m^3 with 70 percent of the total volume contained in the top 5 m. In contrast, the bottom 6 m contained only 7.5 percent of the total volume. This had significance in that the bottom stratum of the lake would be receiving organic matter settling from the much larger volumes of water above. Because of this volume effect (sediment focusing), this made the bottom water of most similar-shaped lakes anaerobic (Likens, 1985). However, as shown in a later section, this was not true for Lake Duminagat, probably because the amount of settling organic matter was not great enough to deplete the dissolved oxygen of the bottom layer.

The lake area (8.04 ha) to watershed area (53.2 ha) ratio was 1:6.6. The small catchment basin implied a lesser amount of inorganic materials that could be dissolved by the surface water flowing into the lake. This contributed further to the low production of the lake.

Some Hydrologic Aspects

The amount of water in a lake is equal to the balance between water input and water output. Because there were no inflow streams in Lake Duminagat, water input was only due to precipitation, surface water runoff, and, possibly, seepage. A single outlet of the lake was in the form of a small stream located at the southwestern side. There seemed to be no great changes in the lake water volume, though because the lake's morphology was such that the outflow passes through only a shallow depression in the lake's rim. Excess water would flow out when there is much precipitation. When there was insufficient rain, the lake water was kept in. During the May 2002 visit to the area (when there was an occurrence of El Niño), there was virtually no outflow. Due to presence of rainfall throughout the year, water evaporated but was replaced immediately. This caused the lake water volume and thus its elevation to be stable. One elderly lakeshore resident remarked that she had not observed the lake exhibiting any visibly marked changes such as a marked change in the lake's elevation over the years (Cati *et al.* 2002, personal communication)

Physico-chemistry

Physical parameters measured in the lake water included temperature, Secchi disk visibility, and turbidity. Temperature was measured at various depths to create a depth-temperature plot (Figure 3). The figure shows temperature stratification in the lake; the upper layer was the epilimnion (0-8 m), the next layer where the change in temperature was great per unit depth was the thermocline or metalimnion (~8-11 m), and the bottom layer was the hypolimnion (from 11 m down). Although the difference in temperature of the water in the various depth layers was not so great, this caused a marked difference in the density of the water, which prevented the various layers from mixing. The lake was said to be stratified. Thus, nutrients that concentrated on the bottom from the falling of dead bodies of aquatic organisms and from allochthonous input were not recycled.

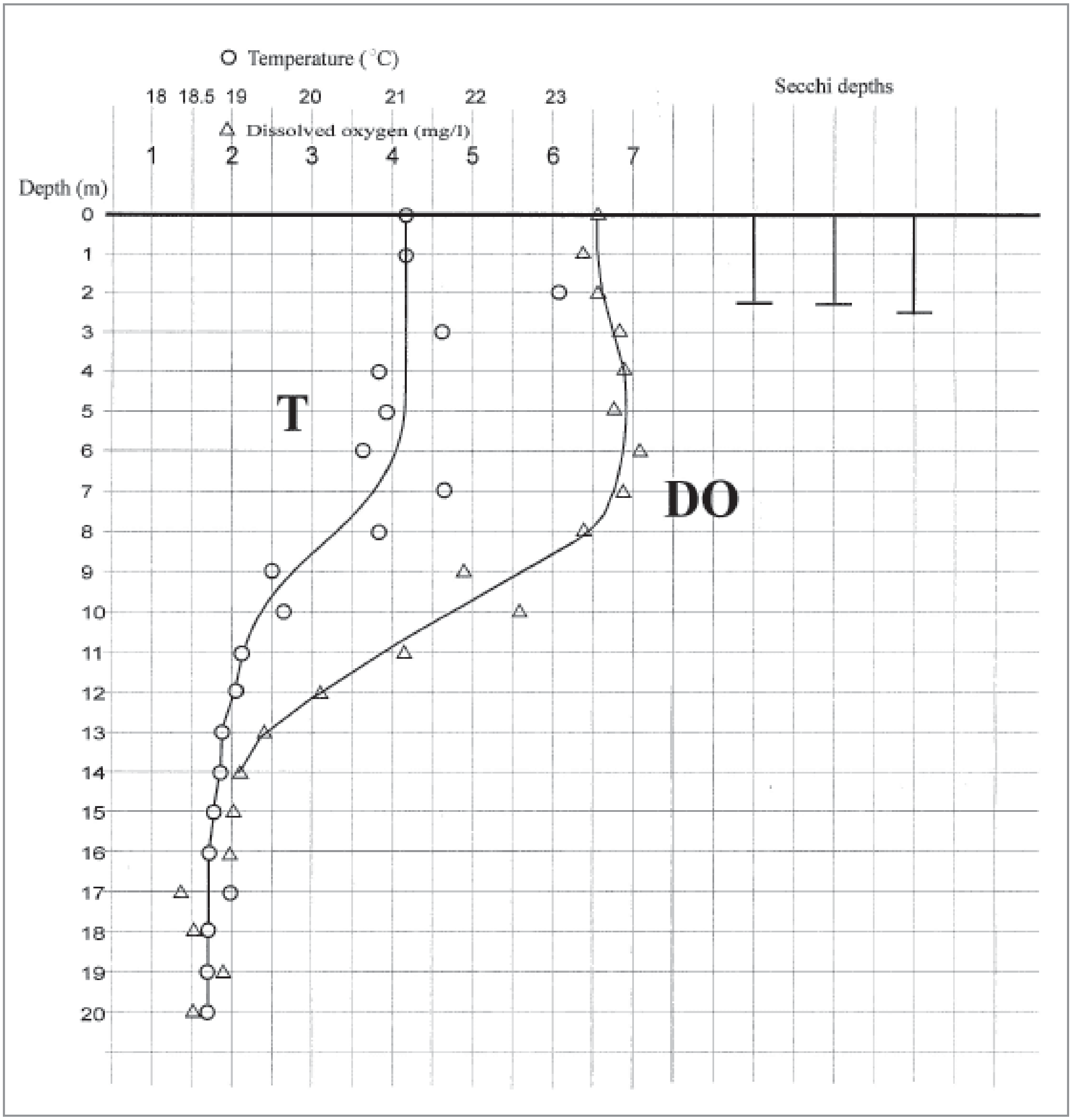

Figure 3. Vertical profile of temperature and dissolved oxygen. Secchi depths are also shown.

However, thermally stratified bodies of water exhibit mixing when their temperature becomes uniform. This happens in temperate lakes during the spring and fall, the so-called spring and fall overturns. Such lakes are thus called dimictic lakes (Wetzel 1983). Those lakes in which mixing occurs only once in a year are monomictic. Whether Lake Duminagat was dimictic, monomictic, or oligomictic (very rarely mixing) could be found out if the depth temperature measurements are made at various times of the year. Mixing would occur only if the temperature in the area becomes cold enough that the upper layer of water (epilimnion), together with the metalimnion, attains the low temperature of the hypolimnion. In the case of Lake Duminagat, this would happen if the temperature becomes uniformly 18.7 ^{o}C. Overturn would cause the recycling of both inorganic and organic nutrients that had precipitated and settled in the sediments.

The Secchi disk depths are also shown in Figure 3. The Secchi depth ranged from 2.0 m to 2.35 m during the March to May measurements. Secchi disk visibility/transparency is an indirect measurement of turbidity; it really measures the degree of light penetration. The Secchi depth could be used to estimate the photic depth, or the depth of one percent surface illumination, which is the limit of the photosynthetic zone. By actual measurement of the photic depth (with a submarine photometer) and relating it to the Secchi depth readings of a particular observer, one could obtain a factor to multiply the Secchi depth with for subsequent estimations. For most natural waters, this factor falls between two and five (Lind 1985). Thus, the bottom limit for photosynthesis in Lake Duminagat probably falls between 4.38 and 10.95 m.

It was surprising that Lake Duminagat had a shallow Secchi depth of ~2.19 m. As shown by the geology of the area, its topography, the lake morphology, and, as shown by the chemical composition of the lake water, the lake was oligotrophic. Oligotrophic lakes are characterized by transparent water, deep light penetration (often below thermocline), and Secchi depth ranging from 8-40 m (Goldman and Horne 1983). For example, oligotrophic Mirror Lake has its Secchi depth ranging from 5-7 m in summer (Likens 1985). Thus, there needs to be an explanation for the shallow Secchi depth of Lake Duminagat. This could be due to the presence of dissolved chemicals, especially the tannins that were present in the bodies of the trees that have fallen into and remain submerged in the lake. Because of the low zooplankton population (see later section) and the low amount of total suspended solids (4.4 ppm), the shallow Secchi depth of the lake could not be ascribed to these factors.

Turbidity values, as measured by the Iligan City Waterworks System on the water samples brought to them, are shown in Table 2 and Table 3. Turbidity refers to the presence of suspended solids, which causes light to be scattered or absorbed in the water, resulting in a decrease in water transparency. It affects the depth of light penetration and thus, the distribution and intensity of photosynthesis in the body of water. Turbidity was expressed in NTU; a nephelometer being an instrument that measures light scattering, higher turbidity causing greater scattering. Turbidity was greater in March (mean of 2.59 NTU) than on the months of April, June, and October.

The chemical analyses of the lake water included measurement of its salinity, dissolved oxygen, pH, total alkalinity, total hardness, TDS, nitrate-nitrogen, total phosphorus, and TSS.

Three replicate measurements of salinity gave readings of 4 ppt, 3 ppt, and 3 ppt, with a mean of 3.3 ppt. This indicated that the lake was really freshwater and discount one of the lake stories that the lake supports some marine organisms. The salinity of inland waters was generally very low in comparison to that of the sea (32-38 ppt).

The most fundamental parameter of lake waters is dissolved oxygen (DO), which is essential to the metabolism of all aerobic organisms. The DO content of the water results from (1) the photosynthetic and respiratory activities of the biota in the water; and (2) the diffusion of oxygen into the water which is dependent on the diffusion gradient at the air-water interface and distribution by wind-driven mixing (Lind 1985). The vertical distribution of dissolved oxygen (DO) is shown in Figure 3. The saturation concentration of dissolved oxygen in pure water at 21^{o}C at an atmospheric pressure of 760 mm Hg was 8.68 mg/l. When corrected for salinity and atmospheric pressure (lake salinity of 3.3 ppt and atmospheric pressure of 615 mm Hg at the lake's elevation), using the values in Table 2 (Brower and Zar 1984), the dissolved oxygen saturation concentration became 7.017 mg/L. The measured value of DO in the surface water of the lake on April 28 was 6.6 mg/l, which means that the water was only 94 percent oxygen-saturated. This DO concentration was more or less uniform in the upper water layer, the epilimnion, where there was mixing of water due to the action of the wind. The DO concentration rapidly decreased below the thermocline (~8-11 m) to less than 2 mg/l (from 14 m depth to the bottom). However, it did not become completely anaerobic. Oxygen reduction in the hypolimnion was expected because there was no replacement of the oxygen used up in biological oxidation of organic matter. There was no replacement because, first, it was below the photic depth so there was no photosynthesis by the phytoplankton that would evolve oxygen, and second, there was no mixing of the denser hypolimnion with the less dense epilimnion and metalimnion. Bacterial decomposition of organic matter dominated, both in the water and especially at the sediment-water interface. In fact, this caused the oxygen concentration in eutrophic lakes to quickly become zero in the hypolimnion (clinograde oxygen curve) because of the great amount of dead organisms falling to the bottom. This did not happen in oligotrophic Lake Duminagat because it did not support a high plankton population and other aquatic biota that would contribute to the dead biomass in the hypolimnion.

The pH, total alkalinity, total hardness, and TDS were measured by the Iligan City Waterworks System on the water samples brought to them for analyses. The data are shown in Tables 2 and 3. The pH of most natural waters falls more often in the range of 6.0 to 8.0, while expected total alkalinities in nature usually range from 20 to 200 mg/L.

The examining laboratory remarked that the water was low in alkalinity and was very soft. The low amount of ions in the lake water was due to the fact that water in the lake only came from precipitation and from surface water runoff in a small catchment basin. Rainwater has virtually no ions/solutes present in it, except in areas where industrial activity emits particulate/soluble matter into the atmosphere. The small catchment area of the Lake Duminagat basin (53.2 ha) and the basaltic nature of this volcanic region of Mt. Malindang further contributed to the low alkalinity and softness of the water. The lack of carbonates and bicarbonates in the igneous rocks of this area was the reason why the pH was at the acidic side of neutrality. All these factors further contributed to the oligotrophic character of the lake.

The nitrate-nitrogen, total phosphorus content, and TSS were determined by the DOST-R.O.10 laboratory on the water samples collected at various depths on various dates in 2002. Data are shown on Table 4. The method used by DOST R.O.10 was not sensitive enough to detect nitrate-nitrogen less than 1.0 mg/L and total phosphorus less than 0.01 mg/L.

Natural concentrations of nitrate-nitrogen rarely exceed 10 mg N per liter and are frequently less than 1 mg N per liter. Oligotrophic lakes have a nitrate concentration of up to 0.3 mg/L while eutrophic lakes range from 0.5 to 1.5 mg/L (Wetzel 1983). In the case of total phosphorus, its concentration in non-polluted waters is usually less than 0.1 mg P per liter (100 mg P l^{-1}) and inorganic (orthophosphate) soluble phosphorus is often less than 0.01 mg P per liter (Lind 1985). Oligotrophic Mirror Lake has less than 5 mg PO_4-P per liter, while eutrophic Lake Erie has 30-50 mg per liter (Likens 1985).

Bacteriological Analyses

All water samples analyzed bacteriologically were surface water samples taken from the middle of the lake where lakeside residents get their drinking water. Results of the analyses performed by the Iligan City Waterworks System are shown in Table 5.

The confirmed test using BGBL broth showed the presence of coliforms on all dates - 5.1, 9.2, and >16 MPN per 100 ml in March, April, and June, respectively. However, growth obtained from these positive tubes plated onto EMB agar showed the presence of atypical colonies. That is, these coliforms were not *Escherichia coli* and it could be concluded that there was no contamination with human fecal matter on that part of the lake. Thus, the water was found to be "reasonably safe" and "probably safe" for drinking purposes in March and April. The water was assessed to be bacteriologically unsafe in June due to the presence of a large number of background heterotrophic bacterial population, which was too numerous to count. The large number of bacterial population in June could be due to frequent rain at that time, which brought a large bacterial load in the surface water runoff draining into the lake.

Both the Philippine National Standards for Drinking Water (1993) and Guidelines for Canadian Drinking Water Quality (1993) set the maximum acceptable concentration for total coliforms in drinking water to be 0 organisms per 100 ml. However, in the Canadian guidelines, some other condition is considered in compliance with the total coliform maximum acceptable concentration: no sample should contain more than 10 total coliform organisms per 100 ml, none of which should be fecal coliforms. The March and April water samples met this condition. The guideline also said that if the sample contains more than 500 HPC (heterotrophic plate counts) colonies per ml, the water should be resampled. The March and April water samples contained 143 and 290 colonies per ml and thus met the guideline.

Zooplankton

It was mainly zooplankton that was collected in the methodology used for plankton collection. The mesh size of the plankton net used, 119 ìm, allowed many phytoplankters to pass through, although they were exceedingly diverse in size and form. Many of the common phytoplankton species were small (a few ìm in diameter).

Table 2. Physico-chemical parameters measured by the Iligan City Waterworks System on water samples from various depths collected on 24 March 2002.

Depth (m)	Turbidity (NTU)	pH	Total Alkalinity (mg/L $CaCO_3$)	Total Hardness (mg/L $CaCO_3$)	Total Dissolved Solids (ppm)
0	2.58	6.5	15.19	6.0	6
2	2.48	6.8	13.02	4.0	6
3	2.89	6.8	15.19	4.0	5
4	2.93	6.7	13.02	6.0	5
15	2.08	6.7	13.02	5.0	5

Table 3. Physico-chemical parameters measured by Iligan City Waterworks System on surface water samples collected at various dates in 2002.

Date	Turbidity (NTU)	pH	Total Alkalinity (mg/L $CaCO_3$)	Total Hardness (mg/L $CaCO_3$)	Total Dissolved Solids (ppm)
March 24	2.58	6.5	15.19	6.0	6
April 28	1.62	6.6	14.49	6.0	5
June 9	1.89	-	13.32	-	5
October 28	1.38	6.5	13.62	6.0	6

Table 4. Chemical analyses done by DOST-R.O.10 laboratory.

Depth (m)	NO_3 (mg/L)			Total P (mg/L)			TSS (mg/L)
	March 24	April 28	June 9	March 24	April 28	June 9	April 28
0	-	1.2	<1.0	-	0.02	n.d.	-
1	1.3	-	-	0.029	-	-	4.44
5	1.0	1.8	-	0.032	0.05	-	-
10	<1.0	1.2	<1.0	0.025	0.04	n.d	-
20	1.0	2.6	<1.0	0.125	0.02	n.d.	-

Legend: n.d. - not detected

Table 5. Results of bacteriological analyses done by Iligan City Waterworks System at various dates in 2002.

Date	Presumptive Test		Confirmed Test			Completed Test		Colony Count (col/ml)		Remarks
	Lactose Broth		BGBL Broth		EMB	EC Medium				
	24 h	48 h	24 h	MPN		24 h	MPN	24 h	48 h	
Mar 24	0/5	3/5	2/3	5.1	*1	2/3	5.1	86	143	**1
Apr 28	5/5	-	3/5	9.2	*1	0/5	<2.2	-	290	**2
Jun 9	5/5	-	5/5	>16	*1	0/5	<2.2	-	TNTC	**3

Legend:
- MPN - most probable number
- EMB - eosin methylene blue agar
- EC med. - *E. coli* medium
- BGBL broth - brilliant green bile lactose broth
- *1 - Atypical colonies

Remarks:
- **1 - Water is reasonably safe for drinking purposes.
- **2 - Water is probably safe for drinking purposes. Disinfection is necessary.
- **3 - Water is bacteriologically unsafe for drinking purposes.

Phytoplankton are said to be best collected with a sampling bottle which collects all phytoplankton regardless of size, inasmuch as more than 90 percent of the phytoplankton would pass through even the finest mesh nets (Goldman and Horne 1983). Nonetheless, some phytoplankton was observed, which included several kinds of diatoms and one-celled green algae. On the other hand, most zooplankton were about 0.5 to 1 mm in length. The zooplankton observed and their abundance is shown in Table 6.

The Shannon index of overall diversity was calculated and gave a value of 0.79. The nauplius was not included in the calculation, inasmuch as it was a developmental stage of a copepod and the copepod species to which it belongs was not known.

Groups comprising the zooplankton are the protozoans, rotifers, cladocerans, and copepods. Both cladocerans and copepods are microcrustaceans. In Lake Duminagat, there was a glaring absence of rotifers and cladocerans. It is said that there is a dominance of cladocerans over copepods in productive (eutrophic) lakes, while copepods usually outnumber cladocerans in unproductive lakes (Goldman and Horne 1983). Up to 500 individuals per liter may be found in eutrophic lakes, while only less than one per liter characterizes most oligotrophic waters. As shown, Lake Duminagat had a total zooplankton abundance of only 1.3 per liter.

There were only 12 species in this freshwater ecosystem, in contrast to larger lakes with as many as 25 crustacean species, and tropical oceans with more than 50 species of copepods, as well as many species of other planktonic groups (Goldman and Horne 1983). This low number of species in Lake Duminagat was consistent with its small size. Despite the lake's oligotrophy, the species diversity may be considered quite high (0.79). This was because there is no correlation between diversity and productivity (Odum 1971).

Aquatic Fauna

There were five kinds of fishes reported to be in the lake (Table 7). Three were collected and photographed: carp, *paitan*, and *pargo*. Only one, the *paitan*, was actually weighed and measured.

Fish catch data by using bamboo fish traps or *bubo* is shown in Table 8. Local residents used hook and line and fish traps only in catching fishes, yielding very low catch per unit effort. The fish trap, locally called *bulantak* or *bubo*, was most preferred because it is just left in the lake and examined hours after, while the hook and line called *bingwit* consumes more time because it needs to be watched, and still catches nothing after many hours.

During the validation and presentation of biodiversity assessment results to the Barangay Lake Duminagat residents in October 2002, additional information on fish catch was obtained. *Kasili* (eel) was reported to have been caught using *taga* or bait. The kind of *kasili* (Bisayan name; also called *blug*) found here was not too long and was said

Table 6. Kind and abundance of zooplankton collected in May 2002.

Zooplankton	# / ml R1	R2	R3	Total	Ave.	# / liter	# / m^3
Cop sp 1	9	6	28	43	14.3	0.53	530
Cop sp 2 *Diaptomus*	8	4	13	25	8.3	0.30	300
Cop sp 3	0	0	1	1	0.3	0.01	10
Cop sp 4	1	0	3	4	1.3	0.05	50
Cop sp 5	0	0	8	8	2.7	0.10	100
Cop sp 6 *Cyclops*	6	0	1	7	2.3	0.08	80
Cop sp 7 *Epischura*	0	4	0	4	1.3	0.05	50
Cop sp 8 *Tropocyclops*	3	0	0	3	1.0	0.04	40
Nauplius	0	1	1	2	0.7	0.02	20
Prot sp 1	4	0	1	5	1.7	0.06	60
Unid sp 1	2	0	0	2	0.7	0.02	20
Unid sp 2	1	0	1	2	0.7	0.02	20
Unid sp 3	1	1	0	2	0.7	0.02	20
					Total	**1.3**	**1,300**

Legend: Cop - copepod; Prot - protozoa; Unid - Unidentified group

Volume of lake water filtered = Mouth area of net x depth
Mouth area was 471.44 cm^2; depth was 17 m or 1700 cm
Volume of plankton concentrate was 29.5 cm^3
1 m^3 = 1,000 liters

Table 7. Fish catch composition in Lake Duminagat (April-May 2002).

Local Name	Scientific Name	Size (L; cm)	Weight (g)	Remarks
Tilapia	*Oreochromis* sp.	-	-	reported
Carp	*Cyprinus* sp.	-	-	collected
Paitan	*Barbodes binotatus*	3-6	10-28	collected
Kasili	*Anguilla* sp.	-	-	reported
Pargo		-	-	collected

Table 8. Fisheries data on 25-27 April 2002 and 16-18 May 2002.

Fishing Gear Types	Total Number of Units	Number of Fishermen	CPUE pcs / gear / day	Species
Hook and line	6	3	-	(*tilapia*,carp), reported
Bamboo trap (*Bulantak/Bubo*)	7	3	38	*paitan*

to be native to the area. *Bingwit* (hook and line) and *taga* (bait) were the means to catch *kasili*. A small hook and line, *sarang baba pait*, which means just enough to enter the mouth of *paitan*, was also used to catch *paitan*.

Due to the residents' belief on the lake as the dwelling place of spirits, fishing in the lake was generally not encouraged. In April and May 2002, it was observed that only the lakeside residents and the Barangay Lake Duminagat *surhano* (spirit medium) were the ones fishing in the lake. However, during the validation meeting with the community, it was said that 20 persons from the *centro* went to the lake to catch fish by hook and line. Thus, the number of hook and line totaled to 26 units. In the case of bamboo trap, seven traps were owned by the lakeside residents and eight by people from the *centro*.

From data in the preceding sections - lake morphology, such as low volume to surface area ratio, low amount of inorganic nutrients, low secondary productivity as indicated by the low zooplankton population - Lake Duminagat was an oligotrophic lake. It was therefore expected that fish, being at the top of the aquatic food chain, would be quite low in number and biomass.

Paitan was identified as *Barbodes binotatus*. However, Cali *et al.* (1999) in their Participatory Rapid Appraisal (PRA) reported it as *Harengula tawilis*, which was recorded to be endemic to Taal Lake by Conlu in 1986. Furthermore, it was stated that *pait-pait* or *paitan* to the local people was a freshwater herring that was very common to the streams and riverine systems before the devastation or denudation of the forest environment of Don Victoriano and Concepcion.

The benthos was sampled using an Ekman grab in the middle of the lake (20.4 m depth). A benthic sample could not be obtained nearshore because of the large number of dead trees that had fallen and accumulated at the bottom. The sediment obtained from the middle of the lake was very fine silt and was brown in color, classified as dy type (Wetzel 1983). No macrobenthic invertebrates visible to the naked eye were observed after sieving the sediment through successive sieves of mesh size 4, 8, and 12 (0.203 in, 0.097 in and 0.060 in, respectively; 0.060 in = ~1.5 mm). There were three possible reasons for this absence: a) the oxygen tension at the bottom (~1.6 mg/L) was not sufficient to support the aerobic benthos; b) the benthic animals were very sparse and very limited in their distribution, another indication of the lake's oligotrophy; and c) the smallest sieve used was not small enough to keep the smaller macroinvertebrates, inasmuch as they were defined as those retained by a U.S. No. 30 sieve (= 0.589 mm spaces).

Aquatic Flora

The true submerged aquatic macrophytes were composed of three species (Table 9). These plants were prominent in the shallow shoreline, the *lusay* (or *lusay-lusay*), appeared like a big violet rose. The *dagum sa tubig* appeared green and needle-like, and the *busikad sa tubig* (also known as *bila-bila sa tubig*) appeared green, shorter than the latter with white globose inflorescence.

All the three macrophytes exhibited the rosette growth-form (or isoetid growth-form), that is, all the leaves arose in a whorl from a greatly shortened stem. The predominance of the isoetid growth-form in the submersed vegetation of softwater lakes and the elodeid form (leaves arising from

Table 9. The macrophyte species in the shallow littoral area of Lake Duminagat (25-27 April 2002 and 16-18 May 2002).

Local Name	Scientific Name	Family	Abundance Individual or Clump / m^2
Lusay	*Sagittaria cristata* (?)	Alismaceae	12 - 58
Dagum sa tubig	*Eleocharis acicularis*	Cyperaceae	15 - 43
Busikad sa tubig	*Eriocaulon* sp.	Eriocaulaceae	4 - 36

the stem at nodes separated by distinct internodes, e.g., *Elodea/Hydrilla*, *Potamogeton*, *Ceratophyllum*) in hardwater lakes is a striking ecologic difference. Moreover, the well-developed root systems of these plants may be a key adaptation to nutrient-poor waters (Likens 1985). These well-developed root systems were actually observed in the specimens. Elodeids, on the other hand, require relatively high concentrations of inorganic carbon which exist in hardwater lakes (Likens 1985). The sub-optimal amounts of inorganic carbon, and possibly other nutrients, were responsible in keeping most elodeids from becoming established in softwater lakes such as Lake Duminagat.

The macrophyte, *lusay*, was difficult to identify because of the absence of reproductive structures. It appeared to be the underwater form of *Sagittaria cristata*. However, it was puzzling why the emergent form was not present. It could be a species new to science.

CONCLUSION

Inasmuch as the residents considered Lake Duminagat as the dwelling place of spirits, they did not encourage fishing in the lake. This was just as well since the lake was oligotrophic and did not support a substantial fish population. The residents themselves knew that they could preserve the cleanliness of the lake by not allowing the construction of toilets beside it. They allowed swimming, bathing, and washing of clothes only near the outlet. The lakeside residents, consisting of five households, acquired their drinking water from the middle of the lake.

Not only the Subanen, but also other people from the outside considered the lake as a source of healing water and believed it to have the capacity to wash away sins. The occurrence of many visitors to the lake, especially during Holy Week, attested to that belief. It was not only for this purpose that people troop to the lake, but for recreation, nature trekking, and enjoyment as well. Thus, the lake, and the adjacent North Peak for mountain climbing, has a very good potential for ecotourism, for as long as possible adverse effects of these activities are prevented.

Considering the need for sustainable livelihood alternatives in conjunction with biodiversity conservation of the lake and its immediate surrounding, since the lake supported a surrounding lush vegetation, it could offer a potential source of ornamentals, medicinals, source of bioactive compounds, raw materials for mat making, source of fiber, etc. if it could be conserved and encouraged to flourish. The lake's surroundings also supported a diverse fauna/ wildlife that could be encouraged to multiply. With these biological resources, coupled with the area's cool climate and general scenery, it may be possible for this area to be developed into a nature park offering indigenous ornamental plants for sale, as well as promoting activities, such as bird watching and mountain climbing, with the residents in charge of these activities, making them hosts and business-entrepreneurs.

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PARTICIPATORY BIODIVERSITY ASSESSMENT OF THE COASTAL AREAS OF NORTHERN MT. MALINDANG, PHILIPPINES[1]

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The Biodiversity Research Programme for Development in Mindanao (BRP) ultimately aimed at biodiversity conservation for sustainable development. To achieve its goal, the program was designed to be implemented at various phases. For the coastal area, the Pre-Implementation Phase (PIP), under which the Participatory Rapid Appraisal (PRA) was conducted in 1999, had unfolded problems on resource depletion and degradation. Part of the reasons was that most coastal communities of northern Mt. Malindang depend mainly on fishing for livelihood. Their high dependence on the coastal resources for food and income may have greatly contributed to resource depletion.

The problems on resource depletion and degradation had to be addressed to sustain biodiversity. The bottom line is to provide lasting economic benefits for the coastal communities. Formulation of management strategy could be an option to sustain biodiversity. However, this requires baseline information that could be derived through resource assessment.

In 2001, the First Generation Research of BRP, particularly the coastal project, had assessed some coastal *barangays* in northern Mt. Malindang to know the state of resources for management interventions and for formulation of research questions needed in the Second Generation Research.

Since this project was implemented using a participatory approach, wherein local partners from the community were involved in planning and data gathering, this report includes both technical and process components. The latter includes protocol, community validation, consensus building, and consultation, while the former mostly deals on assessment of key bioresources. This report focuses on the assessment of coral reef and fishes.

METHODOLOGY

Sampling Site Establishment and Sampling Period

Sampling sites were established in the coastal *barangays* of Tuburan (Aloran), Mobod (Oroquieta), Mansabay Bajo (Lopez Jaena), and Panalsalan (Plaridel). Sampling was conducted twice in the 1-year project duration in 2001. These were in the months of July and December to represent the wet and dry seasons. A reconnaissance survey was done the day before the actual assessment for both the July and December sampling period. This was to inform the community, to get description of and to familiarize with the area, and to establish the sampling spots using Global Positioning System (GPS).

For fish catch assessment in landing sites, two approaches were done. First was the one-shot field sampling in July and December 2001, wherein researchers actually interviewed fishermen while fishing. Second was by requesting the fishermen to record their catch, using a fish catch monitoring form, per fishing trip for five days every month from August 2001 to April 2002.

Participatory Coral Reef Assessment

State of Coral Reef Based on Manta Tow

For coral reef assessment using manta tow, representatives from the community were involved. Two to three local partners assisted in taking down notes on the geographic bearing and in keeping the time, as well as in operating the boat. The local partners were also involved in determining the location of the coral reef, which was the basis of the path taken for the manta towing.

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More Detailed Assessment of Reef Benthos Using the Line Intercept Transect (LIT) Method

Specific sites in the coral reef were closely assessed using the line intercept transect (LIT) method (English *et al.* 1994). Three to seven transects were laid parallel to the reef slope for the July and December sampling period. The corals and other benthic life forms were identified according to poor (0-24.9% live coral cover), fair (25-49.9%), good (50-74.9%), and very good (75-100%) categories (Gomez *et al.* 1994). Length (in cm) of the benthic forms intersected by the transect line was measured and recorded onto the slate board. This was the basis for computing the percent cover.

For LIT, the areas surveyed were limited to where the transects were laid, which may have different coral cover to areas surveyed by Manta Tow.

Reef Fishes

Species Richness and Abundance

The Fish Visual Census Method (English *et al.* 1994), simplified in Uychiaoco *et al.* (2001), was used in determining the reef fish species composition, richness, and abundance. Transect lines were laid on a constant depth contour. After 10 to 15 minutes, observers swam along the line and stopped every 5 m to record the counts of fish per size class until the transect was completed.

Dominant Families and Size Frequency

Occurrence and distribution of reef fish, categorized by family, in the sampling sites were noted. Relative abundance was computed and dominant families were listed. Length (in cm) estimated were used in determining the size frequency.

Re-entry Protocol in the Community

The local government units (LGUs), nongovernment organizations (NGOs), government agencies (GAs), peoples organizations (POs), and previous partners trained during the PRA in the identified sampling sites were visited. These research allies were informed of the BRP's implementation and its long-term targets. More specifically, they were oriented on the coastal project's milestones, objectives, and long-term targets. There was an emphasis on the level of participation of the research allies in the project.

Community Validation

At the outset, a community validation was conducted on 8 January 2001 to present the issues and problems on biodiversity identified in the PRA. The concept proposal was also validated and partner POs were identified. The community were consulted with regard to the extent and degree of their participation in the biodiversity assessment, the terms for giving remuneration, and the selection of enumerators/partners.

During the project implementation, the first level of validation was done when assessment output was presented to the community. The second level was conducted with the mayors and municipal-based research allies to present the issues and problems. The third level was done with the *Sangguniang Panlalawigan*, the Executive Office, and the province-based research allies to conduct multisectoral consultation and establish networking.

Consensus and Team Building

Developing capability and empowering local community by making them research partners was one innovative feature of this project. Conducting workshops for the local partners to learn the methods on participatory resource assessment of fisheries and key bioresources were set in July and December 2001. A two-way learning process was employed in the conduct of the workshop. Mindanao researchers learned some knowledge on resource status from local partners while imparting technical methods on biodiversity assessment.

RESULTS AND DISCUSSION

State of Coral Reef Based on Manta Tow

The manta tow survey conducted in July and December showed that the coral reefs in the four sampling sites in Misamis Occidental were severely stressed. Out of the 209 tows, 153 tows or 73.2 percent manifested reefs in poor condition, 17.7 percent (n=37) in fair condition, 6.6 percent (n=14) in good condition, and only 2.4 percent (n=5) in very good condition (Table 1).

Similar scenario had already been established in a national report for coral reefs in the Philippines by Gomez *et al.* (1994), where reefs, particularly in Misamis Occidental, were rated poor (55.6%) and fair (44.4%). Moreover, earlier studies of the coral reefs in the eastern part of Iligan Bay, where the study sites were situated, also showed a generally poor condition (Imbat 1999 and de los Santos

Table 1. General status of coral reef in the study sites based on Manta Tow.

Class Interval	Frequency	Percentage	Category
0-10	153	73.2	Poor
10-30	37	17.7	Fair
30-50	14	6.6	Good
50-75	5	2.4	Very Good
75-100	0	0	Excellent

1998). The study of Gaite and Arceo (technical report), in the Lopez Jaena coral reef, rated three sites as poor, two sites as fair, and only one portion in the reef area in good condition.

The status of the reefs in the sampling sites was relatively worse compared to Davao Gulf, with only 30 percent of its reefs in poor condition and with a remaining one percent in excellent condition (BFAR-UPV 2001). More so, the reefs in the study sites were more degraded than the reefs in Tangalan, Aklan having 31 to 50 percent live coral and 11 to 75 percent soft coral cover, implying that these reefs were generally in good condition (SEAFDEC 2001).

On a per site basis, it was Panalsalan and Mobod which had a relatively better coral reef status, with remaining four percent and one percent reef areas in very good condition, respectively, and fewer reef areas in poor condition (64% and 62%). Compared to Mansabay Bajo and Tuburan with high percentage (86% and 83%) of reef in poor condition (Table 2). Percentages that did not tally to one hundred percent in Mobod was due to the presence of sandy bottom in the tow that were not included in the computation.

Blasted areas, presumably due to blast fishing, as pointed out in the focus group discussions and interviews with the community, were noted in the tows made. The basis used was sighting of scattered broken coral fragments. As shown in Figure 1, high percentage of blasted area was observed in Tuburan (66.6%), followed by Mansabay Bajo (31%), then Mobod (26%), and Panalsalan (25.9%).

More Detailed Assessment of Reef Benthos Using the Line Intercept Transect (LIT) Method

Figure 2 shows the percent cover of lifeform categories and abiotic factor in the sampling sites. Differences in result, particularly in the percentage of dead coral cover for Mobod, may be attributed to differences of the area surveyed. The Manta Tow covered a wide area because it considered the boundary points of the sampling site, while the LIT covered specific spots where the transects were laid, which may have different percentage coral cover. In Mobod, the highest cover (44%) determined in six transects was occupied by abiotic components consisting of rock, rubble, sand, and water. Hard coral was relatively higher at 28 percent than dead coral (20.1%). Similar to Mobod, the reef in Mansabay Bajo was dominantly occupied by abiotic factors (46.5%) as established in seven transects. However, the dead coral (29.5%) was a little higher than the live hard coral (20.4%). The three transects in Tuburan revealed the dead coral to be the highest in percent cover (40.6%), followed by abiotic factors (33%), then the hard coral (23.1%). The Panalsalan reef had more or less equal percentage of cover for dead coral, hard coral and abiotic factors at 31.9 percent, 30.9 percent, and 30.6 percent, respectively.

Common to all sites was the low percentage of soft coral (1.6-4.2%). Other categories (e.g., zoanthids, ascidians, anemones, and algae) was relatively higher in Panalsalan (2.2%), and Mobod (2.6%), indicating a relatively good condition reef, as supported by their higher percentage of live corals than in Mansabay Bajo (1.4%) and Tuburan (0.39 %). Consistent with the result based on manta tow, live (hard) coral was relatively higher in Panalsalan (30.9%) and Mobod (28.2%) than in Tuburan (23.1%) and Mansabay Bajo (20.4%).

Reef Fishes

Species Richness and Abundance

Assemblage (e.g., number, variety, and sizes) of reef fishes may reflect the health of the stock within the surveyed reef area (Uychiaoco *et al.* 2001). Through Fish Visual Census, species richness and abundance of coral reef fishes were determined. Panalsalan in Plaridel had the highest number, with 24 reef fish families with 75 species. This was followed by Mobod in Oroquieta, which exhibited the second highest number of 21 reef fish families with 73 species. Mansabay Bajo in Lopez Jaena had a total of 19 families with 62 species. The lowest recorded number was in Tuburan, Aloran, with only 14 reef fish families with 34

Table 2. Status of coral reef per study site.

Site	Number of Tow	Poor		Fair		Good		Very Good		Excellent	
		Number of Tows (%)									
Panalsalan	81	52	64%	12	15%	13	16%	4	5%	0	0
Mansabay Bajo	63	54	86%	9	14%	0	0	0	0	0	0
Mobod	50	31	62%	13	26%	1	2%	1	2%	0	0
Tuburan	18	15	83%	3	17%	0	0	0	0	0	0

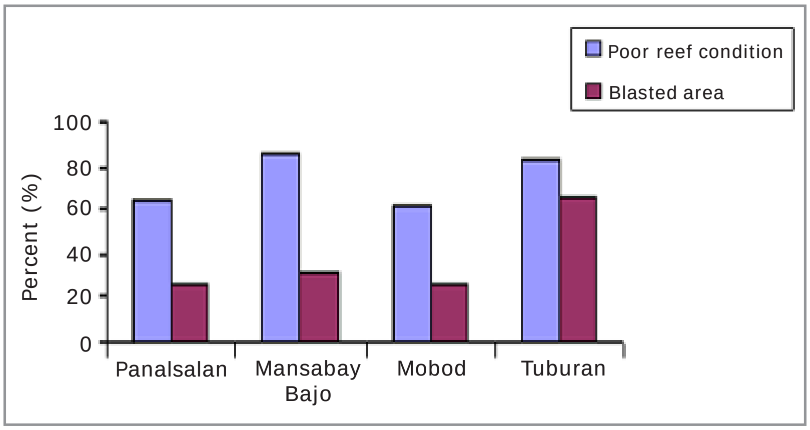

Figure 1. Percentage of reef areas that are blasted and in poor condition.

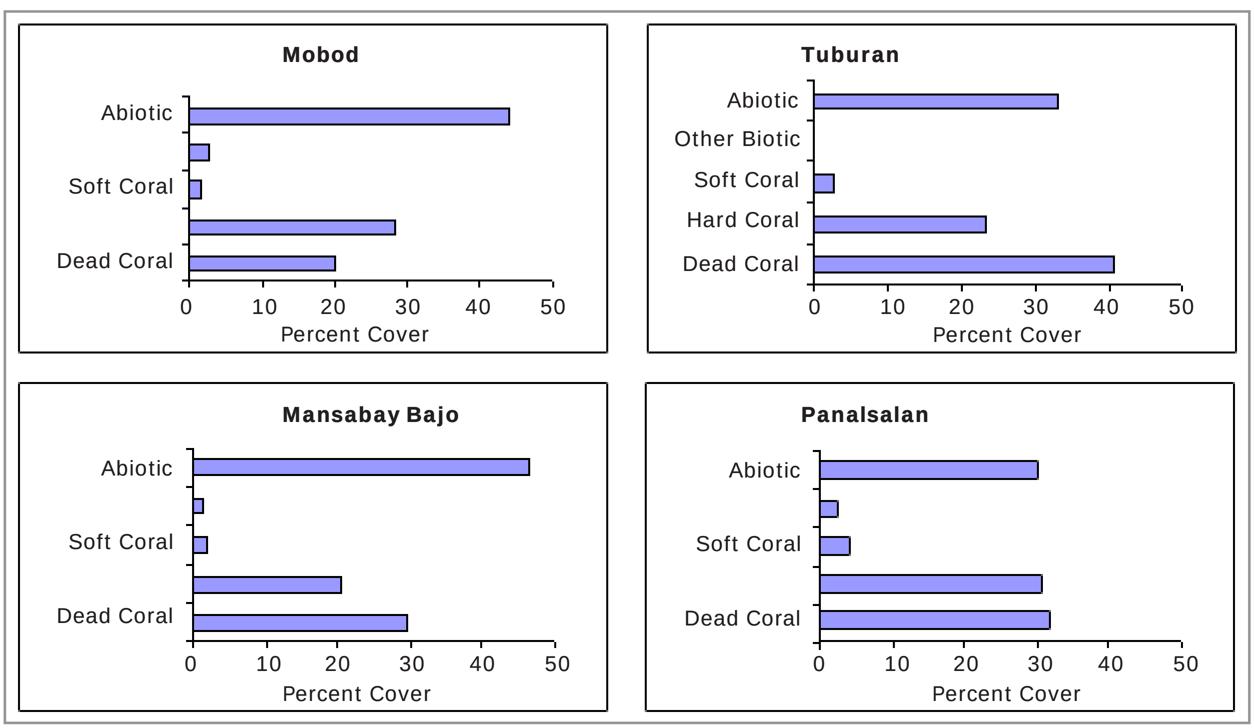

Figure 2. Lifeform categories and abiotic factors observed along the transects in the four sampling sites.

species. Although variation was seen in the total number of species, mean values did not vary much, with a range of 21-26 species per 500 m^2 (Figure 3).

Among the sampling stations, Panalsalan exhibited the highest mean count of 1,968 individuals per 500 m^2 observed during the survey and was followed by Mansabay Bajo with 526 individuals/500 m^2, while Mobod, Oroquieta showed 428 individuals/500 m^2. Tuburan in Aloran had the lowest number of 231 individuals/500 m^2.

Species richness and abundance of the reef fishes in the sampling sites were compared with the benchmark estimate by Hilomen *et al.* 2000 (Table 3). Species richness and abundance were rated moderate. Looking at a wider scope, it was about 70 percent of the country's reef areas where species richness of reef fish communities ranged from poor to moderate. These areas (e.g., Ragay Gulf, Davao Gulf, and Sarangani Bay) were said to be heavily exploited. The dominant species in the said areas are the small benthic predators and small herbivores and grazers. These may be indicators of too much fishing (Russ 1991).

Dominant Families and Size Frequency Distribution

Table 4 shows the six families identified as most abundant in terms of the total number of species and total number of individuals for indicator and target species. Family Pomacentridae consistently showed the highest relative abundance among the reef fishes for all the sites. It comprised 75.5 percent in Tuburan, 65.7 percent in Mansabay Bajo, 57.8 percent in Panalsalan, while the

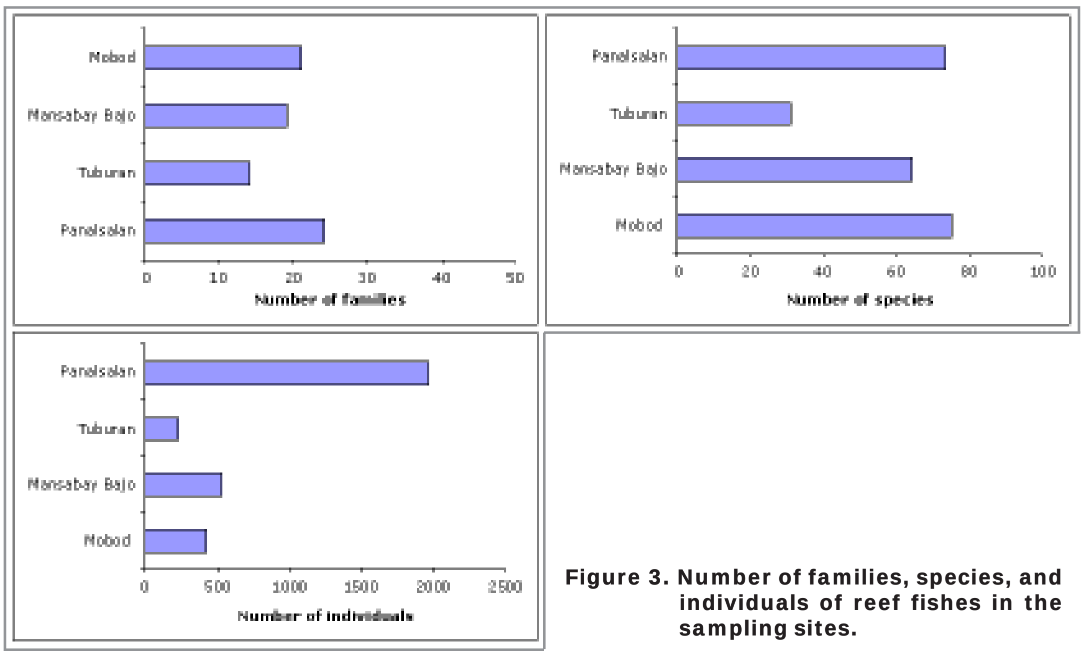

Figure 3. Number of families, species, and individuals of reef fishes in the sampling sites.

Table 3. Summary data of reef fish species richness, abundance, and estimated biomass compared with the benchmark estimate established by Hilomen *et al*. (2000).

Index	This Study	Category by Hilomen *et al.* (2000)
Species Richness	48 ± 5 species/1,000 m^2	Very high (>100 species/1,000 m^2) High (75-100 species/1,000 m^2) Moderate (48-74 species/1,000 m^2) Poor (27-47 species/1,000 m^2) Very Poor (<26 species/1,000 m^2)
Abundance	1,576 ± 796 ind/1,000 m^2	Very high (>7,592 indv/1,000 m^2) High (2,268-7,592 indv/1,000 m^2) Moderate 677-2,267 indv/1,000 m^2) Poor (202-676 indv/1,000 m^2) Very poor (<201 indv/1,000 m^2)

Table 4. The six most abundant families in terms of species and number of individuals in the sampling sites.

Station	Family	Number of Species	Number of Individuals	Relative Abundance (%)
Panalsalan	Pomacentridae	12	781	57.81
	Chaetodontidae	3	51	3.77
	Labridae	5	34	2.52
	Pomacanthidae	2	94	6.96
	Serranidae	1	240	17.76
	Acanthuridae	2	53	3.92
Tuburan	Pomacentridae	16	268	75.49
	Chaetodontidae	1	8	2.25
	Labridae	6	41	11.55
	Pomacanthidae	1	6	1.69
	Serranidae	0	0	0
	Acanthuridae	1	12	3.38
Mansabay Bajo	Pomacentridae	20	859	65.67
	Chaetodontidae	5	25	1.91
	Labridae	5	45	3.44
	Pomacanthidae	2	19	1.45
	Serranidae	3	225	17.20
	Acanthuridae	1	30	2.29
Mobod	Pomacentridae	19	462	44.59
	Chaetodontidae	4	8	0.77
	Labridae	5	37	3.57
	Pomacanthidae	3	6	0.58
	Serranidae	2	411	39.67
	Acanthuridae	5	16	1.54

lowest value (44.5%) was observed in Mobod. The dominance of pomacentrids was also established in other studies for reef fishes in the country (Hilomen *et al.* 2000). Reef fishes belonging to Family Pomacentridae are bottom omnivore fishes with wide food spectrum consisting of zoobenthos, coral, algae, periphyton, zooplankton and small fish. They are considered strict residents that provide stability to fish community in a reef biotope (Sorokin 1995). Family Serranidae ranked second in the three sampling stations with 17.7 percent in Panalsalan, 17.2 percent in Mansabay Bajo, and 39.7 percent in Mobod. There was no serranid species observed in the Tuburan reef. Other abundant fish families included Labridae, Pomacanthidae, and Chaetodontidae.

Majority of the fish size estimate observed in the sampling sites fell under the five to ten centimeter size classes. The small size classes comprised at least 80 percent of the total abundance (Figure 4). This may be an implication for overfishing in the sampling sites.

Relative Abundance Based on Fish Landing Survey

Based on the actual fish catch sampled during the one-shot field sampling, and as recorded by the fisherfolk after every fishing activity, the relative abundance of fish for various gear types in each sampling site for the months of July and August were computed. Figure 5 illustrates that in Tuburan, the most abundant fish family was Hemiramphidae (37%), which included the pelagic fishes such as the halfbeaks or *suwasid*. For Mobod, greatest volume caught belonged to Family Loligonidae, which was mostly squid or *lumiyagan* (38%). Both in Mansabay Bajo and Panalsalan, Family Siganidae had the highest relative abundance of 50 percent and 43 percent, respectively.

Overall, it was Siganidae which was the most abundant fish family (20.12%) and was common to all sampling sites. The finding on the siganid abundance was reinforced with the calendar diagrams drawn by the local community during focus group discussions.

SUMMARY AND CONCLUSION

Resources

Factors, like blast fishing, that threaten coastal resources were manifested in the present state of key ecosystem. Highest percentage of blasted area and dead corals were found in Tuburan, where blast fishing was frequently observed.

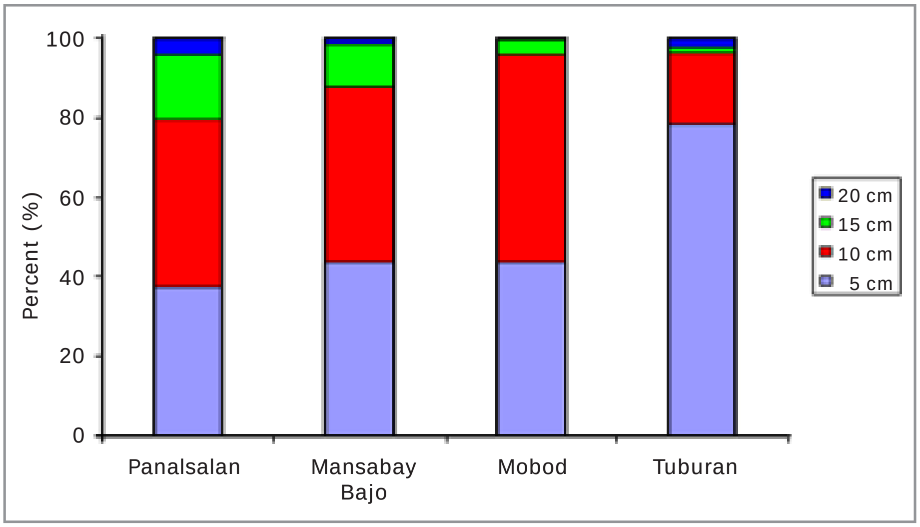

Figure 4. Percent size frequency distribution of reef fishes in the sampling site.

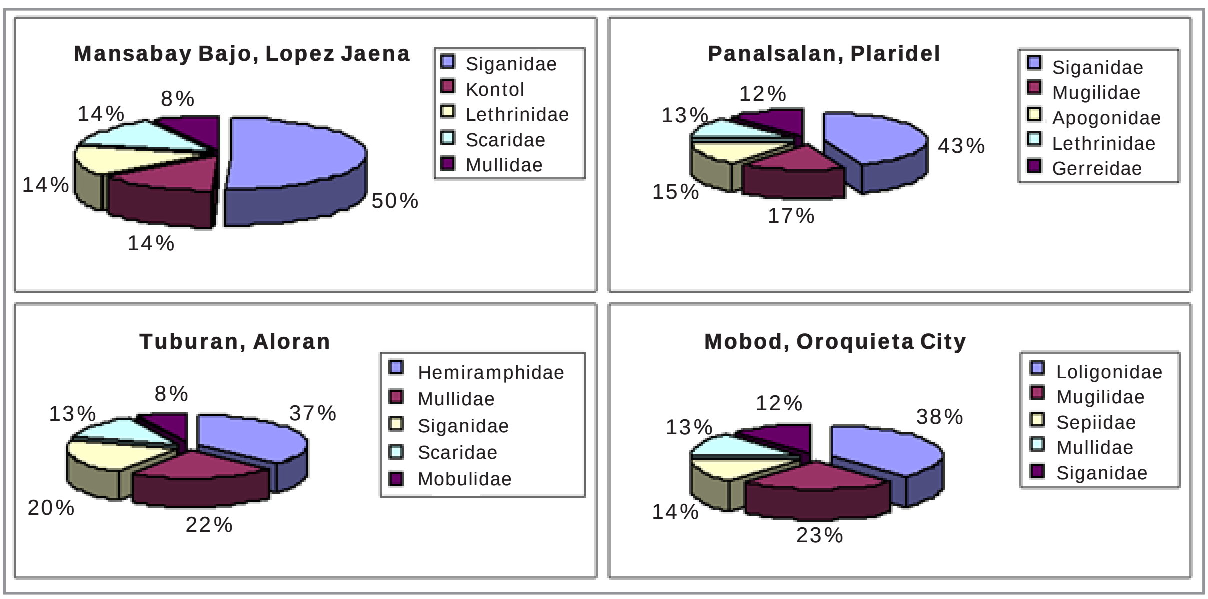

Figure 5. Five most abundant fish families for all gear type per site.

Mansabay Bajo had the second largest percentage of dead coral based on LIT, but highest with Manta Tow. Other practices, like pounding of coral by gleaners or anchor of boats and other destructive fishing gears, may have caused the destruction of corals in Mansabay Bajo.

The remaining low percentage of live coral ranged from 1 to 40 percent, which appeared to complement with the national report of coral reef status in Misamis Occidental, which was poor (55.6%) and fair (44.4%), as reported by Gomez *et al.* (1994).

Although for reef fish, it was indicated that species and abundance were still rated moderate based on benchmark estimate, the fishes identified to be abundant by the community during FGDs, and as a result of fish catch monitoring, may reflect health or "intactness" of the key ecosystems in the sampling sites. In Tuburan, for instance, fisherfolk identified sardines (*malansi*), spanish mackerel (*tangigue*), and anchovy (*bolinao*) to be the most abundant fishes in the area based on FGDs. While in actual fish catch monitoring, halfbeaks came out to be most dominant. These species were seasonal and were offshore migratory species. This may indicate that the territorial fishes, which thrive in key ecosystems, were indeed depleting in the coastal areas of Tuburan. On the other hand, siganids (*danggit*) was identified to be commonly abundant in three sampling sites (e.g. Mobod, Mansabay Bajo, and Panalsalan). This paralleled with the presence of seagrass meadows, which are the primary habitat of siganids, in the sampling areas.

Dynamics Among Stakeholders

The coastal *barangays* depended highly on fishing for their food and income. To meet their need for daily subsistence, they resorted to illegal fishing. Now, these fisherfolk are faced with problems on low fish catch, lack of livelihood opportunities, and impoverished condition. There had been various livelihood projects granted to the coastal community, but a lot had failed because of technical inadequacy and attitudinal problems. Others had no the access to funding sources and had no capability to prepare requirements, such as feasibility study, proposals, and resolutions.

Issues concerning stakeholders in the community, *barangay*, municipal, and provincial levels seemed to be confined within each stratum. There were no clear feedback mechanisms to bring out issues in both top-down and bottom-up ways. Moreover, there seemed to be a lot of projects and undertakings regarding environmental concerns at each level, but there was no concerted effort for coastal resource management considering the transboundary nature of the coastal zone.

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PARTICIPATORY BIODIVERSITY INVENTORY AND ASSESSMENT OF LAKE DUMINAGAT, MT. MALINDANG NATURAL PARK, MISAMIS OCCIDENTAL[1]

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The Philippines-Netherlands Biodiversity Research Programme (BRP) for Development in Mindanao was focused on a wedge-shaped area that contained part of Mt. Malindang, the whole range of which had been declared the Mt. Malindang Natural Park. Located in this area is Lake Duminagat, a crater lake situated at one of the mountains adjacent to North Peak, one of the notable peaks at the park.

The two communities close to it are the *barangays* or villages of Gandawan and Lake Duminagat, both about an hour walk away. Access to both these communities and the lake was only by foot/horse trails. The natives of the Mt. Malindang area were called the Subanen. Though the Subanen is considered an indigenous group, they have generally been enculturated by the Bisayan and Western cultures through association and the influence of mass media (Suminguit 1989).

The biodiversity inventory and assessment of Lake Duminagat included collection of vital and accurate information to characterize the communities of people living close to its site. Their demographic and socioeconomic-cultural characteristics were part of the inventory because they are in constant interacion with the lake and its surroundings, affecting the biodiversity status of both the lacustrine and terrestrial ecosystems. These also included their perceptions, beliefs on and uses of the lake and its resources.

METHODOLOGY

Participatory Methodology

The first step in the involvement of the community was for the researchers to follow the entry protocol. Entry to the community was carried out by making courtesy calls with the mayor of the Municipality of Don Victoriano, the *barangay* captains of Barangays Gandawan and Lake Duminagat, and the *timuay* (Subanen religious leader) of Barangay Lake Duminagat. Community meetings were also held, where both the BRP and the Lake Duminagat project were presented during the entry protocol, as well as at the onset of the research. This allowed the development of rapport and mutual acceptance between the researchers and the community.

Appropriate permits were obtained from the Office of the Mayor and from the Department of Environment and Natural Resources Protected Area Wildlife Bureau (DENR PAWB). Prior informed consent was also obtained from the two *barangays*.

The participatory techniques employed came mostly from those already used in community-based coastal resource management (IIRR 1998). The methodology may be referred to as Participatory Biodiversity Assessment (Steinmetz 2003).

Local researchers and key informants were identified. Training and orientation of local researchers on the methods, such as household survey/house-to-house interview, group interviews, and focus group discussions, were done. They were also trained on determining the lake's biodiversity. As one aspect of participant observation, the researchers respected and followed the customs and practices of the local community, such as performing the *pamuhat*, i.e., making a *halad* (offering) to the *diwata* (spirits) of the lake. This was essential to allow the academic and local researchers to do the fieldwork in the lake. The data gathered were referred back to the community for validation and awareness. At the end of the research, the results were presented to and discussed with the community.

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[1] Paper presented at the 7th International Conference on Philippine Studies, 16-19 June 2004, Leiden, The Netherlands
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Biodiversity Inventory and Assessment

Plankton

An integrated vertical sample of plankton was obtained by lowering a plankton net with 25-ml bucket (119 mm mesh size; 24.5 cm mouth diameter) to almost the bottom (about 19 m) and hauling it vertically. The concentrated plankton sample in the bucket was poured into a bottle (amber) and preserved with Lugol's iodine to make a one percent final concentration (about the color of weak tea). (Zooplankton should preferentially be preserved with 10% neutral formalin to make a 4-5% concentration [Lind 1985]).

In the laboratory, 1-ml aliquot samples were examined under the microscope using a Sedgwick-Rafter counting cell for the identification and enumeration of the zooplankton species. Total count was made for each species in the 1 ml of water. These data were converted back to the number in the unconcentrated lake water by using the formula as follows:

$$\text{Organisms per liter of lake water} = \frac{\text{Organisms per ml of concentrate x 100}}{\text{Concentration factor}}$$

where

$$\text{Concentration factor} = \frac{\text{Volume of lake water filtered (ml)}}{\text{Volume of concentrate (ml)}}$$

Volume of lake water filtered was obtained by multiplying the mouth area of the plankton net (πr^2) with the actual depth through which the net was towed.

Aquatic Fauna

Lake fishes were collected using the residents' traditional fishing methods, namely, fish traps or *bubu*, and hook and line. A mosquito net was dragged around to catch whatever pelagic organisms were there. For benthos, an Ekman dredge was used to collect sediments from various points of the lake, specifically two replicate samples from the middle of the lake (20.4 m depth) and near the shore. Sampling near the shore proved to be difficult because of the large number of dead trees that had fallen and accumulated at the bottom. Thus, a near-shore sample was not taken. The sediment obtained was sieved successively through sieves of mesh size 4, 8, and 12 (0.203 in, 0.097 in and 0.060 in, respectively, as marked in the sieves; six-hundredth inch is approximately 1.5 mm). The concern of this study was the macrobenthic invertebrates visible to the naked eye.

Aquatic Flora

The sampling stations for the aquatic flora, in particular the submerged macrophytes, were the same as those for the shoreline flora by extending the station to the lake's littoral area. There were 10 stations - Stations 1 and 2 were near the residential houses in the east, then going on to the other stations in a counter-clockwise direction. Because the shoreline length is 1,060 m, the stations were approximately 100 m apart.

At each station, a 1 x 1 m quadrat was laid out in the lake's littoral, and species density counts were determined. Local names and local uses, if any, were recorded for each plant. For plants whose local names were not known to the local researchers, the specimens were referred to key informants. Representative plants were collected, photographed and prepared into herbarium voucher specimens.

Community Characterization

A brief historical background of each of the two *barangays* was obtained from secondary data (DENR NAMRIA 1989, Noorduyn *et al.* 2002) and from key informants. The key informants selected were those from among the oldest residents and the *timuay* (Subanen religious leader).

Demographic and economic data were generated from the house-to-house interview conducted by the local researchers, using an interview schedule translated to Bisayan. There were 79 out of 85-90 households surveyed in Barangay Gandawan, whereas 42 out of 55 households were surveyed in Barangay Lake Duminagat. The sampling method used was opportunitistic sampling, based on whom the local researchers could survey within the two-week schedule given to them. Additional data was obtained from focus group discussions (FGDs) and from direct/participant observation.

Cultural beliefs on the lake were obtained from semi-structured interview of key informants. The researchers followed the ritual of *pamuhat*, making an offering to the lake spirits so as to be allowed to do the fieldwork in the lake.

All the data gathered were validated by presenting them back to the community.

RESULTS AND DISCUSSION

Biodiversity Inventory and Assessment

Zooplankton

It was mainly zooplankton that was collected. The mesh size of the plankton net used, 119 ìm, allowed many phytoplankters to pass through. Many of the common phytoplankton species were small (a few ìm in diameter). On the other hand, most zooplankton were about 0.5 to 1 mm in length. The zooplankton observed and their abundance is shown in Table 1.

The Shannon index of overall diversity was calculated and gave a value of 0.7872. The nauplius was not included in the calculation, inasmuch as it was a developmental stage of a copepod and the copepod species to which it belongs was not known.

Groups comprising the zooplankton are the protozoans, rotifers, cladocerans and copepods. Both cladocerans and copepods are microcrustaceans. In Lake Duminagat, there was a glaring absence of rotifers and cladocerans. It was said that there is a dominance of cladocerans over copepods in productive (eutrophic) lakes, while copepods usually outnumber cladocerans in unproductive lakes (Goldman and Horne 1983). Up to 500 individuals per liter may be found in eutrophic lakes, while only less than one per liter characterizes most oligotrophic waters. As shown, Lake Duminagat had a total zooplankton abundance of only 1.3 per liter.

There were only 12 species in this freshwater ecosystem, in contrast to larger lakes with as many as 25 crustacean species, and tropical oceans with more than 50 species of copepods, as well as many species of other planktonic groups (Goldman and Horne 1983). This low number of species in Lake Duminagat was consistent with its small size. Despite the lake's oligotrophy, the species diversity may be considered quite high (0.79). This was because there is no correlation between diversity and productivity (Odum 1971).

Aquatic Fauna

There were five kinds of fishes reported to be in the lake, namely, *tilapia* (*Oreochromis* sp.), carp (*Cyprinus* sp.), *paitan* (*Barbodes binotatus*), *kasili* (*Anguilla* sp.), and *pargo*. Three were actually collected - carp, *paitan*, and *pargo*.

Local residents used hook and line and fish traps only in catching fishes, yielding very low catch per unit effort. The fish trap, locally called *bulantak* or *bubo,* was most preferred because it is just left in the lake and examined hours after, while the hook and line, called *bingwit*, consumes more time because it needs to be watched, and still cathes nothing after many hours.

Due to the residents' belief on the lake as the dwelling place of spirits, fishing in the lake was generally not encouraged. This was just as well since Lake Duminagat was an oligotrophic lake. It was therefore expected that fish, being

Table 1. Kind and abundance of zooplankton collected in May 2002.

Zooplankton	Mean # / ml of Plankton Concentrate	# / Liter of Lake Water	# / m^3
Cop sp 1	14.3	0.53	530
Cop sp 2	8.3	0.30	300
Diaptomus			
Cop sp 3	0.3	0.01	10
Cop sp 4	1.3	0.05	50
Cop sp 5	2.7	0.10	100
Cop sp 6	2.3	0.08	80
Cyclops			
Cop sp 7	1.3	0.05	50
Epischura			
Cop sp 8	1.0	0.04	40
Tropocyclops			
Nauplius	0.7	0.02	20
Prot sp 1	1.7	0.06	60
Unid sp 1	0.7	0.02	20
Unid sp 2	0.7	0.02	20
Unid sp 3	0.7	0.02	20
	Total	**1.3**	**1300**

Legend: Cop - copepod; Prot - protozoa; Unid - Unidentified group

Volume of lake water filtered = Mouth area of net x depth
Mouth area was 471.436 cm^2; depth was 17 m or 1700 cm
Volume of plankton concentrate was 29.5 cm^3

at the top of the aquatic food chain, would be quite low in number and biomass.

The benthos was sampled using an Ekman grab in the middle of the lake (20.4 m depth). A benthic sample could not be obtained nearshore because of the large number of dead trees that had fallen and accumulated at the bottom. The sediment obtained from the middle of the lake was very fine silt and was brown in color, classified as dy type (Wetzel 1983). No macrobenthic invertebrates visible to the naked eye were observed after sieving the sediment through successive sieves of mesh size 4, 8, and 12 (0.203 in, 0.097 in, and 0.060 in, respectively; 0.060 in=~1.5 mm). There were three possible reasons for this absence: a) the oxygen tension at the bottom (~1.6 mg/L) was not sufficient to support the aerobic benthos; b) the benthic animals were very sparse and very limited in their distribution, another indication of the lake's oligotrophy; and c) the smallest sieve used was not small enough to keep the smaller macroinvertebrates, inasmuch as they were defined as those retained by a U.S. No. 30 sieve (= 0.589 mm spaces).

Aquatic Flora

The true submerged aquatic macrophytes were composed of three species: *lusay*, *dagum sa tubig* (*Eleocharis acicularis*), and *busikad sa tubig* (*Eriocaulon* sp.). These plants were prominent in the shallow shoreline, the *lusay* (or *lusay-lusay*), appeared like a big violet rose. The *dagum sa tubig* appeared green and needle-like, and the *busikad sa tubig* (also known as *bila-bila sa tubig*) appeared green, shorter than the latter, with white globose inflorescence.

All the three macrophytes exhibited the rosette growth-form (or isoetid growth-form), that is, all the leaves arose in a whorl from a greatly shortened stem. The predominance of the isoetid growth-form in the submersed vegetation of softwater lakes and the elodeid form (leaves arising from the stem at nodes separated by distinct internodes, e.g., *Elodea/Hydrilla*, *Potamogeton*, and *Ceratophyllum*) in hardwater lakes was very striking. The well-developed root systems of the plants with rosette growth-form may be a key adaptation to nutrient-poor waters (Likens 1985). Elodeids, on the other hand, require relatively high concentrations of inorganic carbon, which exist in hardwater lakes (Likens 1985). This prevents them from becoming established in softwater lakes such as Lake Duminagat, which contains sub-optimal amounts of inorganic carbon.

Socioeconomic-cultural Profile of Barangay Gandawan

The DENR Mt. Malindang topographic map (DENR NAMRIA 1989), was compiled in 1956 from 1947 to 1953 photographs. The map showed many houses and numerous foot paths on both the left and right fringes of the Mt. Malindang Range, at some places up to 900 meters above sea level (masl). However, the rest of Mt. Malindang was denoted as being wooded. No houses were shown in the area of what is now Barangay Gandawan (easily recognized because of its topography), although a scrub portion was shown, possibly clearings made by early settlers. Other landmarks/places already had names labeled on them, such as North Peak, Mt. Malindang, South Peak, and on the right fringe, the villages of Mapa and Gala, Sungan Creek, and Clarin River.

Rand and Rabor (1960; as cited by Noorduyn *et al.* 2002) described Gandawan in 1956 as covered with virgin forest, except for some 10 hectares (ha) of cultivated patches within an area of 200 ha and several new clearings where the trees had been felled but not yet burned. They stated that only one family was living there, with several families from elsewhere coming to plant and harvest crops now and again. One resident in Barangay Mansawan recalled living in Gandawan during the early '60s, but transferred to Barangay Mansawan in 1963 to go to the elementary school there (Lumaray 2002, personal communication). It seemed that logging commenced at this time and opened the area to more settlers. In 1993, Fraser (1995; as cited by Noorduyn *et al.* 2002) reported that Gandawan was mostly under cultivation or grassland, with only secondary forest present, and 45 families living there.

The place was first known as Gandawan Valley according to the key informant, Diego Ubas, the *timuay* of Barangay Gandawan and the 72 year-old son of Juan Ubas who was one of the first settlers of the area. Juan Ubas was also known as "Gumitao". Gandawan was said to be a forested area when he and his contemporaries first settled there.

About 40 percent of the household head respondents were Subanen. The great majority (97%) earn their living from gardening or cultivation of less than 1-2 ha of land, where they averaged a monthly income of only PHP 1,873.42.

The common problems encountered and identified by the residents included heavy rains that destroy the roads and crops and causes leaching of applied fertilizers, bad roads, decreased fertility of soil that requires the use of chemical fertilizers, high cost of rice and fertilizer but low income, and lack of food and rest.

Fifty-four percent of the respondents indicated that they visit Lake Duminagat only once a year. Various reasons for going to the lake included bathing/swimming, enjoyment of nature, and procuring water for healing. Very few (two respondents) went to the lake to fish. The results indicated that majority of the respondents would agree should there be a plan to develop the lake for ecotourism.

The residents held various beliefs/stories regarding Lake Duminagat. It was claimed that the *timuay* (Subanen religious leader) had seen the lake filled with buildings or similar to a city, and that a photograph taken of the lake showed a person and house in the middle, where three children waving their hands were at the window. The lake was considered a sacred body of water with healing powers (for cysts, boils, and fever), and the lake water was believed capable of washing away sins. The lake was also believed to have the ability to renew one's powers during Holy Week. One story was that a soldier who shot at a fish in the lake died without reaching the nearest municipality. Another one was that there is a giant fish inhabiting the lake, as well as ducks that come out only during full moon.

Socioeconomic-cultural Profile of Barangay Lake Duminagat

The DENR Mt. Malindang topographic map (DENR NAMRIA 1989), based on 1947-1953 photographs, showed the absence of houses and footpaths in the part that is now Barangay Lake Duminagat (*centro*), easily recognized because of its topography. It was denoted as being forested. A small clear area was shown on the northeastern shoreline of the lake, possibly a clearing made by early settlers. The lake was not labeled yet.

Rand and Rabor (1960; as cited by Noorduyn *et al.* 2002) described that Lake Duminagat in 1956 had only one abandoned house near the lake, formerly a house of worship. There were no clearings, only a few fish traps in the water belonging to somebody living in Gandawan. From interviews of key informants, the discovery of the lake was ascribed to a Subanen, Pedro "Mali" Villamino, who was said to be a *surhano* (spirit medium) around 1930. A number of residents of the *barangay* today are his descendants. It seemed, however, that the majority settled in the area in the 1960s.

Ninety-five percent of the household head respondents were Subanen. Their main source of income was gardening, many cultivating 1-2 ha with subsistence and cash crops. The residents considered themselves poor, reporting an average monthly income of just a little more than PHP 500. Gardens were observed mainly on the slopes of the surrounding mountains. One lakeside resident cultivated a small area for cabbage near the outlet stream.

In terms of farming activities, residents of Barangay Lake Duminagat believed in cooperativism. They organized *hunglos* or cooperative farming, wherein families help each other in farming activities, such as cleaning, cultivating, and harvesting, including marketing of their produce. A group of 8-10 families exchanged services to facilitate farming activities and to make these activities enjoyable for them.

The crops planted for cash were chayote, onions, abaca, and cabbage. The root crops were usually subsistence crops. It was observed, but not reported in the household survey, that some households grow the introduced ornamental plant milflores, *Hydrangea macrophylla*, which were sold in the lowland cities such as Dipolog. Replanting and propagation of native lakeside plants that had ornamental potential and selling them as additional income source was suggested to the local researchers. However, they said that the DENR prohibits any gathering and cultivation of these plants.

Although lakeside residents and some others from the *centro* do some fishing in the lake, it was generally discouraged because of the residents' belief in the lake as the dwelling place of spirits. Many of the residents go to the lake during Holy Week. They considered the lake useful for healing, and for washing and bathing. The lakeside residents (consisting of only five households who are related to the ascribed founder of the lake) obtain their drinking water from the middle of the lake.

It was learned that the Municipal Development Plan of Don Victoriano included the use of Lake Duminagat for fish cultivation through the use of fish cages, and for constructing a hydroelectric plant. Based on the obtained data on productivity and hydrology of Lake Duminagat, these plans were not feasible. The people themselves had blocked a previous attempt to put fish cages in the lake because they were aware that this would pollute the lake (Luminding, personal communication). The *barangay* captain (village head) thought that inasmuch as people get water from the lake, if they were given funds, they could bottle the lake water and sell it to the outsiders. However, he himself did not believe in the general Subanen cultural belief on the healing property of the lake water.

The exact number of visitors from outside the community was monitored during the Holy Week in 2002 because it was said that visitors to the lake are most numerous especially during this season. The most number of visitors was tallied on Maundy Thursday and Good Friday, 253 and 225, respectively, which was probably indicative of the belief that bathing in the lake could wash away sins.

During all the field visits of the external researchers, there were always some outside people reported or observed either at the lake or going to the lake: a busload in

December 2001, about 30 people in January, an extended family in May, a religious group accompanied by DENR personnel in June, and about 30 people (a group of Adventists) in October. In April, about eight motocross riders rode their motorcycles to the lake through the road that goes directly to the lake from Barangay Gandawan. This was the road that was bulldozed in 1999 to make it passable by motor vehicles. However, residents of Barangay Lake Duminagat objected to this planned road. In October, the Adventist group was camped at the centro rather than at the lake itself because the *barangay* residents no longer allow people to camp at the lake. Furthermore, the *barangay* had started collecting a fee of PHP 10 per head since this regulation had already been passed by the Provincial Board.

Based on the number of people going to the lake for various reasons – religious, sightseeing, nature trekking, and others, there was really a high potential for the lake to be developed for ecotourism (said to be part of the Municipal Development Plan). It was actually not only the lake that was attracting outside people to this area, but also the North Peak, which was visited often by mountain climbers. The *barangay* would need to know what ecotourism really is and how it could be developed without adverse effects on the environment (Libosada 1998).

The residents held various beliefs regarding Lake Duminagat: that it is sacred because it is a city of the spirits; that it has healing powers; that it can cleanse away sins and change character; that it is a remnant of the great flood that engulfed all the earth during Noah's time; that it is the "navel" of the entire world so it is prohibited to make noise and do foolish things on the lake.

Though the Subanens believed in God as a supreme and powerful being, they also believed that there are lesser gods or spirits (*diwata*) who are also powerful. Thus, they usually make an offering to these spirits during *daktol* or full moon. They also worship and make an offering to these spirits twice a month, on full moons and new moons.

Lake Duminagat was considered sacred for it is believed to be the city of the spirits; they are then very careful not to offend the spirits. For this reason, the BRP researchers inquired about the ritual ceremony and offerings required so that they and the local researchers could carry out research work in the lake. Numerous requirements were asked as offerings for they could not afford to make the spirits in the lake angry and retaliate to them in the form of sickness. The required offering consisted of one pig, four chickens (two roosters and two hens), four eggs, 28 cigarettes, four bottles of local liquor, and one ganta of rice. A ritual (*pamuhat*) was made after the pig and the chicken were butchered and cooked in water and salt. A table was set for four people with four plates and glasses, surrounded by four chairs. The *pamuhat* ritual was performed by the *timuay's* wife and the *surhano* (local medium for the spirits).

SUMMARY AND CONCLUSION

Situated at a high elevation (1,560 masl), Lake Duminagat is a small (8.04 ha), thermally stratified lake. Its various morphometric and physico-chemical characteristics, such as low surface area to volume ratio, low lake area to watershed area ratio, low alkalinity, and low amount of dissolved solids all contributed to its low productivity. Its macrophytes (representing one component of primary productivity) and zooplankton (representing secondary productivity) population were thus low in numbers, aside from being limited in number of species. Consequently, the fish population, which is at the top of the aquatic food chain, was also low in kind, number, and biomass. Nonetheless, the lake supported a high diversity of indigenous shoreline fauna and flora.

In the two *barangays* adjacent to the lake, the majority of the settlers probably started residing there in the early '60s when the area was opened up due to logging. Prior to this period, it was claimed that the lake was discovered by a Subanun, Pedro "Mali" Villamino, a number of whose descendants still reside by the lakeside itself and in the main settlement of Barangay Lake Duminagat (the *centro*; about an hour walk away).

The population of the two *barangays* consisted of about 60 households each, the majority being Subanen. The population has a high potential to increase because a greater sector of the population was at their reproductive age. There is also the potential for in-migration to the area, even as other parts of the Philippines/Mindanao have a growing population. However, there could also be out-migration for people who want to seek "greener pastures". Although the area has an attractive cool climate because of its high elevation (from 1,240 to 1,560 masl), it was beset by heavy rains, bad roads, leeches, lack of food, difficult livelihood, lack of electricity, and lack of the finer amenities of life. This may just as well be because making the place more attractive by providing more basic services could lead to increased in-migration that could overshoot the area's carrying capacity. How to strike a balance between a better quality of life and sustainable management of the environment is the question that the local residents and researchers should explore.

The major source of income in the community was gardening or farming. However, the farm produce were being sold at a low price resulting to low income,and yet the basic necessities (e.g., rice) commanded a high price. Consequently, most of the residents regarded themselves as poor. Gardening could not really lift up the economic condition of the residents in addition to the fact that further opening of the area to agricultural pursuits would destroy the park. There should be development of livelihood alternatives.

The residents considered the lake as the dwelling place of spirits and discouraged fishing in the lake. This was just as well since the lake did not support a substantial fish population. The residents themselves knew that they could preserve the cleanliness of the lake by not allowing the construction of toilets beside it. They allowed swimming, bathing, and washing of clothes only near the outlet. The lakeside residents, consisting of five households, acquired their drinking water from the middle of the lake.

It was not only the Subanens, but also people from the outside who considered the lake as a source of healing water and believed it to have the power to wash away sins. The occurrence of many visitors to the lake, especially during Holy Week, attested to that belief. It was not only for this purpose that people troop to the lake, but also for recreation, nature trekking, and enjoyment. Thus, the lake, and the adjacent North Peak for mountain climbing, has a very good potential for ecotourism, so long as possible adverse effects of these activities are prevented. The beliefs of the residents themselves on the sacredness of the lake and its supernaturality play a great role in the lake's conservation.

Considering the need for sustainable livelihood alternatives in conjunction with biodiversity conservation of the lake and its immediate surroundings, coupled with the area's cool climate and general scenery, it may be possible for this area to be developed into a nature park that offers indigenous ornamental plants for sale, and promotes activities such as bird watching and mountain climbing. The local residents themselves should be in charge of these activities, making them hosts and businessmen-entrepreneurs. Thus, it is hoped that results of this research would be used and would empower the local communities to come up with a strategy of conserving and sustainably utilizing the lake's biodiversity and resources so as to open up various livelihood possibilities.

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ASSESSMENT OF SEAGRASS AND SEAWEED MEADOWS AND ASSOCIATED FAUNA IN THE COASTAL *BARANGAYS* OF NORTHEASTERN MT. MALINDANG[1]

Wilfredo H. Uy[2], Rene N. Rollon[3], and Erik de Ruyter van Steveninck[4]

The landscape approach to understanding the biodiversity and relationship of the mountain, river, and sea, focused on two major watershed areas in the Mt. Malindang Range flowing through the Layawan River in Oroquieta and Langaran River in Plaridel, Misamis Occidental. This report covers the status and extent of distribution of the seaweeds and seagrasses of Mt. Malindang.

Field activities were conducted in a participatory manner with local stakeholders, during the northeast and southwest monsoon season. Survey methods employed standard techniques as follows: transect-quadrat, stratified random point quadrat, and core sampling. Coordinates of all stations established were recorded using the Global Positioning System (GPS) and plotted in the Geographic Information System (GIS).

Seagrass cover was generally increasing from the river mouth. However, seagrass vegetation had been observed to occur about a kilometer in Oroquieta, while in Plaridel, seagrasses occured a few meters from the river mouth. Average seagrass cover was generally higher in Plaridel (27.7%) than Oroquieta (15.9%), with a total of eight and seven seagrass species for Plaridel and Oroquieta, respectively. The *dugong* grass, *Thalassia hemprichii*, and the round-tipped seagrass, *Cymodocea rotundata*, dominated the seagrass. Variations in the internodal length indicated a temporal pattern in growth towards the northern part in both rivers, with peak generally occurring during the cold months of December to February. While temporal pattern in the south was less clear, reproductive efforts appeared to be high, with higher fruiting frequencies during the cold months in both rivers.

Seaweed vegetation was also in patches and occured along rocky areas and reef edges dominated largely by the brown seaweeds, *Sargassum* and *Padina*. A total of 59 species were recorded, represented by 16 green algae, 24 red algae, 15 brown algae, and four blue green algae. Twenty species were recorded new for the Mt. Malindang region.

Results indicated that the impact area to biotic components appeared to be greater in magnitude in the Layawan River (approximately a kilometer) as compared to Langaran River (less than 100 m). A scenario leading to increased river discharge and reduced water quality would widen impact areas, thereby reducing the already limited extent of seagrass and seaweeds along river mouth. Management implications and recommendations are provided in this report towards biodiversity conservation and sustainable development of the coastal resources of the Mt. Malindang area.

INTRODUCTION

Seagrasses are fully submerged marine flowering plants inhabiting shallow coastal seas. Like the terrestrial grasses, they posses erect leafy shoots and creeping rhizomes. In contrast to other submerged marine plants, like seaweeds or algae, seagrasses bear flowers, develop fruits, and produce seeds. In contrast, the seaweeds are not considered as true vascular plants because they lack a specialized vascular system (an internal conducting system for fluids and nutrients), roots, stems, leaves, and enclosed reproductive structures like flowers and cones, although they have a plant-like appearance. In the tropics, particularly in the Philippines, seagrasses reach their highest species diversity and abundance, forming extensive, dense meadows that are a major component of the coastal zone (Fortes 1988, Phillips and Meñez 1988). A total of 16 species were reported for the seagrasses and about 200 species for macroscopic benthic algae or seaweeds in the Philippines (Meñez *et al.* 1983, Fortes 1989, Calumpong and Meñez 1997, Trono 1997).

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The value of seagrass and seaweeds to human is not so much on the direct use, but the services the vegetation provide to the overall functioning of the coastal zone system as follows: Seagrass and seaweed meadows enhance biodiversity and habitat diversity of coastal waters. They support the production of living marine resources as nursery and foraging areas for a number of commercially and economically important fish (e.g., siganids), crustaceans, and shellfish species. They improve water quality by reducing sediment or particle loads in the water and absorbing dissolved nutrients, thus contributing to the overall nutrient dynamics in the ecosystem; they interact with the coral reefs and mangroves in the reduction of wave energy, sediment relationships, and flow regulation; and play an important role in the global carbon and nutrient cycle. Specifically, the seagrasses help stabilize sediments because of the intricate network of below-ground structures, such as the roots and rhizomes (Phillips and Meñez 1988, Fortes 1989, Hemminga and Duarte 2000).

The presence of submerged marine plants, like seagrasses and seaweeds, in the shallow coastal areas critically depends on the availability of light to allow photosynthetic processes and growth (Duarte 1991, Vermaat *et al.* 1997, Uy 2001). Deterioration of light conditions brought about by increased sediment loading and eutrophication as a consequence of industrialization, urbanization, and agricultural intensification in the coastal zone, is presently a major threat to tropical seagrass and seaweed meadows. A number of studies have already shown the negative effects of reduced light as caused by heavy siltation (Fortes 1988, Terrados *et al.* 1998, Duarte 1991).

OBJECTIVES

The study aimed to determine the status of the seagrass and seaweed ecosystem of Mt. Malindang relative to the river mouth, in terms of vegetation cover, flora and fauna associates, nutrient contents of seagrass leaf tissues, and some aspects of the reproductive biology of the seagrass. These would then be related to the environmental conditions of the area.

METHODOLOGY

To determine the general distribution of the seagrasses and seaweeds on the coastal areas fronting the two river system, a wide area survey was conducted through ocular inspection from a boat with the local researchers. Personal interviews were also conducted among fishermen present in the area.

An imaginary box of the coastal areas was defined with dimensions of 2 km on either side of the river mouth and 1 km offshore, enclosing an area of 4 km^2 for each river system (Figure 1). The maximum distance of 2 km from the river mouth was based on the preliminary survey done. The method used was the modified random point quadrat technique that required minimal personnel and time to cover the relatively extensive seagrass beds during the dry season from 3-10 April 2004. Local researchers also joined in the field sampling and processing of samples, after a short training on sampling protocols.

Within each box, a minimum of 40 sampling points was sampled at an estimated distance between points of 100-200 m. Three quadrats measuring 0.5 x 0.5 m were randomly thrown within a 15 x 15 m perimeter area at every sampling point. All species occurring in the quadrat were listed, and cover class was assigned per species based on the modified Braun-Blanquette Abundance Scale (Table 1). Observations in every sampling point were also noted. Coordinates were read from a GPS (Garmin II) in every stop. To enhance the data, density of the dominant species of seagrass was made in every sampling point for the Plaridel station only.

Associated flora and fauna of the seagrass meadow were also recorded. In both sites, the local counterpart team did quantitative estimates of the invertebrates. In every sampling point, three quadrats (using 0.5 x 0.5 m quadrat and folded four times to get an area of 1 m^2) were randomly thrown. The observers recorded and counted all macroinvertebrates found in every quadrat using local names. No quantitative assessment was done for the seaweed associates, except for the macroalgae, such as *Sargassum*, *Turbinaria,* and *Padina*. A checklist was made for other species of seaweeds.

During the wet season (October to November 2004), the same method was applied, with additional transects laid at both sites. The line transects were laid from the shoreline to the reef edge to represent the permanent transects for seagrass monitoring. Further, sampling was also conducted outside of the imaginary box to determine variations in seagrass cover and dynamics.

Core samples (20 cm diameter x 20 cm deep) (Figure 2) were also collected in different locations relative to the river mouth during the wet season sampling. The collection area was extended beyond the 2 km imaginary box to determine presence of any variations in the dynamics of the seagrass. No samples, however, were collected less than a kilometer from the river mouth in Oroquieta since no seagrass occurs within this distance.

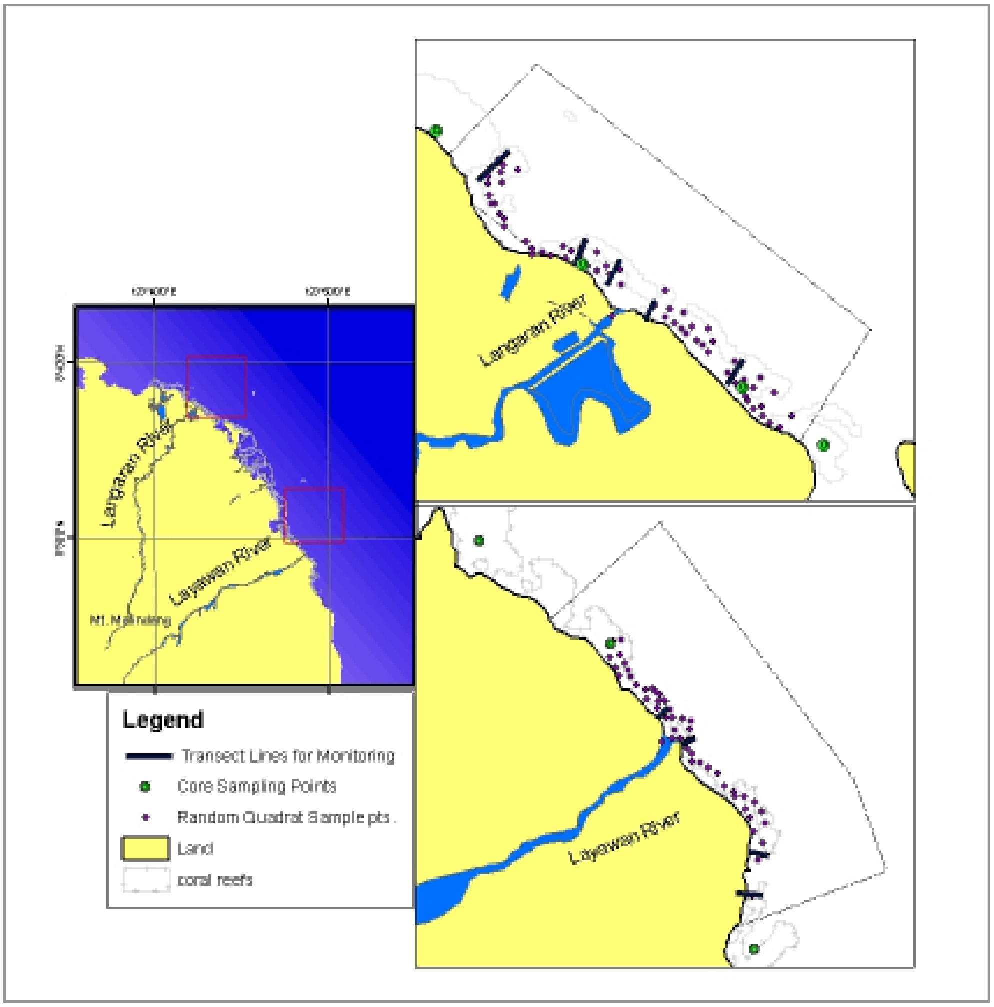

Figure 1. Location of sampling points for seagrasses and seaweeds in Oroquieta and Plaridel. X-axis is longitude and y-axis is latitude expressed in decimal degrees. The broken lines represent the boundary of the imaginary box.

Table 1. Modified Braun-Blanquet Abundance Scale was used to estimate percent seagrass and seaweed cover by species. Cover is defined as the fraction of the bottom that is obscured by the species when viewed by a diver from directly above.

Abundance Scale	Description	Equivalent % Cover
0	Absent	0
1	less than 5% cover	3.0
2	5-25% cover	15.0
3	25-50% cover	37.5
4	50-75% cover	62.5
5	75-100% cover	87.5

A total of ten cores were collected and placed separately in pre-labeled net bags. These were processed immediately in the field, with the assistance of the local researchers. Species were separated and counted; the number of apical rhizomes (new branches) was counted per species; the number of leaf bites per shoot was also counted and classified further as sea urchin bites (serrated or irregular cuts at leaf margins) or fish bites (smooth-edged and usually rounded [Deocadez 2000]).

Shoots of similar species per station were pooled in a separate container. Then, 100 shoots from the pooled samples were randomly collected, and their corresponding age and branching patterns were recorded. Ages of the shoots were determined by counting the number of leaf scars. The occurrence and timing of fruiting or flowering was also determined by the presence of fruit scars.

A total of ten shoots, having very long vertical rhizome or stem, were selected from the samples in every station. These selected shoots belong to the ten oldest shoot of every station. They were then used to determine growth patterns of *Thalassia hemprichii* using the age reconstruction technique (Duarte *et al.* 1994). This was done by measuring the distances, to the nearest millimeter, between internodes along the vertical rhizome and plotting these against time. The leaf turnover rates or leaf plastochron interval (the time needed to produce two successive leaves) was pegged at 10 days, based upon several reports (Vermaat *et al.* 1995, Rollon *et al.* 1998, Uy 2000). Therefore one leaf scar was assumed to have an equivalent of 10 days (Figure 3).

Profiles and distribution of the different parameters were plotted in the map using the surface mapping system (Surfer ver. 7.0). Maps were digitized from the NAMRIA bathymetric map dated 1910. Specific locations of the different sampling points are shown in Figure 1.

RESULTS AND DISCUSSION

A total of seven species of seagrasses were identified along the river mouth of Layawan River in Oroquieta and eight species along Langaran river mouth in Plaridel (Table 2). The *dugong* grass, *Thalassia hemprichii,* was the dominant species in both sites (42-49% cover), followed by *Cymodocea rotundata* (12-26%) (Figure 4). The Tropical eel grass, *Enhalus acoroides*, was not recorded in all the quadrats sampled at Oroquieta, but was observed to occur in small patches in the area. The small Spoon grass, *Halophila ovalis*, ranked second in Oroquieta (25%) since it occurred in most of the stations sampled. Two of the relatively rare species reported in Mt. Malindang (*Halophila decipiens* and *Halophila spinulosa*) were not recorded within the 2-km radius from the river mouth in the present study sites. They were reported only in Aloran, Tuburan (Galope-Bacaltos *et al.* 2002). Species composition of the area was comparable to Panguil Bay with eight species reported (Uy and de Guzman 1992), Bolinao Bay with seven species (Rollon and Fortes 1990), and Sulawan point with seven (Arriesgado 2000). In most tropical regions, a mixed seagrass bed has five to eight species normally occurring in a certain area. On the other hand, in the temperate regions, only one to two species are normally reported, but these can occur as extensive seagrass beds

Figure 2. Stainless steel corer 20 cm diameter used to collect seagrass samples.

Figure 3. Leaf scars along vertical rhizomes or stem of *Thalassia hemprichii.*

supporting major fishery resources such as shrimps (Fortes 1989, Hemminga and Duarte 2000).

For the seaweeds, a total of 59 species were recorded, represented by 16 green algae, 24 red algae, 15 brown algae, and four blue green algae (Table 3). Twenty species were recorded new for the Mt Malindang region, based on those reported during the First Generation Research of the Biodiversity Research Programme (BRP), covering the entire coastal area of the Mt. Malindang wedge. In the present study, the brown algae, *Sargassum* (at least six species), dominated the seaweed community followed by *Padina* (at least four species) (Figure 5).

Average seagrass cover was higher in Plaridel (27.7%) than in Oroquieta (15.9%) (Figure 6). Seagrass vegetation in Oroquieta started approximately a kilometer at both sides from the river mouth. While patches of the brown algae, *Sargassum* spp. and *Padina* spp., were found immediately in front of the Layawan river mouth and approximately 1 km in both sides (Figure 8). The generally low seagrass cover in Oroquieta could be attributed to the substrates type, which was generally sandy along the beach and stony (fist-size to head-size) from the midreef towards the deeper end. The stony substrates were covered by the brown algae *Padina* and *Sargassum*. Although conditions may favor the growth of seagrass along sandy area near the river, data indicated none. Substrate type from the river mouth towards the north was generally sandy and relatively deep.

In Plaridel, seagrasses were recorded throughout the reef areas, even immediately in front of the Langaran river mouth. Similarly, the brown seaweeds, *Sargassum*, were also found in most of the reef areas, along the reef crest forming a narrow band of *Sargassum* beds. Considering the presence of seagrasses near the river mouth, there appeared to be no pattern in the seagrass vegetation in the Plaridel area, unlike those in Oroquieta. This may indicate the seemingly minimal influence of the river outflows to the vegetation (Figure 8).

The estimated seagrass areas within the 2-km radius from the river mouth were 31.3 ha for Plaridel and 15.1 ha for Oroquieta (Figure 8). These values were small compared to some areas with extensive seagrass beds, such as in Bolinao Bay, Pangasinan (3,700 ha), Pagbilao Bay (189 ha), Puerto Galera (114 ha), and Ulugan Bay (297 ha) (Fortes 1990). In Northern Mindanao, areas with extensive and still pristine seagrass beds are in Sulawan, Laguindingan (106 ha) and Murcielagos Bay (3,610 ha) (Uy 2000).

Average seagrass density was 1,864 m^{-2} in Oroquieta and 2,322 m^{-2} at Plaridel. *Thalassia hemprichii* accounted for at least 47.9 percent and 66.2 percent of these values, respectively (Figure 7). Average leaf area (leaf width x leaf length) plotted against distance from the river mouth did not show any pattern. Initial results indicated that the river system did not influence shoot morphology of the dominant seagrass. Variations in leaf morphology could be attributed to substrate type and degree of exposure to tidal fluctuations.

Seasonality in the growth of the dominant seagrass represented by *Thalassia hemprichii* is shown in Figure 9. Peaks indicate high growth rate of the vertical stem as a consequence of climatic conditions, while the trough or the lowest internodal distance may indicate low productivity. Preliminary results indicated that the north side of the river exhibited strong seasonality in growth of the seagrass during summer, between the months of April to July (1.5 km north of Layawan River) and July to August (0.6 km north of Langaran River) for Oroquieta and Plaridel, respectively.

There was a high incidence of fruiting of *Thalassia hemprichii* in Oroquieta than in Plaridel (Figures 9 and 10). Further, there appeared to have higher fruiting incidence of this seagrass towards the south than in the north, for both Plaridel and Oroquieta. This seemed to indicate greater influence of the water discharge from the river mouth flowing to the south, bringing in nutrients to the seagrass meadows.

Horizontal elongation rates of *Thalassia hemprichii* were significantly higher in Oroquieta (44.6 mm d^{-1}) as compared to Plaridel (13.2 mm d^{-1}, $p = 0.043$, Mann Whitney Test). This indicated that *T. hemprichii* was still expanding in Oroquieta, thus chances of recovery was still high. However, net recruitment was negative in both sites, indicating that mortality was still higher than recruitment, except in the south 3 km from the river mouth (Table 4). Vertical elongation rates ranged from 1.76-4.32 mm d^{-1}, with no significant difference between sites.

For the associated fauna in the seagrass meadow, the shells (44%), composed mainly of small-sized Strombus, dominated in Plaridel, followed by the Brittle stars (28%). While in Oroquieta, the starfish was the dominant invertebrate largely represented by the Horned seastar, *Protoreaster nodosus*. The urchins ranked second in dominance, represented largely by the *Diadema setosum* and *Tripneustes gratilla* (Table 5). The dominance of the sea urchins could explain the relatively high grazing rate on *Thalassia hemprichii* leaves at Oroquieta (390 bites m^{-2}) than at Plaridel (144 bites m^{-2}). There was no difference in fish bites with average values of 44 fish bites m^{-2} in both sites.

Table 2. List of seagrass species identified in the two sites.

Species	Common Name	Plaridel	Oroquieta	Mt Malindang*
Thalassia hemprichii	*Dugong* grass	✓	✓	✓
Halodule uninervis	Fiber-strand seagrass	✓	✓	✓
Halodule pinifolia	Fiber-strand seagrass	✓	✓	✓
Cymodocea rotundata	Round-tipped seagrass	✓	✓	✓
Cymodocea serrulata	Toothed seagrass	✓		✓
Enhalus acoroides	Tropical eel grass	✓	✓	✓
Halophila ovalis	Spoon grass	✓	✓	✓
Halophila minor	Small spoon grass		✓	✓
Halophila decipiens **	Spoon grass			✓
Halophila spinulosa **	Branching spoon grass			✓
Syringodium isoetifolium	Syringe grass	✓	✓	✓

* Species reported during the BRP First Generation Research (2002), covering the area from Panalsalan, Plaridel to Aloran, Tuburan, Misamis Occidental.

** Species reported only in Aloran, Tuburan, Misamis Occidental (Galope-Bacaltos, unpublished).

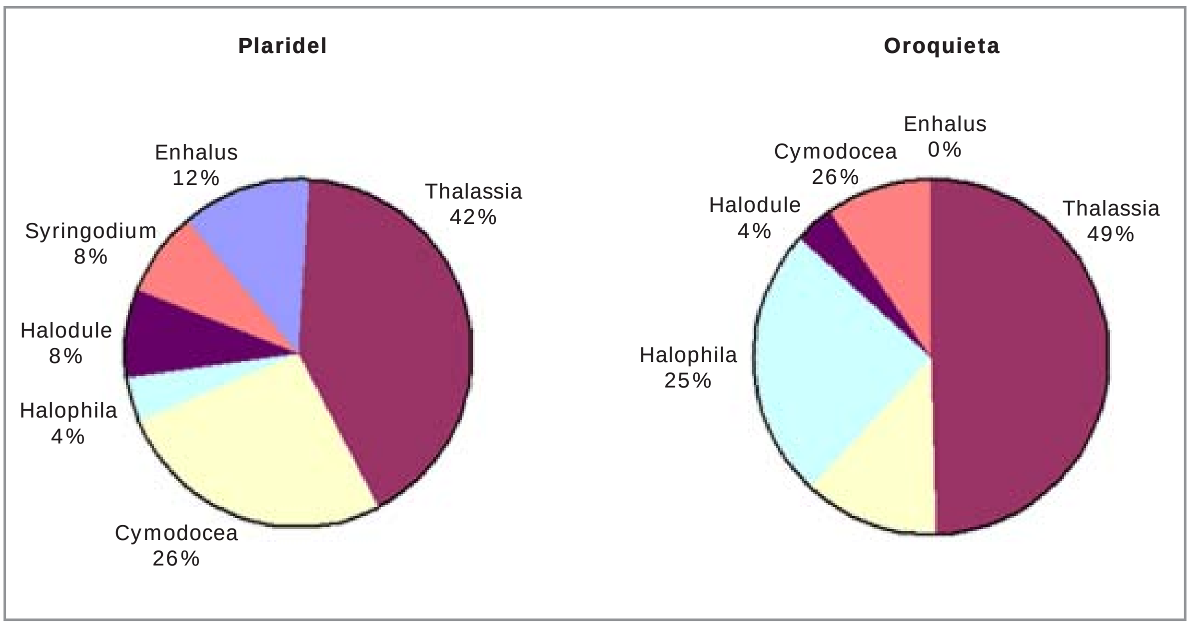

Figure 4. Pie chart showing relative abundance of seagrasses in the two sites, Plaridel and Oroquieta.

Table 3. List of seaweed species identified within the 2-km radius of the river mouths of Layawan River in Oroquieta and Langaran River in Plaridel.

	Oroquieta	Plaridel	Mt. Malindang*
Division CHLOROPHYTA (Green algae)			
Acetabularia major Martens	✓		
Anadyomene wrightii Harvey ex J.E. Gray	✓	✓	✓
Boergesenia forbesil (Harvey) Feldmann			✓
Bornetella oligospora Solms-Laubach	✓		✓
Bornetella sphaerica (Zanardini) Solms-Laubach	✓	✓	✓
Caulerpa brachypus (Harvey)			✓
Caulerpa racemosa (Forsskal) J. Agardh	✓	✓	✓
Caulerpa serrulata (Forsskal) J. Agardh	✓		✓
Caulerpa sertulariodes (S.G. Gmelin) Howe		✓	✓
Chloredesmis fastigiata (C. Agardh) Ducker			✓
Chloredesmis hildebrandtii A. Gepp and E.S. Gepp			✓
Codium arabicum Kutzing	✓	✓	
Codium edule P.C. Silva			
Dictyosphaeria cavernosa (Forsskal) Borgesen	✓	✓	✓
Dictyosphaeria versluysii			✓
Enteromorpha intestinales (Linnaeus) Nees	✓	✓	
Halicoryne wrightii			✓
Halimeda macroloba Decaisne	✓	✓	✓
Halimeda opuntia (Linnaeus) Lamouroux	✓	✓	✓
Halimeda sp.		✓	
Halimeda tuna (Ellis and Sollander) Lamoroux	✓	✓	
Neomeris vanbosseae Howe	✓	✓	✓
Ulva lactuca Linnaeus			
Ulva reticulata Forsskal	✓	✓	✓
Valonia ventricosa	✓		✓
Division PHAEOPHYTA (Brown algae)			
Colpomenia sinuosa (Mertens ex Roth) Derbes and Solier	✓	✓	✓
Dictyota cervicornes Kutzing	✓	✓	✓
Dictyota dichotoma (Hudson) Lamouroux	✓	✓	✓
Hormophysa cuneiformes (J.F. Gmelin) P.C. Silva	✓	✓	
Hydroclathrus clathratus (C. Agardh) Howe	✓	✓	✓
Lobophora variegata (Lamouroux) Womersly	✓	✓	
Padina australis Hauck	✓	✓	✓
Padina japonica Yamada	✓	✓	✓
Padina minor Yamada	✓		✓
Padina tetrastomatica Hauck	✓	✓	
Sargassum oligocystum Montagne	✓	✓	✓
Sargassum polycystum C. Agardh	✓	✓	✓
Sargassum sp. *(Sargassum cristaefolium?)*	✓	✓	✓
Turbinaria conoides (J. Agardh) Kutzing	✓	✓	✓
Turbinaria decurrens Bory de Saint-Vincent	✓	✓	✓
Turbinaria ornate (Turner) J. Agardh	✓	✓	✓

* Species reported during the BRP First Generation Research in Mt. Malindang

Table 3. Continued…

	Oroquieta	Plaridel	Mt. Malindang*
Division RHODOPHYTA (Red algae)			
Acanthopora spicifera (Vahl) Borgesesn		✓	✓
Actinotrichia fragilis (Forsskal) Borgesen	✓	✓	✓
Amansia glomerata C. Agardh			✓
Amphiroa foliacea Lamoroux	✓	✓	
Amphiroa fragilissima (Linnaeus) Lamoroux	✓	✓	✓
Amphiroa rigida			✓
Claudea multifeda	✓	✓	✓
Coralline algae	✓	✓	✓
Euchema denticulatum (Burman) Colins and Hervey		✓	✓
Eucheuma gelatinae J. Agardh	✓	✓	
Galaxaura oblongata (Ellis and Solander) Lamouroux		✓	✓
Galaxaura subverticillata Kjellman	✓	✓	
Gelidiella acerosa (Forsskal) Feldmann et Hamel	✓	✓	✓
Gelidiopsis sp.	✓	✓	✓
Gracilaria arcuata Zanardini	✓	✓	✓
Gracilaria edulis	✓	✓	✓
Gracilaria eucheumoides Harvey	✓	✓	✓
Gracilaria salicornia (C. Agardh) Dawson		✓	✓
Halymenia dilatata Zanardini			✓
Halymenia durvillaei Bory de Saint-Vincent	✓		
Hypnea boergesenii Tanaka			✓
Hypnea cervicornis J. Agardh	✓	✓	
Hypnea pannosa J. Agardh		✓	✓
Jania adhaerens Lamouroux	✓	✓	✓
Laurencia papillosa (C. Agardh) Greville	✓	✓	
Laurencia sp. 1	✓	✓	✓
Liagora ceranoides Lamouroux			✓
Mastophora rosea (C. Agardh) Setchell	✓	✓	✓
Peyssonnelia rubra (Greville) J.Agardh	✓	✓	✓
Portieria hornemannii (Lyngbye) P.C. Silva	✓	✓	✓
Division CYANOPHYTA (Bluegreen algae)			
Hormothamnion solutum Barnet et Grunow ex Barnet et Flahault	✓	✓	
Lyngbya majuscula (Dillwyn) Harvey ex Gomont	✓	✓	
Phormidium sp.	✓	✓	
Symploca hydnoides Kutzing ex Gomont		✓	

*Species reported during the BRP First Generation Research in Mt. Malindang

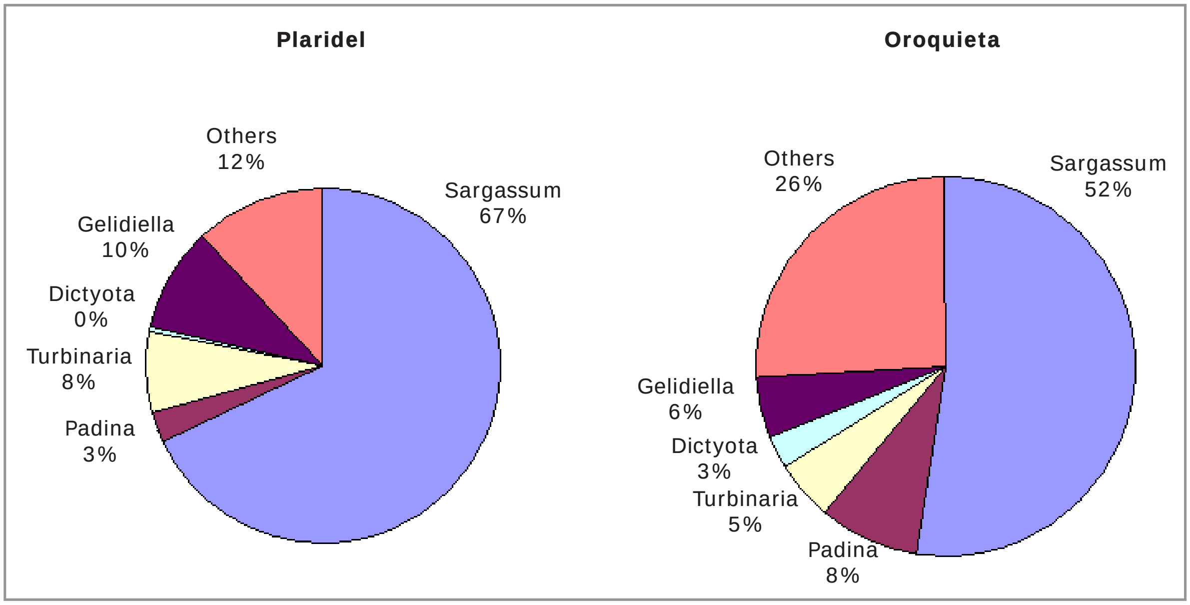

Figure 5. Pie chart showing relative abundance of major seaweed genera in Plaridel and Oroquieta.

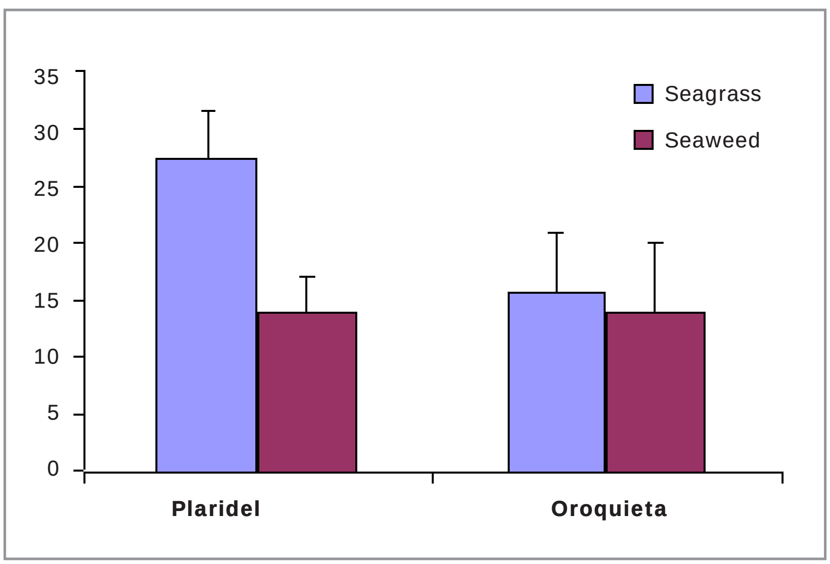

Figure 6. Average percent cover (± SE) of the seagrass and seaweeds in Plaridel and Oroquieta.

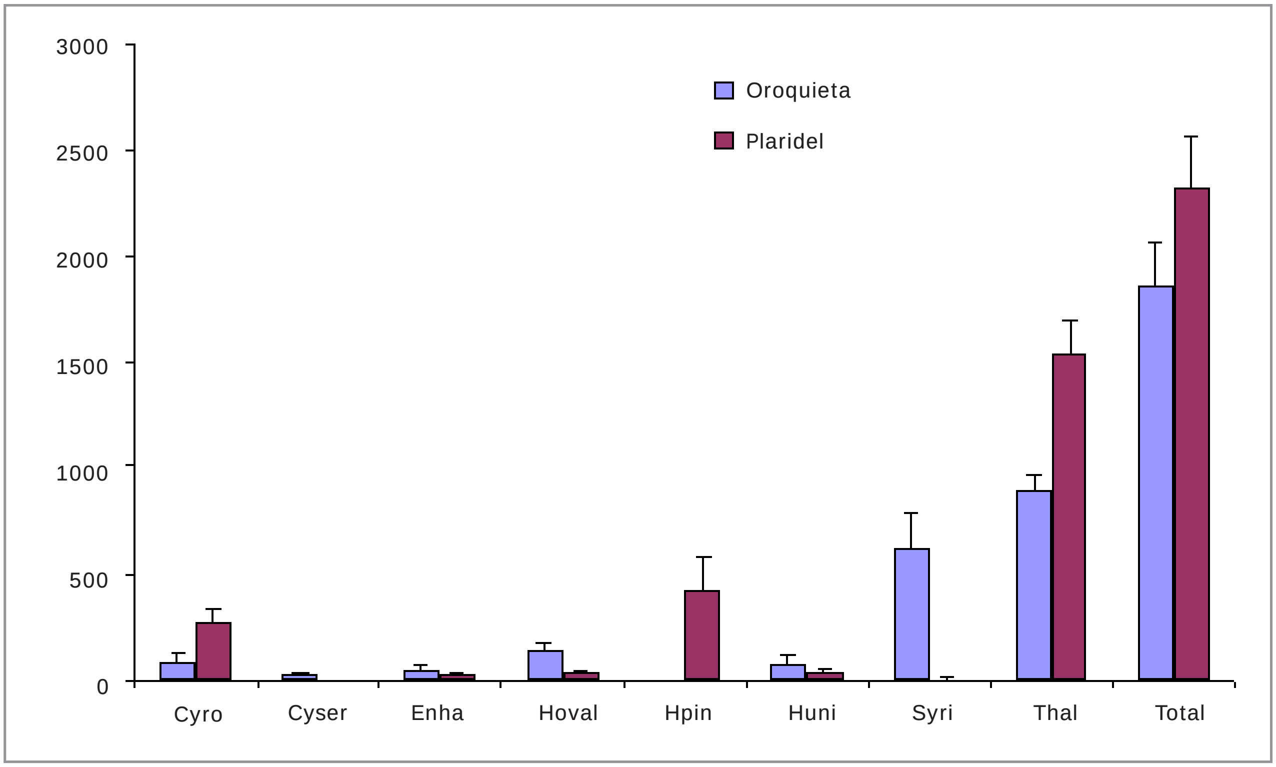

Figure 7. Shoot density of seagrasses in the river mouths of Layawan and Langaran Rivers in Oroquieta and Plaridel, respectively. (Cyro = *Cymodocea rotundata*; Cyser = *Cymodocea serrulata*; Enha = *Enhalus acoroides*; Hoval = *Halophila ovalis*; Hpin = *Halodule pinifolia*; Huni = *Halodule uninervis*; Syri = *Syringodium isoetifolum*; Thal = *Thalassia hemprichii*; Total = sum of all seagrass species expressed per square meter).

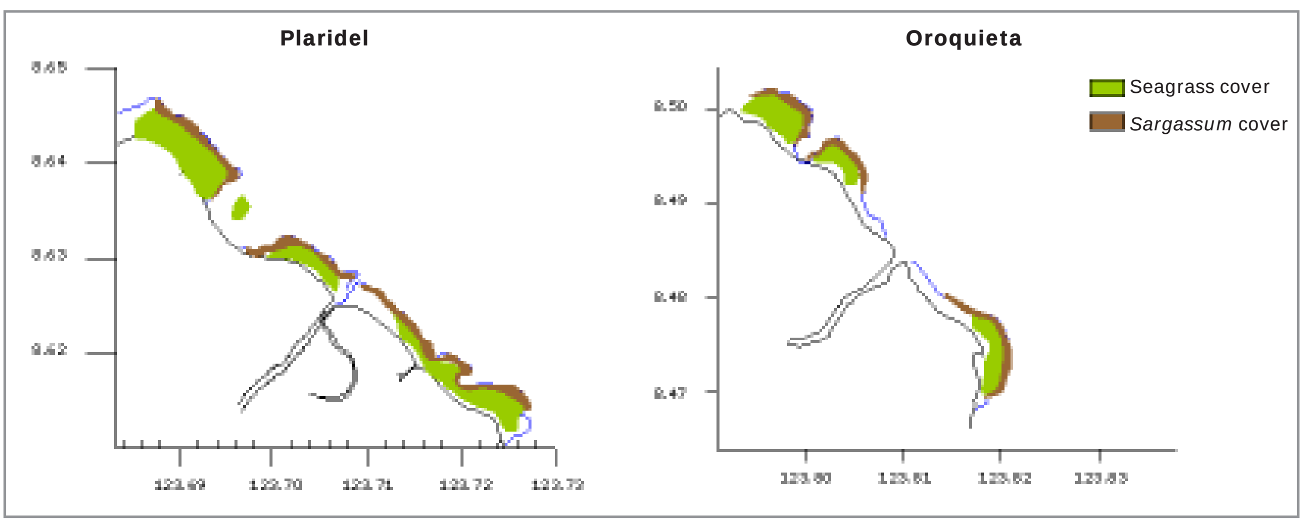

Figure 8. Distribution of the seagrasses and seaweeds, represented by the brown algae, S*argassum*, in Plaridel and Oroquieta.

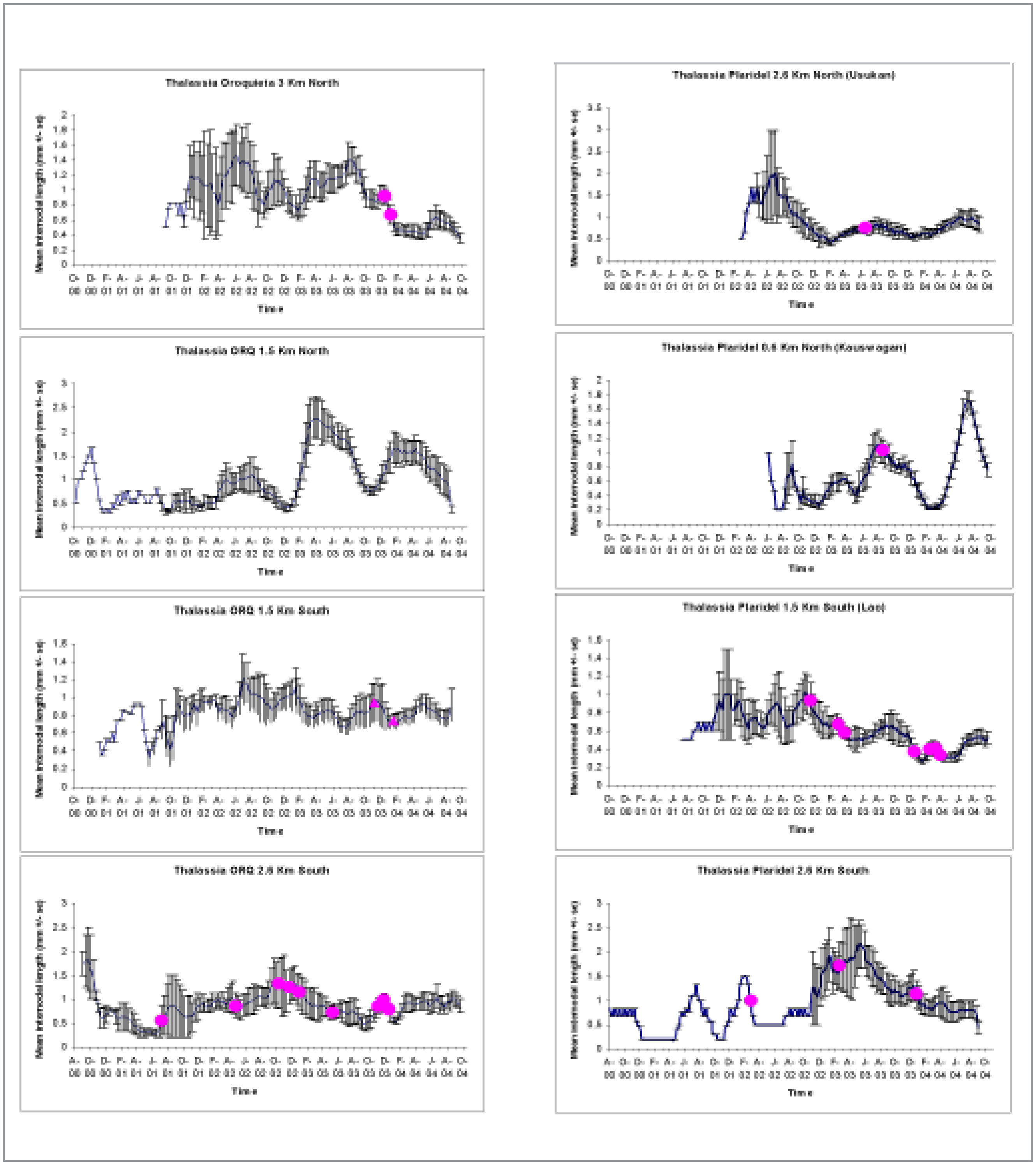

Figure 9. Age reconstruction of *Thalassia hemprichii* using internodal distances of vertical rhizomes or stems against time (months) in Oroquieta (A-D) and Plaridel (E-H). Error bars are standard errors of n=10. Pink circles indicate occurrence of fruit stalks.

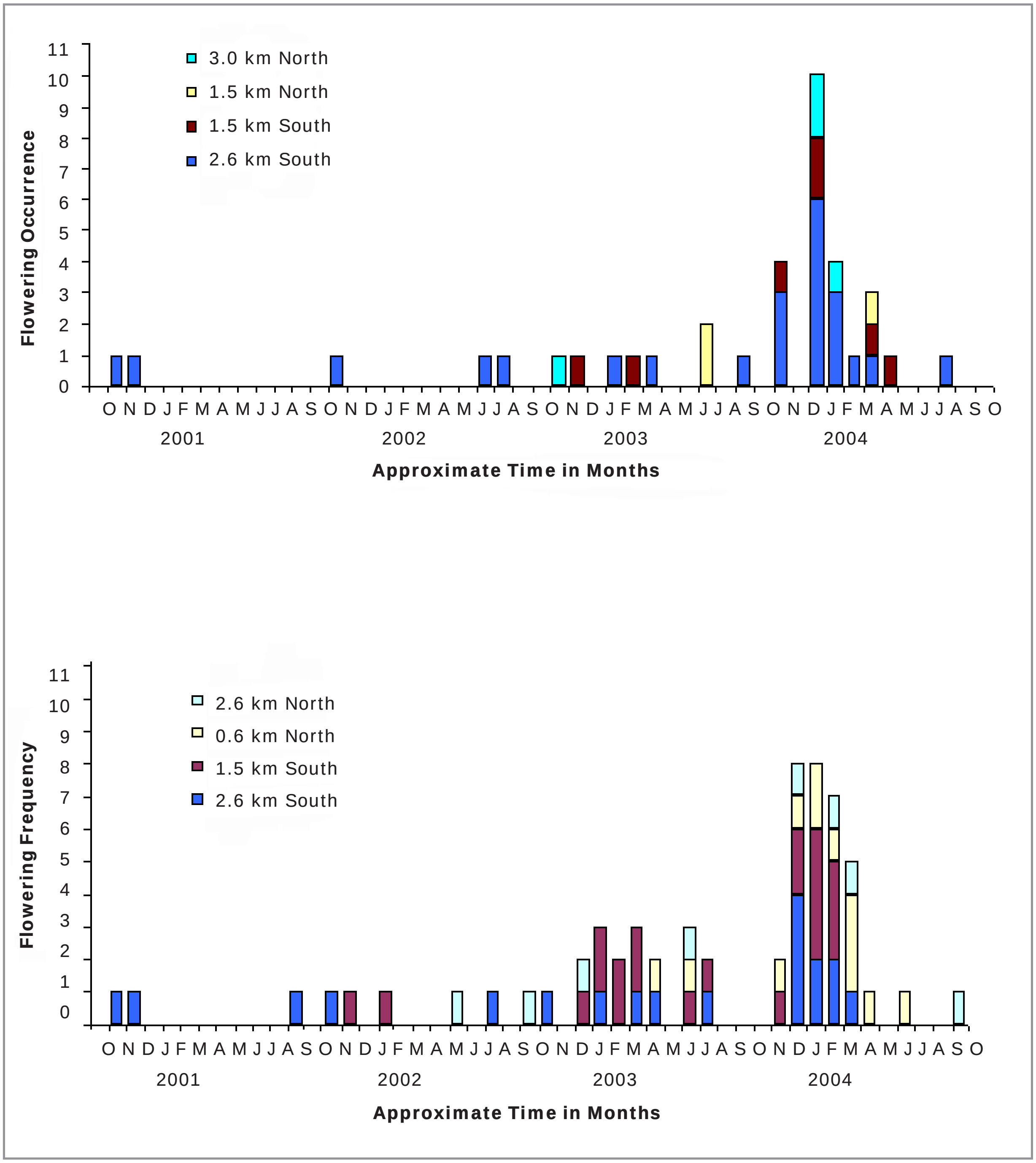

Figure 10. Flowering frequency of the dominant seagrass, *Thalassia hemprichii*, against time in months at Oroquieta (A) and Plaridel (B).

Table 4. Average values (± SE) of the shoot dynamics of the dominant seagrass, *Thalassia hemprichii*.

Site	Vertical Elongation Rate (mm/day)	Horizontal Elongation Rate (mm/day)	Percent Flowering	Gross Recruitment	Mortality	r^2	R_{net}
Layawan river mouth, Oroquieta City							
3.0 km North	3.20 ± 0.11 (102)	18.1 ± 5.2 (5)	3.92	0.4978	1.2058	0.9473	-0.7080
1.5 km North	4.32 ± 0.17 (102)	61.9 ± 7.6 (5)	2.94	0.5306	0.8992	0.9869	-0.3686
1.5 km South	1.98 ± 0.12 (99)	37.8 ± 7.3 (7)	6.06	0.4520	0.9309	0.9292	-0.4789
2.6 km South	3.60 ± 0.13 (111)	44.6 ± 6.3 (21)	15.18	0.9295	0.5851	0.9044	0.3444
Langaran river mouth, Plaridel, Misamis Occidental							
2.6 km North	1.76 ± 0.10 (113)	6.0 ± 1.2 (5)	9.52	0.2719	0.5424	0.9455	-0.2705
0.6 km North	2.88 ± 0.11 (113)	9.7 ± 2.4 (8)	9.37	0.6419	1.0673	0.8498	-0.4255
1.5 km South	2.51 ± 0.10 (104)	23.7 ± 11.4 (18)	13.33	0.5764	0.6824	0.9480	-0.1060
2.6 km South	3.34 ± 0.20 (82)	13.2 ± 6.1 (12)	15.85	0.8353	0.5555	0.9523	0.2798

Table 5. Preliminary list of invertebrates in the seagrass and seaweed meadows along the river mouths of Langaran River in Plaridel and Layawan River in Oroquieta.

Scientific Name	Common/Local Name	Plaridel	Oroquieta
MOLLUSC			
Lambis sp.	Spider conch	✓	
Trochus sp.	Top shell/*Amomongpong*	✓	✓
Conus sp.	Cone shells	✓	✓
Strombus sp.	Conch/*Anso-anso*	✓	✓
Cypraea moneta	Money cowrie	✓	
Cypraea spp.	Cowries	✓	✓
Turbo sp.	Turban shells	✓	
Pectin sp.	Shells	✓	
Corculum sp.	Heart cockle		✓
Malleus sp.	Hammer shell	✓	
Bursa sp.	Shell	✓	✓
Rock oysters	*Tapirok*	✓	✓
Assorted shells	Hermit crabs/*Umang*	✓	✓
Mussels	*Amahong*	✓	✓
ECHINODERMS			
Synapta sp.	*Bahag-bahag*	✓	✓
Sea cucumbers	*Balat*	✓	✓
Dolabella auricularis	Sea hare/*Dunsol*	✓	✓
Protoreaster nodosus	Horned seastar	✓	✓
Culcita sp.	Starfish	✓	✓
Culcita novaeguineae	Cushioned star		✓
Achantaster plancii	Crown of thorns/D*ap-ag*	✓	✓
Archaster nodosus	Sand starfish	✓	✓
Linckia laevigata	Blue starfish	✓	✓
Nardoa sp.			✓
ECHINOIDS			
Brissus latecarinatus	Heart urchin	✓	✓
Diadema setosum	Long-soined urchin	✓	✓
Echinometra mathaei	Rock-boring urchin	✓	✓
Echinotric calamaris	Banded sea urchin	✓	✓
Metalis spatagus	Heart urchin	✓	✓
Salmacis sp.	*Siyok*	✓	✓
Tripneustes gratilla	Gracious sea urchin	✓	✓
OTHERS			
Sponges		✓	✓
Jelly fish		✓	✓
Tunicates		✓	✓
Hydrozoans		✓	✓
Alpheids	Burrowing shrimps	✓	✓
Crabs	Crabs	✓	✓
Polychaetes		✓	✓
Shrimps		✓	✓
Sea anemone		✓	✓

SUMMARY AND RECOMMENDATIONS

Results of the study indicated that relatively intact seagrass meadows were still found within the 2-km radius from the river mouth of the two study sites. Although less extensive seagrass were found in Oroquieta as compared to Plaridel, these areas provided an important habitat for a number of commercially important species of fish, such as siganids (*danggit*), macroinvertebrates, such as sea urchins (*tuyom* and *swaki*), and various species of clams and seashells. Seagrass species in the Mt. Malindang area did not have local names unlike the mangroves. This indicated that the resource was yet unknown to the local people except for the fact that they were *kalusayan* or seagrass meadow, where a number of important species could be harvested.

To effectively manage the seagrass resources of the remaining seagrass within the 2-km radius of the river mouth, it is recommended to have a public awareness campaign on the qualities and economic values of the seagrass ecosystem. There is also a need to implement a long-term monitoring program to assess the condition or change in the seagrass beds with time. Several semi-permanent transects were set-up in this project (see Figure 1), which could be used for future monitoring of seagrasses in these areas.

Particularly in Oroquieta, further development and construction of seawalls nearshore and other coastal infrastructures may change the hydrology, possibly resulting to coastal erosion which could wash out the sediments and change the substratum of the existing seagrass beds. Increase housing developments along coastal areas have been identified as a common cause of worldwide seagrass decline (Short and Burdick 1996).

Further, unregulated use of the river could cause excessive sedimentation that could physically smother the seagrass and coral reefs along the river mouth. As a consequence, it may cause turbidity that could greatly reduce photosynthetic activities of the plants, triggering a domino effect that could kill all organisms dependent on the system, e.g., small fish, *danggit*, and invertebrates, including filter feeders.

Local stakeholders had indicated their interest in the possible expansion of seagrass meadow through transplantation or restoration. Although planting techniques are now available, it is still recommended to preserve the existing available resources. However, a more detailed assessment of the feasibility of restoration of damaged or degraded seagrass beds through the use of aerial maps can be done. Suitable sites can be identified for reintroduction or restoration of seagrass.

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FROM THE RIVER TO THE SEA: BIODIVERSITY ASSESSMENT OF THE MT. MALINDANG WATER SYSTEMS[1]

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With the specific aim of knowing the state and patterns of biodiversity and the interrelating factors, such as inputs for management and conservation, the Aquatic Ecosystem Master Project (AMP), as part of the Philippines-Netherlands Biodiversity Research Programme (BRP) for Development in Mindanao: Focus on Mt. Malindang and Environs, was implemented from January 2004 to May 2005 in the two major rivers (Layawan and Langaran Rivers) of Mt. Malindang. Employing a landscape approach, the research project dealt with three studies to cover the headwaters, river, and the coastal ecosystems. There were sub-studies which included assessment of flora, fauna, macroinvertebrates, coliform, fish, coral, seagrass/ seaweed, plankton, and the physico-chemical factors. A participatory approach was adopted by involving and training 80 residents as local researchers from the project sites. Results showed that species richness of flora and fauna in the project site was comparable to that in other areas of the country and the sites covered by the Terrestrial Ecosystem Master Project (TEMP). Number of endemic species, particularly for birds was quite high with endemicity of 39 percent as compared to the national figure of 33 percent. The number of tree species decreased downstream in both rivers, while that of bird species increased downstream in the Layawan River. Water quality in the river and the quantity of its discharge to the coastal areas were factors that cut across and connect the aquatic ecosystems. Considering the levels of concentration and load of total suspended solids (TSS), as well as family composition of bioindicators, results indicated the healthy state of the aquatic zones of the two rivers. The physico-chemical parameters (e.g., TSS, dissolved oxygen (DO), and nutrients), except coliform load, were within the DENR standards in both rivers and in the vicinity near its mouth towards the coast, referred to as "impact area". Macroinvertebrates present in the two rivers were dominated by the excellent and good water quality indicators. Despite the acceptable levels of the important physico-chemical parameters transported to the coastal area, their impacts are still manifested in the state of the coastal biota. Probably considering the long-term effects and not only the levels of concentration and loads measured *in situ*, these may have created negative impacts on the coastal biota, such as the poor to fair coral cover (<50%) in the coastal sites, especially in Oroquieta (Layawan river mouth), and the absence of seagrass in the "impact area" (1 km north and south in Oroquieta and < 400 m in Plaridel). Furthermore, the reef fish profile, being generally small-sized, could be the effect of the poor to fair state of coastal habitats. However, it was also an indication of overfishing, as noted in the Socioeconomic and Cultural Studies (SECS) Master Project, which was a socioeconomic-policy concern. Given the scenario, further increasing river discharge and transporting poorer water quality (e.g., higher TSS), with destructive human activities both upstream and in the coastal zone, would widen impact areas, thereby degrading more coastal biota and depleting fish resources.

INTRODUCTION

The overall goal of the BRP was biodiversity conservation for sustainable development. To achieve such goal, the Programme had undertaken a series of progressive researches beginning with the Pre-Implementation Phase (PIP) and followed by the First and Second Generation researches. After the implementation of the First Generation Research, knowledge gaps and issues on the linkages and processes that cut across bio-physico-chemical and social dimensions along the river/riparian ecosystems down to the coastal area were identified. These knowledge gaps and issues along the landscape were

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addressed in the second generation researches, particularly in the aquatic master project.

Dealing with two major concerns that affect the aquatic ecosystems, specifically the river and the coast, this project attempted to look into the sustainability of the river systems and the poor state of fish stock in coastal waters. The Langaran and Layawan Rivers are the two major rivers in Mt. Malindang, which are presently utilized for various uses, which include, among others, quarrying, agriculture, and water reservoir. Significant economic benefits are derived from these rivers but, as was apparent from the First Generation Research, such utilization patterns may not be sustainable. These may be considered as threats that could have effects on the river basin down to the coastal ecosystems.

The information on the poor state of the fish stock in coastal ecosystems was revealed in the First Generation Research, which may or may not be one of the effects of river threats. The poor state of fish stock is also a major concern considering the proportion of people that are economically dependent on fish in the research area.

To address these concerns, the environmental conditions and the state of biodiversity were assessed. The prevailing socioeconomic-policy factors in the area may relate to the poor state of fish stock in coastal waters. Integration of the AMP results with the results of the SECS and TEMP was done to possibly explain other issues not directly related to the bio-physico-chemical aspects.

Moreover, knowledge gathered in this project, together with the information generated from the First Generation Research, may be used to propose more appropriate actions towards enhancement and conservation of biodiversity and sustainable development in the Mt. Malindang area.

Employing a landscape approach in the project implementation, this report integrates three studies for the headwaters, river, and coastal ecosystems. These are entitled as: 1) “Biodiversity and physico-chemical profiling in the headwaters of Layawan River”; 2) “Comparative assessment of Langaran and Layawan Rivers”; and 3) “Comprehensive analysis of the ecological factors useful for the development of strategies to sustain coastal biodiversity and to improve fish stock management”. There are sub-studies under each of the headwaters, river, and coastal studies. These include assessment of flora, fauna, macroinvertebrates, coliform, fish, coral, seagrass/ seaweed, plankton, and physico-chemical factors.

REVIEW OF LITERATURE

Definition of Biodiversity

The term “biodiversity” was coined to relate to a response for global destruction of both species and their habitats. Basically, biodiversity is defined as “an umbrella term for the degree of nature’s variety” that encompasses all species of plants, animals, and microorganisms and the ecosystems and ecological processes of which they are part (McNeely *et al.* 1990). Among the various ecosystems, the forests received the most attention for the reason that they are easily observed. Among the forest types, the tropical rain forests are singled out because they contain the highest species richness. While for the marine ecosystems, coral reefs are considered to be highly diverse similar to rain forest (Reaka-Kudla 1997). In addition to tropical rain forests and coral reefs, tropical lakes and tropical wetlands are also ecosystems of high biodiversity that are worthy of research. Examples of these are Lakes Victoria and Malawi, which have exceptionally high fish endemism at more than 70 percent (Myers 1997).

Importance of Biodiversity

The value of biodiversity to humans may be categorized into three aspects. First is the ecosystem services it provides, such as providing and regulating water resources, the soil, nutrient storage and cycling, pollution breakdown and absorption, and other functions. Water supply is affected, for example, by whether or not catchments are vegetated, while soil health is especially important for agriculture, and the pollution breakdown and absorption capacity of natural systems is very necessary to deal with human wastes. Second is the biological resources, wherein individual species provide the raw materials for many human uses. Domesticated and wild plants and animals provide the majority of food for the world’s population. Biodiversity also provides medicinal resources and many chemical compounds which are produced synthetically. Raw material, such as wood and fiber, and ornamental blooms are supplied by many species. Third is the social dimension of biodiversity, which is crucial and complex. It is important to understand that human beings interact with the natural world. The way this occurs is a result of a variety of ecological, historical, social, cultural, economic, and political factors. Some groups in society, like the indigenous people, have very strong cultural attachments to species or habitats as a part of their belief systems. Moreover, looking at some nature-based recreational activities, such as fishing and wildlife photography, which are pursued by many people, may indicate that environmental features are dominant motivation behind tourism. For example, the rise of ecotourism, with the specific purpose of experiencing environmental values, is an evidence of the importance of biodiversity. Lastly, the knowledge that natural systems and species exist is valuable in itself for many people. These existence values may be the reason behind the concern and support expressed to prevent rainforest destruction or species loss in many places (Furze *et al.* 1996).

State of Biodiversity in the Philippines

Despite an alarming rate of loss, biodiversity of the Philippines remains impressive. Its forests are among the world's most diverse. Of the total 13,500 species (i.e., 5% of the world's flora) found in the country, 3,500 (26%) were endemic flowering plants comprising a total of 25 endemic genera. Terrestrial fauna was also highly diverse with some 1,090 species of terrestrial vertebrates, 45 percent of which were endemic, 185 species of mammals, 558 species of birds, 251 species of reptiles, and 93 species of amphibians. The marine environment harbored 1,400 species of fish, 240 of which were endemic, and about 15,000 species of crustaceans. The Philippines lies at the global centre of hermatypic (reef building) coral and coral reef fish diversity, and is home to seven of the nine species of giant clams and the most diverse seagrass assemblages in Southeast Asia, at 16 out of the world's 50 species (La Viña *et al.* 1997).

Some taxonomists and systematists conclude that biodiversity (at the species level) is declining. This may be due to problem on declining populations and habitat (Holling *et al.* 2002). Myers (1990) called for more attention to areas considered as "hot spots" where there is eminent habitat destruction. The Philippines is a "hot spot" where a large number of vertebrate endemics are either nearly extinct or are severely threatened (Alcala 2001).

Threats to Biodiversity

There are six fundamental causes of the loss of biodiversity identified by the Global Biodiversity Strategy (WRI *et al.* 1992). First is the unsustainably high rate of human population growth and natural resource consumption. Human use of the earth's resources increases as population bloats. At present, it is estimated that people use or destroy 39 percent of photosynthetic material produced on land. Human also alter areas of high biodiversity, like rivers, by removing riparian forest (Hopkinson and Vallino 1995). Others argue that high demand for resources are more specifically linked to poverty, industrialization, and the global distribution of economic benefits, food products, literacy and numeracy, amongst other issues. One resulting cause of degradation from human terrestrial activities is sedimentation. This is due to unsound agriculture and forestry practices, mismanagement of watersheds, exploitation of mangroves, earth-moving for construction, and the dumping of terrestrial mine tailings and effluents (White 1987). The coastal resources are similarly threatened by various human activities since 87 percent of the population live within 50 km of the coast, thus putting pressure on coral reef resources (White 1987). The direct reef destruction are coral stone and coral sand extraction (coral mining activities), whether for local use or international trade, and destructive fishing methods, such as dynamite blasting, reef-front or reef-bottom trawling, *muro-ami*, and *kayakas* fishing techniques. The second threat to biodiversity is the steadily narrowing spectrum of traded products from agriculture, forestry, and fisheries. Agriculture has specialized in crops that have high demand on the world market, leading to the decline of local species that are more suitable in traditional agricultural ecosystems. Forests with many species are converted to cash crops in order to satisfy demand for one product. Fisheries are also affected, as drift netting captures and selects huge quantities of desired species. Third is the economic systems that fail to value the environment and its resources. Natural environment qualities are commonly undervalued or not included at all in decision making. Conversion of natural areas to agricultural uses or logging concessions is done even when the net effect on society is negative. Fourth is the inequity in the ownership, management, and flow of benefits from both the use and conservation of biological resources. Inequitable distribution of benefits and costs, based on inequitable social, economic, and political structures, can lead to rapid exploitation and loss of biodiversity. The fifth is the paucity of knowledge and its application. Scientific knowledge for understanding biodiversity conservation may be insufficient. Even if knowledge is sufficient to make relatively informed decisions, it often does not reach decision makers. And the sixth is the legal and institutional systems that contribute to the unsustainable exploitation. Biodiversity conservation requires a cross-sectoral approach. Most national and international institutions operate strictly along sectoral lines that tend to be centralized and closed, hindering local participation and obstructing access to groups within society and nongovernment organizations. Institutions with responsibility for conservation are often financially and politically disadvantaged, even when they are part of the government structure, and lack coordination among themselves, resulting to inability to plan strategically or comprehensively (Furze *et al.* 1996).

RATIONALE

This project was conceptualized to address the gaps and issues that would lead to a better understanding of the linkages and interactions of bio-physico-chemical parameters and processes along the landscape. Results of this project may serve as inputs for the formulation of a more effective and more relevant strategy towards biodiversity conservation and sustainable development in the Mt. Malindang environs.

Concerns on the threats for sustainability of the two major river systems studied, the Layawan and Langaran Rivers, as well as the poor state of fish stock in the rivers' coastal waters were placed as the core research questions where all efforts are anchored. The latter may not be a result of threats like siltation that ran through from the river basin to the coastal ecosystems, but is still a major concern to be investigated because of the number of residents that are economically dependent on fish. Emphasis was given to riverine and coastal areas, where the pressures and impact brought upon by human use of environmental space and resources were particularly intense and fairly obvious.

OBJECTIVES

In general, the research activities under the Aquatic Ecosystem Master Project aimed at obtaining valuable information (1) for the formulation of River Basin Management Plan, and (2) for the development of management strategies for biodiversity conservation in the aquatic ecosystems in the Mt. Malindang environs.

Specifically, the objectives of the individual studies for the headwaters, river, and coastal ecosystems were as follows: (1) for the headwaters study, these were to: a) assess the riparian flora and compare it with the surrounding forest ecosystem plants and the aquatic macroinvertebrates, most of which are the larval stages of the terrestrial insects found at or near the river as well as the river fishes; b) measure the water quality (total alkalinity, total hardness, total dissolved solids, siltation and sedimentation, nitrate-nitrogen, phosphate-phosphorus) and water quantity (flow rate, river discharge) in the three major headwater streams; and c) further describe the physiographic, topographic, and vegetational characteristics of the catchment area as well as the indigenous knowledge on the utilization of the river and its biological resources; (2) for the river study, these were to assess the water quality and quantity in order to establish benchmarks and to generate information useful for the development of protocols for basic monitoring systems and environmental management; and (3) for the coastal study, it was to asses the prevailing biological, physical and chemical factors that may have caused poor fish stock and to develop the necessary protocol for basic fish stock monitoring systems. The data gathered were then integrated with the results of the TEMP and SECS.

METHODOLOGY

Selection and Description of the Project Sites

The Langaran and Layawan Rivers were selected for the reason that they exemplify the features ideal for the conduct of a landscape approach biodiversity research, with the interconnection of the headwaters, river, and coastal ecosystems. Figure 1 shows the sampling sites of the project. Langaran River, being the site for the First Generation river assessment project, was observed to supply irrigation waters (through three dams) to farms in *barangays* along the river, under the jurisdiction of the Municipalities of Calamba, Baliangao, Lopez Jaena, and Plaridel, Misamis Occidental. Quarrying and use of illegal fishing methods were also found to be prevalent in this river.

Langaran River is one of the rivers that drain the Mt. Ampiro and Mt. Balabag watersheds. It stretch starts from the foot of Mt. Ampiro in the Municipality of Conception, bisects the Municipality of Calamba, and courses through the Municipality of Plaridel, finally emptying the water into the coasts of Barangay Kauswagan, Plaridel. There are three big dams constructed along the river. The first is built in

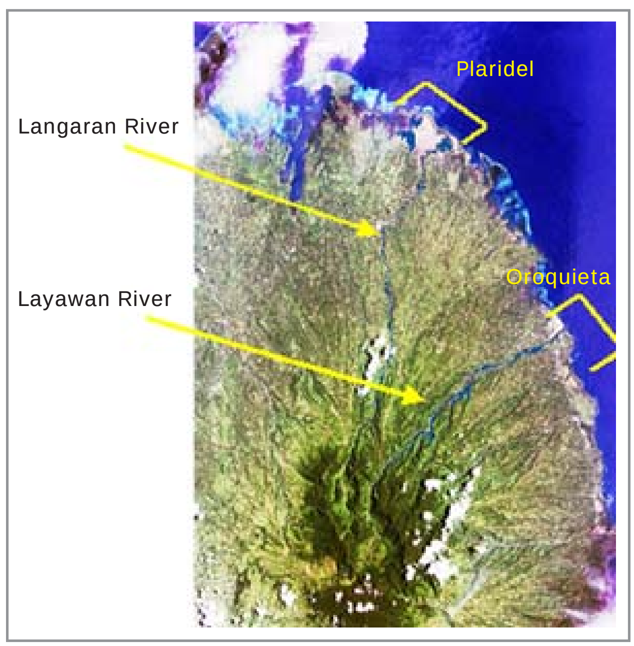

Figure 1. Map showing the sampling areas of Aquatic Ecosystem Master Project (AMP).

Napisik-Sipukat area, within the jurisdiction of the Municipality of Calamba. The irrigation water is distributed to the rice fields of Baliangao and Calamba. According to the Municipal Agricultural Office of Calamba, around 1,000 hectares (ha) of fields in the Municipality of Baliangao and approximately 300 ha in Calamba are served by the waters coming from this dam. The second dam, called Communal Irrigation System, is built in Nazareno of Barangay Tipolo by the Association of Farmers. This is the biggest among the three dams. The water irrigates more than a thousand hectares of rice fields in most of Calamba and Plaridel. The third dam is relatively small and is also in Tipolo, serving the rice fields in the remaining parts of Plaridel towards the Municipality of Lopez Jaena (Gomez-Roxas, *et al.* 2002).

The Langaran River is also a site for the River Profiling Project of DENR-Misamis Occidental Provincial Office. The impact of rainfall and physical characteristics of the watershed are significant factors to consider on soil deposition. The existing land use is another factor to consider because much of the watershed have been devoted to various land uses that influence/affect the erodability and compactness of the soil. The water of Langaran River was tested in November 1994 and the laboratory analysis result was then compared to the Class C water standards stipulated in DENR Administrative Order No. 35, Series of 1990. It revealed that the quality of surface water of the river was still within the water quality criteria (Ecological Profile of Misamis Occidental).

Based on the existing Soil Erosion Map of Misamis Occidental, the watershed can be dissected into several types of soil erosion. Erosion at the forested portion of the watershed is relatively insignificant due to the presence of thick vegetation in the area. Erosion at the settled/cultivated portions of Concepcion, Lopez Jaena, and Calamba are observed to be moderate. However, severe erosion is occurring at areas just adjacent to Langaran River beginning at Calamba down to Barangay Cadre of Plaridel. The plain areas of Plaridel have no apparent erosion (DENR-CENRO Report).

On the other hand, the Layawan River was awarded the "Cleanest and Greenest River", both in the regional and national level, which may imply good management. Its headwater is located in Barangay Sebucal, a remote area of Oroquieta City located at 08^0 19'26'N and 123^0 38'10'E of the crater valley of Mt. Malindang, with elevation ranging from 700-1,400 meters above sea level (masl). Layawan River cuts across the Barangays of Mialen, Toliyok, Bunga, and Villaflor. Barangay Mialen, with elevation of 315-475 masl and located at $8^0$24'41'N and $123^0$40'29'E, is situated in a small valley flanked by a chain of small mountains roughly oriented east-west, with precipitous slopes approaching nearly 90 degrees. Barangay Toliyok is located on the footslope of Mt. Malindang from 165 to 475 masl at $08^0$25'45'N and $123^0$42'28'E, with rocky, precipitous slopes approaching nearly 90^o.

In consideration of data integration to establish connectivity for the river and coastal studies, the coastal areas investigated in this project were limited within the 2-km radius from both sides of the river mouth and extending 1 km offshore, thus enclosing a total of 4 km^2 in both rivers.

Additional study site was added within the Danlugan cove in Lopez Jaena to address specific problem on water quality. The mayor of this municipality is pro-active and has raised concerns related to environmental management. A number of groups like the Philippine-Australian Local Sustainability (PALS) and Center for Integrative Development Studies (CIDS) have also initiated projects in this *barangay*.

Barangays Taboc Sur and Taboc Norte in Oroquieta City are very near the mouth of Layawan River. Its coastal waters are affected by inflow of freshwater from the river. Sampling in this *barangay* extended to Mobod, where a city-managed marine sanctuary is located. The sites for the different components of the coastal focused only within a hypothetical box defined by the researchers, which was 2 km on both sides of the river mouth and 1 km offshore at the Layawan River in Oroquieta and the Langaran River in Plaridel.

Because data from the different studies were integrated into one report, sampling and measurement for all the sub-studies in the coastal study were done in the three stations within each site (i.e., *barangay*), except for some variables like pesticide load. This was determined in selected stations only. In this report, the site refers to the river and the station refers to the specific area within the river mouth where data was collected.

The study sites for the river study were chosen based on the information obtained from the First Generation Research and during site visits. In Langaran River, the five *barangays* covered in the First Generation Research, namely, Singalat, Mamalad, Bonifacio, Tipolo, and Catarman, were also the study sites covered in the river study. These *barangays* were chosen for their unique socioeconomic-cultural and political characteristics. The characteristics of the *barangay* that were perceived to affect biodiversity were used as basis in selecting the parallel study *barangays* in Layawan River. The purpose of selecting parallel *barangays* was for comparison of the parameters studied. At the upstream end, Barangay Mialen was chosen because of its lush riparian vegetation (as per visual inspection). This *barangay* is parallel with Barangay Singalat in Langaran River. The residents are mainly Subanen. The area is not accessible to any vehicle but can be reached by walking. Barangay Tolyok is where people going to and coming from the upper *barangays* converge since it is the last stop of the very few jeepneys that ply this route. The houses are concentrated near the jeepney stop. This *barangay* is parallel with Barangay Mamalad in Langaran River. Barangay Bunga is a mid-stream *barangay*, where people from both sides of the river closely interact because of the presence of the hanging bridge, which allows people to freely cross either side. Its proximity to the city makes it a potential site for infrastructure development. As a study site, this barangay is parallel with Barangay Bonifacio in Langaran River. Downstream is Barangay Villaflor, where the single irrigation dam in Layawan River is located. It is only a few kilometers away from the river mouth. The presence of the dam makes it the *barangay* parallel to Tipolo in Langaran River. Because the Langaran River is longer than the Layawan River, Barangay Catarman was added to the former. Both sides of the river in this *barangay* are intensively farmed, a scenario that is also seen in Barangay Villaflor in Layawan River.

To establish the connection between the TEMP and AMP, upstream study sites, i.e., Barangays Mialen and Toliyok in Layawan River, and Barangay Mamalad in Langaran River, were also the study sites of the TEMP researches. Meanwhile, the SECS Project collected data from the same *barangays* identified by the AMP teams.

Entry Protocols

A visit to the municipalities and political units that have jurisdiction over the aquatic ecosytems to be studied was done. Local maps were obtained from the local government to determine the general location of the ecosystems.

The project was discussed with the local leaders and key persons of the nongovernment organizations (NGOs), government agencies (GAs), and government organizations (GOs) in the *barangays* included in this project. The *barangay* leaders were requested to schedule a general assembly, during which the participatory nature, objectives, and expected outputs of the project were presented to the community. In this meeting, the members of the community were asked to identify from among themselves the local researchers who would participate in the conduct of the different studies under the project.

Training of Local Researchers

A two-day training on methods was conducted for local researchers. The methods to be employed were presented and experienced hands-on by the participants. Local opinions on how data could be obtained and how commonly employed techniques could be modified were solicited. It was emphasized that every aspect of the project would require their participation. The training also served as a venue for the team members and local researchers to get acquainted and be comfortable with each other in preparation for their partnership in research work.

Sampling Methods

Methods used in the coastal resource assessment study followed the standard techniques as follows: manta tow for wide area survey of coral reef status; line intercept transect (LIT) in the shallow (3 m) and deep (10 m) for coral benthos and associates; daytime fish visual census along the same coral transect; stratified random point quadrat sampling, transect quadrat and core sampling for seagrass and seaweeds; and predetermined sites for water quality sampling stations covering the whole hypothetical box for both shallow and deep. Coordinates of all stations established were recorded using the Global Positioning System (GPS). Silt traps were also deployed to determine sedimentation rates.

Under the river study, the methods used in the assessment of the different components were as follows: on each sampling site, riparian floral plots of 40 x 10 m dimension were established for tree assessment. Within the tree plot, a 5 x 5 m and 1 x 1 m subplots were randomly chosen for the shrub and herbs-grasses assessment, respectively. For faunal inventory, the appropriate method was employed depending on the faunal group, such as mist netting and transect walk for birds, traps for mammals, hand picking for amphibians and reptiles, netting and bamboo traps for fishes, dip and kick net method for aquatic macroinvertebrates, and standard coliform analytical method for coliform analysis. The physico-chemical parameters considered were mostly measured *in situ* which included temperature, pH, total dissolved solids (TDS), TSS, DO, nutrients, conductivity, and river discharge.

Project Implementation and Sampling Schedule

Sampling and measurements for the selected parameters were taken during dry and wet season. This was done with the presumption that parameters studied may show seasonal variation brought about by migration or reproduction. For parameters that were not critically affected by seasonal fluctuations in environmental conditions (e.g., flora and corals), sampling was done following a different set of criteria (e.g., flowering season). Meaning, the sampling was strictly done during the onset of rainy or dry season.

Community Validation

As part of the participatory nature of the project, community validation was conducted in 5-9 March 2005 in some *barangays*. Preliminary research results were presented and validated with the local stakeholders and local researchers.

Data Management

The steps taken to ensure integrity and preservation of data were as follows: a) collection and documentation of data were done with the use of record books, dummy tables, photos, notes, and specimens and b) storage of data in Excel and Word files, with back ups in CDs and diskettes.

Data Analysis

The sites were descriptively featured using the physico-chemical parameters considered and in terms of community indices (e.g., species richness, diversity, cover, etc.) for the biological components. Using these parameters, comparisons were made between and among the sites along the river and between the two rivers. Statistically, the quantitative data on the physical and biological components were correlated and regressed with each other and with the data on fish stock in the coastal ecosystems. Classification and ordination methods (e.g., TWINSPAN and CCA) were employed to determine patterns in data sets. Physico-chemical parameters were compared with existing standards (e.g., DENR standards).

RESULTS AND DISCUSSIONS

State of Biodiversity in Layawan River and its Headwaters, Langaran River, and the Adjacent Coastal Areas

Based on the report of the BRP First Generation Research and the data gathered from the Second Generation Research of AMP, the state of biodiversity in the Layawan River and its headwaters, the Langaran River, and the adjacent coastal areas are described in the succeeding sections.

Flora. An approximated total of 108 and 165 morphospecies of trees and other plants, respectively, were recorded in the sampled areas (plots and rapid appraisal) of the headwaters of Layawan River. Among the tree species identified in Sebucal headwaters, relatively the five most abundant types were *bulase* (*Pilea melastomoides*), abaca (*Musa textiles*), mahogany (*Swietenia macrophylla*), and *bosyong* (*Ficus* sp.). For the other plants, *moti-moti* (*Mikania cordata*), *lukdo-lukdo* (*Nephrolepis*), and *lakatan* (*Paspalum* sp.) came out to be the most abundant.

The Shannon index of trees for the whole Sebucal area was 1.53, a relatively high value that reflects the evenness of distribution in terms of number of individuals, except in one station where mahogany was the dominant tree species.

Going to a lower elevation (about 250 masl) where the Sebucal headwater connects to Layawan River, the sampled riparian area had a record of 105 morphospecies of trees and about 111 morphospecies of shrubs, herbs, and weeds. While in Mt. Makiling, there are about 84 to 134 tree species as categorized according to size (Gruezo 1997). The count of tree species in plots per sampling area were 60 species in Mialen, 62 in Toliyok, 39 in Bunga, 24 in Purok IV of Villaflor, 15 in Purok II of Villaflor, and nine in Purok I of Villaflor. Abundant tree species were coconut (*Cocus nucifera*), *ipil-ipil* (*Leucaena leucocephala*), and *binliw* (*Osmoxylon* sp.). While for other plants, the *burikat* (*Wedelia trilobata*), cover crop (*Centrosema pubescens* Benth.), *lakatan* (*Paspalum* sp.), *moti-moti* (*Mikania cordata*), and *gaan-gaan* were abundant.

In Langaran River, the data for its flora diversity was obtained during the First Generation Research. Unlike in Layawan River, where trees, shrubs, and herbs were separately identified and counted, in the flora assessment in Langaran River, plants were not categorized as such. A total of 251 species of vascular plants belonging to 185 genera in 80 families were recorded within the established transects in the five *barangays* along the Langaran River. Of these, only 212 species were identified taxonomically. Barangay Singalat had the highest number of plant species at 191. Moving downstream, Barangay Mamalad had 54, Tipolo had 53, Bonifacio had 43, and Catarman had 41 plant species. *Hydrilla verticillata* of Family Hydrocharitaceae was the only aquatic plant recorded and was found in only one belt in Tipolo (Gomez-Roxas *et al.* 2002).

There were 45 species of trees found in the TEMP sampling areas that also existed in either Layawan or Langaran River. The hypothesis that riparian flora composition would have plants that may have been dispersed from the surrounding terrestrial forest ecosystem and that most riparian plants, especially the trees, would be very similar to those from the forest may be supported by the commonality of some tree species in the riparian and forest sites. However, it was also possible that some plant species were limited only to the riparian area considering some unique elements, like the presence of gravel bed in the active water zone. The expected plants in the riverbank would be those that could adapt to the sandy-gravel substratum and intermittent flooding in the river. Two of the common trees in Layawan and Langaran Rivers, as well as TEMP areas, were *antotongaw* (*Melastoma malabathricum*), and *hagimit* (*Ficus minahassae*).

Fauna. Based on the recorded number of faunal species, it was in the Layawan River where most species of birds, mammals, reptiles, and amphibians were observed as compared to that in Langaran and the headwaters (Table 1). However for fish, it was in Langaran River where most species (26) were observed. The birds (6 species) recorded in the study were mostly in the riparian areas, in which case, there may be lower existing species as compared to that in the forest ecosystem, like in Mt. Talomo in Davao with a record of 93 species, of which 13 are endemic (Ibañez 2003), and in Mt. Makiling with 109 bird species (Gonzalez and Dans 1997).

Considering that the avifauna are good indicators of the health of a river system (Ibanez 2003), the focus of the discussion was on birds. Out of the 60 species of birds in Layawan River, 19 of these were Philippine endemics, and of these, six were endemic to the Mindanao faunal region only - Writhed hornbill (*Aceros leucocephalus*), Mindanao tarictic (*Penelopides affinis*), Silvery kingfisher (*Alcedo argentata*), and Brown tit-babbler (*Macronus striaticeps*). Endemicity was high at 39 percent compared to the national figure of 33 percent (Collar *et al.* 1998).

The most abundant species in the sampling sites of Layawan River were the Purple-throated sunbird (*Nectarinia sperata*, 9.1%), Glossy swiftlet (*Collocalia esculenta*, 7.9%), and theYellow-vented bulbul (*Pycnonotus goiavier*, 7.1%). These three species also dominated the three study sites of Mialen, Toliyok, and Bunga, while the lowermost study site (Villaflor) was dominated by the Little egret (*Egretta garzetta*, 17.8%), the Yellow-vented bulbul (*P. goiavier*, 9.8%), and the Glossy swiftlet (*C. esculenta*, 8.4%). Together, these four species represented the dominant habitats in the area. Their abundance would indicate tolerable or preferred habitats. The presence of dense undergrowth and shrubs and a variety of flowering and fruiting trees in agricultural areas along the river, as well as the forest along the margin of the slopes would all contribute to a variety of feeding opportunities and habitats favored and tolerated by these birds.

It was noted that some forest species were recorded in the Layawan area. Among them were the Red jungle fowl (*Gallus gallus*), the Writhed hornbill (*Aceros leucocephalus*), and the Tarictic hornbill (*Penelopides affinis*). The Writhed hornbill and the Tarictic hornbill were among the 28 species of birds listed as restricted-range species in the Mt. Malindang National Park (Mallari *et al.* 2001). *A. leucocephalus* was recorded as near-threatened by Collar *et al.* (1998). Another notable species was the Silvery kingfisher (Alcedo argentata). It was recorded as endangered by the Philipppine Red Data Book (Collar *et al.* 1998), and recorded as being partial to clear and unpolluted streams and rivers, where they feed on various aquatic organisms like small fishes, frogs, as well as terrestrial insects.

In Langaran River, a total of 927 individuals belonging to 52 species of birds were observed during the First Generation Research. Thirty four species were recorded in Singalat, 36 in Mamalad, 32 in Bonifacio, 18 in Tipolo, and 17 species Catarman.

Eight endemic bird species were found in the Langaran River. These were *Phapitreron leucotis*, *Cintropus viridis*, *Penelopides panini*, *Rhididura superciliaris*, *Aethopyga shelleyi*, *Dicaeum sustrale*, *Alcedo argentata* (named *Ceyx argentatus* by DuPont 1971), and *Dicaeum pygmeum*. Two of these species, namely, *R. superciliaris* and *A. argentata* were considered uncommon (Kennedy *et al.* 2000). According to WCSP (1997), *A. argentata* was endangered with no information on its nesting habit (Gomez-Roxas *et al.* 2002).

Table 1. Total number and endemic species of faunal group.

	Headwaters		Layawan River		Langaran River	
	Total Number of Species	Number of Endemic Species	Total Number of Species	Number of Endemic Species	Total Number of Species	Number of Endemic Species
Birds	46	22	60	19	52	8
Mammals	10	5	12	7	11	3
Fish	5	0	13	2	26	0
Reptiles	13	4	17	0	11	2
Amphibians	8	5	10	4	6	1

Comparing the number of bird species in the study area with that of the Philippine and Mindanao list (Table 2), the record in the study area was quite low. However, the number of endemic birds was higher in the study area compared to that from Mt. Talomo in Davao (Ibañez 2003).

Coral Reef. Overall coral cover ranged from poor to fair (<50%), except at few sites in Plaridel. In general, coral cover in Plaridel (Langaran River) was a bit higher than in Oroquieta (Layawan River) as shown in Figure 2. There was a blast fishing device found off the waters of Oroquieta and some observed blasted coral area during sampling (Figure 3).

Reef fish biomass was also low with average values ranging from 3.5 to 13.3 kg ha^{-1} in both areas, generally composed of small individuals dominated by the pomacentrids, such as damsel fish. Species richness of fish, however, was higher in Layawan river mouth (83-123 species) as compared to Langaran (63-65 species) for shallow and deep stations. Species composition of reef fish was mainly composed of the common types like wrasses and damsels, which have no commercial importance. The size structure of these reef fishes were mostly below 5 cm. This was more apparent in the coastal area of Layawan.

Seagrass and Seaweeds. Average overall seagrass cover (Figure 4) was generally higher in Plaridel (33%) than in Oroquieta (18%), with a total of six and seven seagrass species for Plaridel and Oroquieta, respectively.

In terms of cover by species, the *dugong* grass, *Thalassia hemprichii*, accounted for 46 to 48 percent of the total seagrass, making it the dominant species in both sites. This was followed by *Cymodocea rotundata* at 14 to 23 percent cover. The Tropical eel grass, *Enhalus acoroides*, was not recorded in the quadrats sampled at Oroquieta, but the species occurs in the area.

For the seaweeds, a total of 59 species were recorded, represented by 16 green algae, 24 red algae, 15 brown algae, and four blue green algae. Twenty species were recorded new for the Mt. Malindang region, based on those reported during the First Generation Research of BRP. The brown algae, *Sargassum* (at least six species), dominated the seaweeds, followed by *Padina* (at least four species). A commercially-important agarophyte, particularly *Gelidiella acerosa*, was observed at 10 percent cover.

Plankton. The microscopic plants, represented by the phytoplankton, had more species recorded in Oroquieta (47) as compared to Plaridel (40). Forty-five species was also recorded in one sampling area in Danlugan, Lopez Jaena. Among these phytoplankters, the diatoms were the most dominant group, followed by the dinoflagellates, while the flagellates were the least dominant group.

The zooplankton were classified up to genera level and specific groups with a total of 44 identified in Oroquieta, 46 in Plaridel, and 43 in Danlugan. Overall, the zooplankton composition in the areas sampled was dominated by crustacea group.

Trends and Patterns of Biodiversity and Physico-Chemical Parameters Along the Rivers and Towards the Coast

Flora. A decreasing trend of the number of tree species from the headwaters down to the *barangays* along the stretch of the Layawan River was observed. One attributing factor may be the relatively lower human population in the more upstream *barangays* as compared to the downstream *barangays*. Settlement would mean conversion of riparian forest to residential lots and agricultural lands. Total population, with increasing trend downstream, in the *barangays* sampled is given in Table 3.

Table 2. Number of bird species in the Philippines, in Mindanao, Sitio Utan, Upper Tamayong, Mt. Talomo (Ibañez 2003).

	Philippines	Mindanao	Mt. Talomo				
			TOTAL	Disturbed Montane	*Parang*	Undisturbed Montane	Reforestation Site
All species	556	341	93	52	62	54	54
Breeding	385	248	43	21	28	22	30
Philippine endemic	173	96	34	22	25	20	17
Mindanao endemic		23	13	8	8	11	4
Threatened species	135	58	20	11	12	14	6

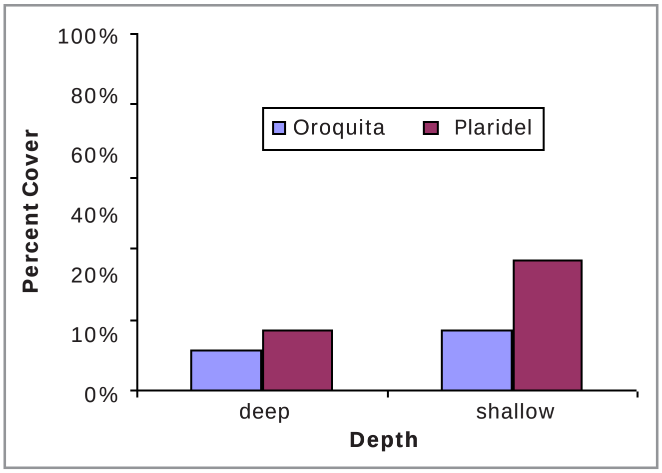

Figure 2. A graph comparing the coral cover for both rivers and for both depths.

Figure 3. Blasted coral area in the sampling site.

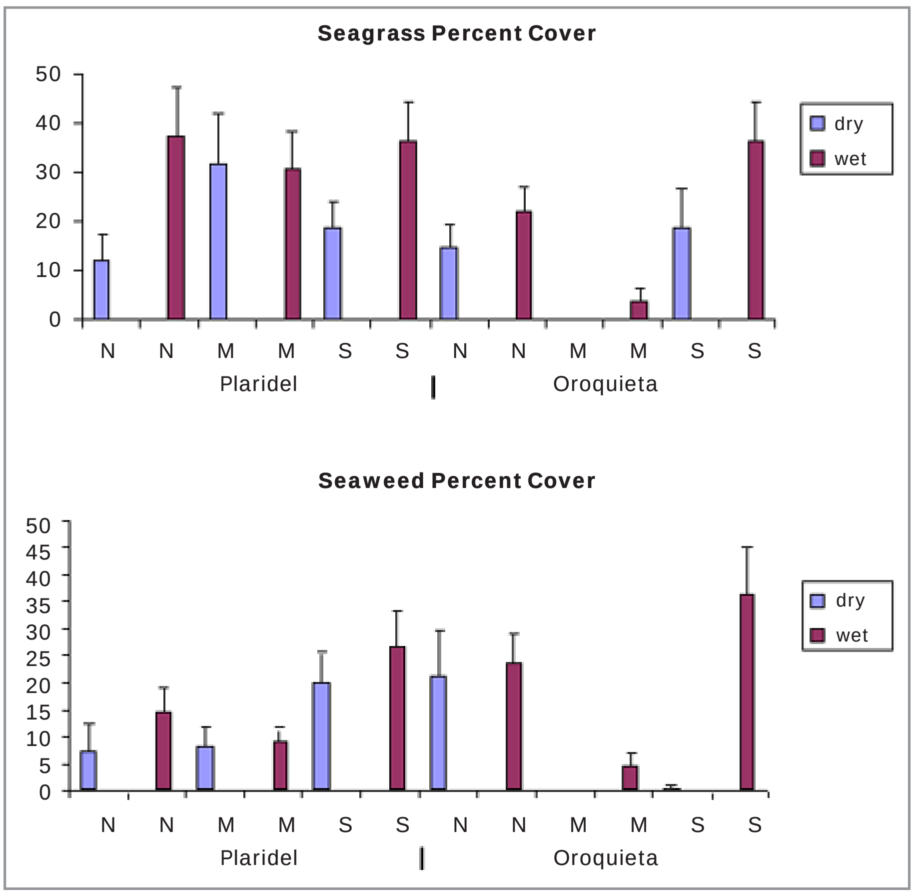

Figure 4. Average percent cover of the seagrass and seaweed during the dry and wet seasons relative to their position from the river mouth (N = north; M = middle; S = south).

Table 3. Total population in each *barangay* along Layawan River.

Barangay	Total Population	Household Population	Number of Households
Sebucal	268	268	56
Mialen	494	494	101
Toliyok	522	522	110
Bunga	931	931	190
Villaflor	3,554	3,554	773

Source: National Statistics Office, as of 1 May 2000.

Another hypothesis explaining the trend, which needs to be further investigated, was the river channel morphology and topography. Where the river had more sections with steep sides, one could expect a greater number of tree species because the steepness prevented these places from being cultivated. In addition, the plants in these steep areas could then serve as the source of propagules for dispersal to other areas.

The First Generation landscape assessment of the vegetation in Langaran River revealed that the riparian vegetation in upstreammost portion of the river was generally more diverse, composed of more endemic and unique species, compared to downstream.

Fauna. There was an increasing trend of species of birds downstream in Layawan River, while, on the contrary, it decreased towards the river mouth in Langaran River. However, the correlation was weak. One possible reason may be the presence of a variety of habitats for birds, like agricultural lands, aside from riparian forest. Villaflor, with its intensive rice cultivation mixed with second-growth forest, showed a higher number of species compared to Mialen, Toliyok, and Bunga. The upper two *barangays* that were relatively less exposed to human activities, and whose riparian habitats still contain a good amount of forest because of the steeper slopes bordering the river basin, showed higher diversity values with a higher number of endemic species. Barangay Bunga, whose upper riparian boundary adjacent to Toliyok still has patches of original forest but whose lower regions have increasing agricultural areas, showed a moderately high diversity, which approximated the diversity of the two upper *barangays*.

Macroinvertebrates and Coliform. There appeared to be a decreasing trend of macroinvertebrates that were excellent and good water quality indicators downstream, particularly in Barangay Villaflor of Layawan River. Computing the water quality using the identified macroinvertebrates showed that WQI decreases as one moves to the lower reaches of the river. The downstream sampling areas revealed impoverished macroinvertebrate assemblages with increasing tolerant species (poor water quality indicators). This may be due to increasing TSS downstream. It was also likely that with the decreasing riparian tree species in the river channel, the macroinvertebrates' functional feeding group also changed and decreased. Comparing the density of macroinvertebrates in two moving sections of the rivers, higher number of individuals per unit area was collected in the fast than in the slow sections.

The coliform, expressed in MPN/100 ml, did not show a trend along the rivers of Layawan and Langaran (Table 4). However, one thing apparent was its concentration in some sampled areas that exceeded the standard set by DENR (<1,000 MPN/100 ml for Class B waters).

Seagrass. Considering the presence of seagrasses immediately in front of the river mouth of Langaran River, there appeared to be no pattern in the seagrasss vegetation in the said river, unlike in Oroquieta (Layawan River) where seagrass were found 1 km from the river mouth. Similarly, the brown seaweeds were also found in most of the reef areas in Langaran River.

There was a high incidence of fruiting of *Thalassia hemprichii* in Oroquieta than in Plaridel. Further, there appeared to have higher fruiting incidence southward of the river mouth than northward in both the Layawan and Langaran Rivers. This may be partly explained by the southward tranport of river discharge, which brought in more nutrients. This was generally at its peak during the cold months (November to February). In terms of variation in vertical internodal lengths, there was clear lower growth (shorter internodes) during the cold months (December to February) north of both rivers. But southward, the temporal pattern was less clear, which was perhaps due to other intervening factors like river plume. There was no clear spatial variation in vertical and horizontal elongation rates and demographic parameters.

Physico-chemical Parameters. Quantification of some selected physico-chemical parameters like river discharge

Table 4. Concentration (MPN / 100 ml) of coliform in Langaran and Layawan Rivers during the dry and wet seasons sampling.

	Most Probable Number (MPN) / 100 ml		
	1st Sampling (dry season)	2nd Sampling (wet season)	3rd Sampling (wet season)
Langaran River			
Singalat	4	129	80
Mamalad	17	59	1,000
Bonifacio	7	25	1,183
Tipolo Quarry	240	53	1,133
Tipolo Dam	8	1,233	1,366
Layawan River			
Mialen	25	24	24
Toliyok	372	433	750
Bunga	22	680	401
Purok 4-Villaflor	656	105	1,133
Purok 2-Villaflor	61	575	1,073
Purok 1-Villaflor	37	238	87
RIVER MOUTH			
Langaran River	840	15	617
Layawan River	57	30	1,600

expressed as volumetric flow, TSS, TDS, and nutrient (NH_4) was done to determine their patterns. The volumetric flow in Layawan River stations increased as it moved downstream in both seasons. Correlation analysis showed that the difference in the volumetric flow was not significant during dry season but significant during wet season (Figure 5). The predominantly southward transport of river discharge may be the influence of the northeast winds, although this had to be further investigated by conducting a hydrodynamic study in the area.

In Layawan River, there was a significant increase of TSS level and TSS load from upstream to downstream stations during dry season. The trend of TSS and TDS load from Barangay Bunga, i.e., increasing downstream up to Villaflor (Purok 4), but decreasing towards the last sampling point in Purok 2, maybe due to the presence of a dam (Figure 6). The TSS level in Langaran River showed an insignificant difference during dry season, but the TSS load significantly increased towards the river mouth. The levels of TSS were relatively low in Langaran and Layawan Rivers and were within the DENR standards.

Nutrients are essential substances necessary for plant growth. The various forms of nutrients from the catchment into the flowing waters may change levels downstream while moving between various biotic and abiotic compartments (Downes *et al.* 2002). In Layawan River, the concentration of ammonia had no significant increase from upstream to downstream stations during dry season, but exhibited significant increase during wet season (Figure 7).

Dissolved oxygen (DO) was also measured because it is a direct indicator of water quality. There was no apparent variation in DO concentration from upstream to downstream for both the Langaran and Layawan Rivers (Figure 8).

Coral Cover and Fish. More or less, similar trends of coral cover and fish abundance were established in the adjacent coastal areas of Langaran and Layawan Rivers, as shown in Figure 9. In general, in the areas where there were no corals, fish was also absent. Although fish abundance and coral cover did not show strong correlation. This result was consistent with similar studies, like in the Pacific Seaboard.

Fish biomass was correlated to live coral using scatter plot diagram (Figure 10). Results showed no correlation between fish biomass and live coral cover. This was probably due to the relatively narrow range of values and low coral cover of reefs in both sites. The weak or absence of correlation between fish biomass and coral cover may also be explained by other factors like fishing pressure.

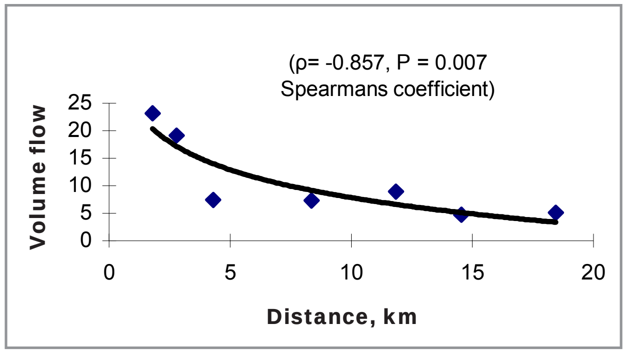

Figure 5. Volumetric flow (river discharge) during wet season in Layawan River.

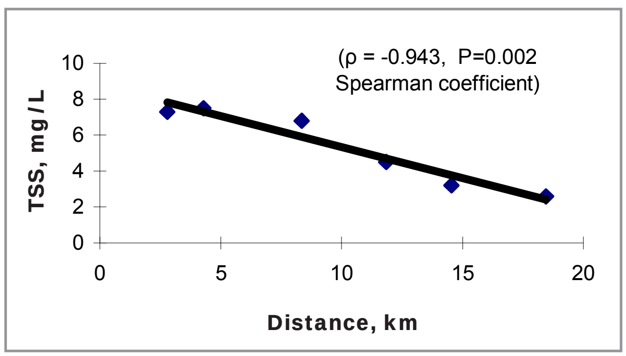

Figure 6. Total suspended solids during dry season in Layawan River.

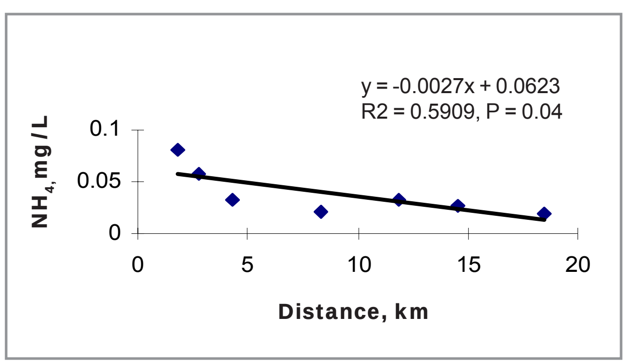

Figure 7. Ammonia (NH4) level during wet season in Layawan River.

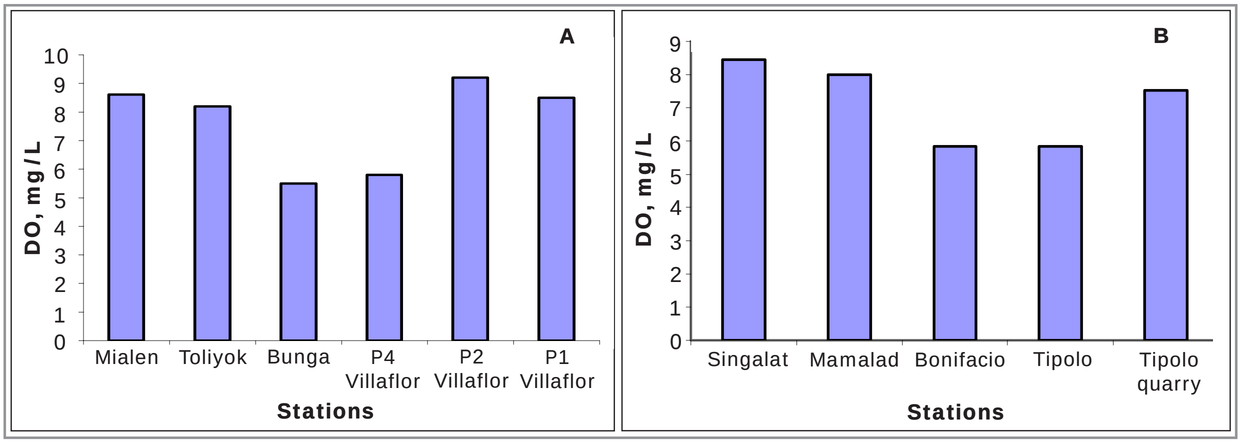

Figure 8. Dissolved oxygen during dry season in Layawan (A) and Langaran (B) Rivers.

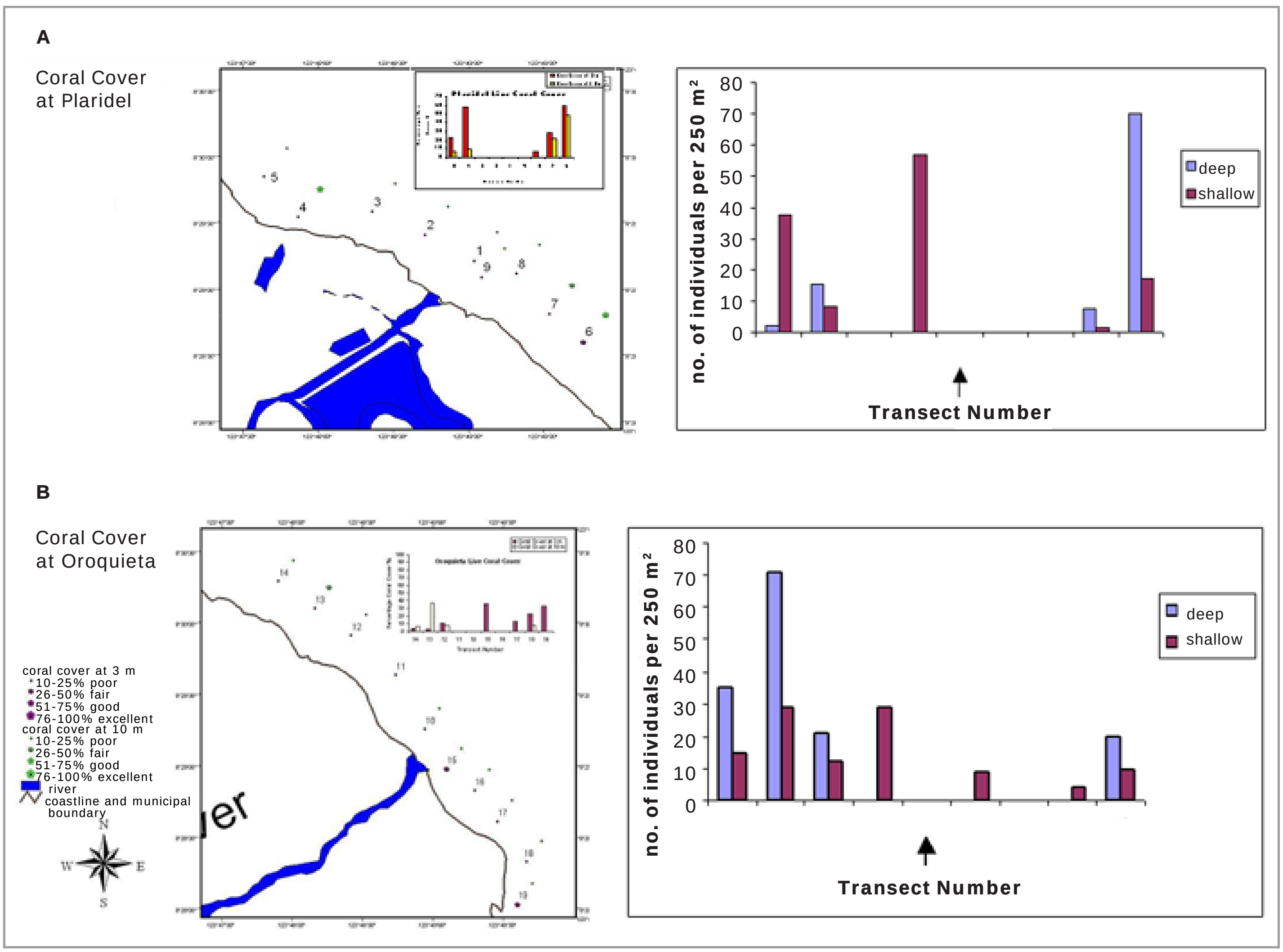

Figure 9. Coral cover and fish abundance in Langaran (A) and Layawan Rivers (B). (Arrow indicates the relative position of the river mouth).

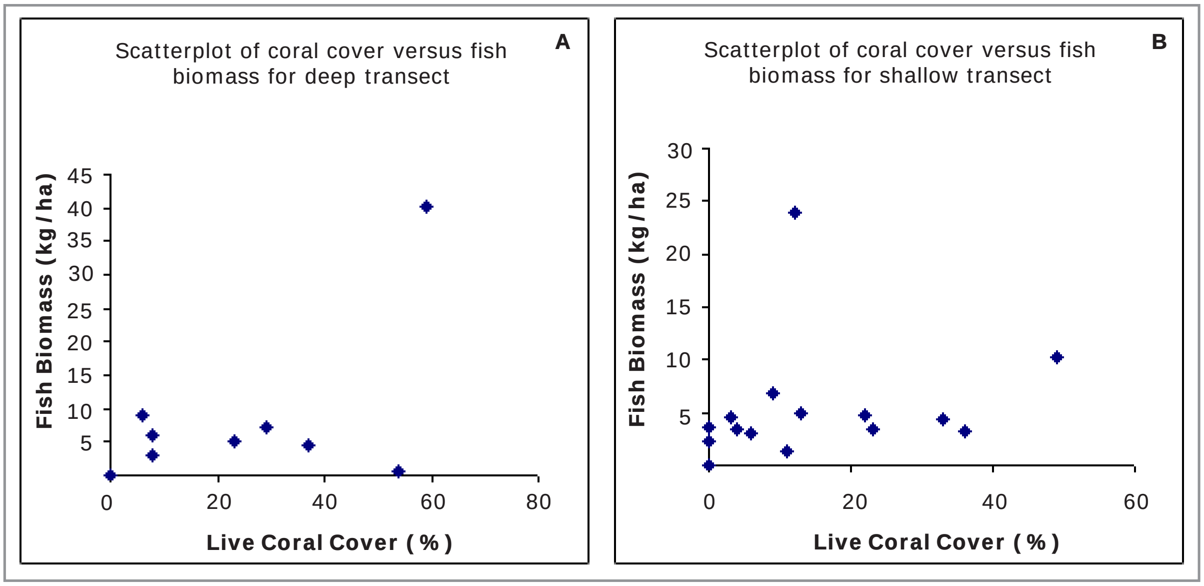

Figure 10. Relationship of percent coral cover versus fish biomass for Plaridel (A) and Oroquieta (B).

There may be high coral cover in some of the sampling stations, which theoretically implies high fish biomass. However, if there was overfishing in the area, this may give the impression of low fish biomass.

Impacts on Coastal Resources

River Discharge, Salinity, and Sedimentation on Coral and Seagrass Cover. It appeared that the river discharge of Layawan River during dry season was lesser than Langaran River, probably due to the opening of the dam in Villaflor and closing of the dam in Tipolo. With snapshot assessment, data on river discharge could not ascertain that greater volume of freshwater was carried to the coastal area of Langaran River than in Layawan River for the reason that factors like tide level as well as time and point of sampling (e.g., presence of dam) had to be considered. But the salinity profile (Figure 11) reflected the longer extent of freshwater discharge, especially in the southernmost portion of the mouth of Layawan River.

Both river discharge and the salinity profile may indicate the freshwater influx to the coastal area that somehow contributed to the TSS level and to varying sedimentation rates that may have created impact on the coastal biota. Although values for TSS and sedimentation rates did not show significant difference in the two rivers being studied during the sampling period, long-term monitoring may exhibit effects on the coastal biota. In Langaran River, there was relatively higher coral cover and presence of seagrass, as well as seaweed, near the river mouth. Whereas, in Layawan River, lower coral cover was observed with seagrass occurring only about one kilometer from its mouth. The generally increasing coral cover, particularly shallow sites, southward from the river mouths of both Layawan and Langaran Rivers may be an impact of freshwater on the coral cover, although there was one contrary observation of high coral cover in the deep site northward of Layawan River. Likewise, the variations in the pattern of seagrass in both Layawan and Langaran Rivers may also be an impact of the river water.

Transparency and Density of Phytoplankton. Occurrence of algal bloom in the Layawan and Langaran Rivers and one cove in Danlugan may have caused the water to become turbid. Transparency values were lower in Danlugan which happened to have the highest density of phytoplankters, with a maximun value of 1,719 cells/liter. For Oroquieta where Layawan river discharges, specifically in Barangay Taboc Sur, the phytoplankton density varied from 2 to 167 cells/liter. For Plaridel, where the Langaran River flows out, phytoplankton density ranged from 5 to 469 cells/liter.

Bioindicators of Water Quality

Macroinvertebrates as Bioindicators. Biotic index systems give numerical scores to specific “indicator” organisms at a particular taxonomic level (Armitage *et al.* 1983). Such organisms have specific requirements in terms of physical and chemical conditions. Changes in numbers, morphology, physiology, behavior, or presence/absence of these organisms can indicate that the physical and/or

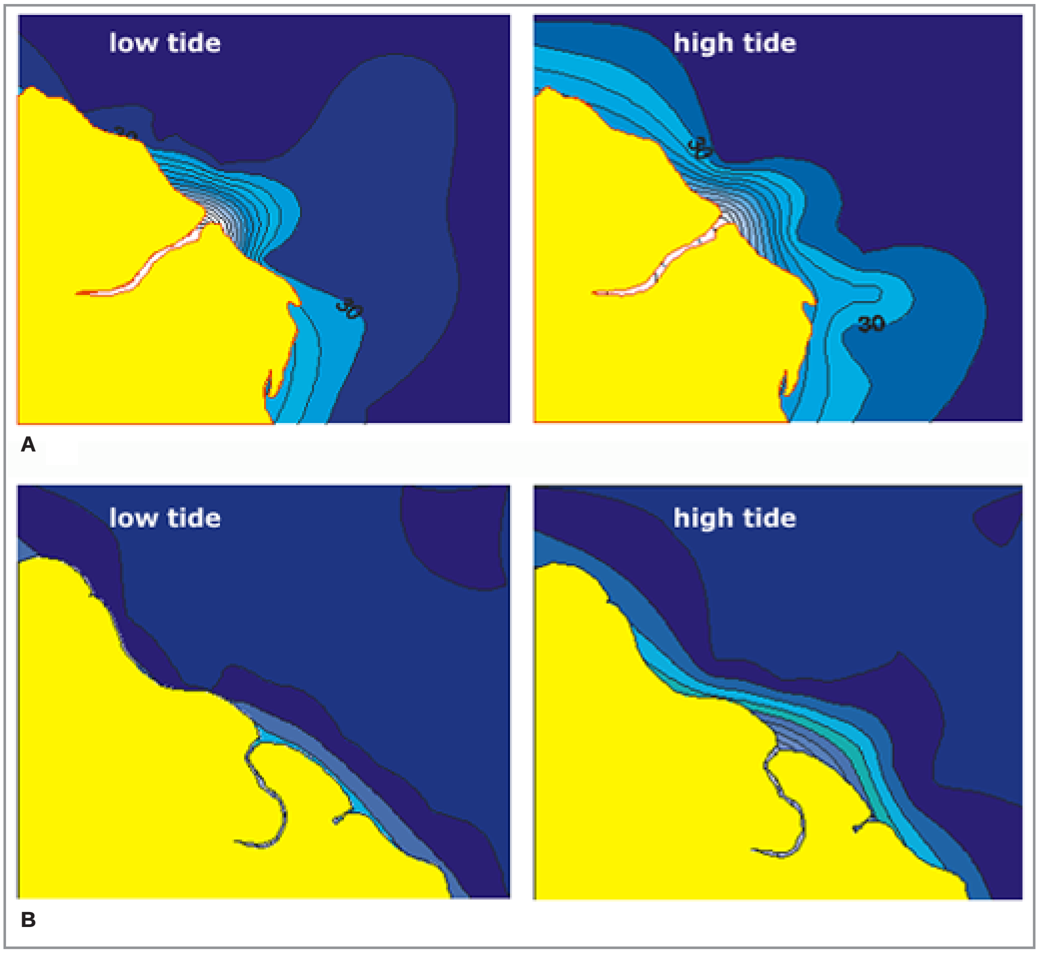

Figure 11. Salinity profile in Layawan (A) and Langaran (B) Rivers.

chemical conditions are outside their preferred limits (Rosenberg and Resh 1993).

The insects under class Ephemeroptera (mayflies), Plecoptera (stoneflies), and Tricoptera (caddisflies), collectively known as EPT, are generally considered pollution-sensitive and are normally used to evaluate community balance. The said taxonomic classes were represented in almost all the sampling sites, but in varied densities. During the wet season sampling, not a single Plecopteran family was obtained in Tipolo (bridge) in Langaran, just as it was also absent in Purok 2 of Villaflor of Layawan River. Except in Tipolo (bridge), all sampling sites of both rivers and in both the dry and wet seasons, families under Ephemeroptera consistently yielded the highest among the three classes (EPT). Ephemeropterans feed on plants growing on weeds and stones, and need good water quality with lots of oxygen. Evidently, the presence of the Ephemeropterans in almost all sampling sites showed that the said sites were able to provide the requirements of the mayflies.

In general, the Layawan and Langaran Rivers were dominated by macroinvertebrates that were excellent and good water quality indicators during the dry and wet seasons, hence, implying the healthy state of the rivers. Unlike the Lipadas-Tolomo Rivers in Davao, where macroinvertebrates were non-existing in some portions, or if these were present, only those pollution-tolerant families were found (Gamboa and Otadoy 2003).

Phytoplankton as Indicators of Red Tide Occurrence. The coastal waters in all sampling areas harbored a total of six genera of red tide-causing organisms, namely, *Ceratium* sp., *Dinophysis* sp., *Gambierdiscus* sp., *Gonyaulax* sp., *Noctiluca* sp., and *Peridinium* sp. *Ceratium* is the only harmful but non-toxic algae, while the rest of the taxa produce toxins (Paerl 1998, Turner 1997, Zmijewska *et al.* 2000, Moestrup 2004).

In Danlugan Cove, Lopez Jaena, five genera of red tide-causing organisms were observed, with an aggregate relative abundance of 44.2 percent. *Ceratium* sp. (44.04%) formed the maximum relative abundance with the species. *Ceratium lineatum* dominated the entire bulk of the population (43.7%) (Figure 12). During field collection, red coloration of the water was observed for a short period of time. This event was caused by the presence of *Ceratium lineatum* in large numbers, which may be a consequence of eutrophication on algal bloom due to high nutrient input.

SUMMARY AND CONCLUSION

The overall state of biodiversity in Layawan and Langaran Rivers of Mt. Malindang was comparable to that in other areas of the country, like Mt. Makiling in Laguna and Mt. Talomo in Davao. Total number of tree morphospecies ranged from 108 in headwaters to 105 in Layawan River. While in Mt. Makiling, there were about 84 to 134 tree species, as categorized according to size .

Fauna species richness in the two rivers studied ranged from 47 to 60 for birds, 10 to 12 for mammals, nine to 17 for reptiles, and three to 25 for fish. Number of endemic species, particularly for birds, was quite high, with endemicity of 39 percent as compared to the national figure of 33 percent. The birds recorded in the study were observed in the riparian areas, in which case, there may be lower number of existing species as compared to that in the forest ecosystems like in Mt. Talomo in Davao with a record of 93 species of birds, of which 13 were identified as endemic, and in Mt. Makiling with 109 bird species .

Looking at the pattern of biodiversity along the riparian stretch of the rivers, the number of tree species decreases downstream. Possible causes may be the lower human population in the more upstream *barangays* than downstream. Settlements would mean conversion of riparian forest to residential lots and agricultural land. Another possible factor was the river channel morphology and topography in the upstream portions of the rivers, which have more steep sides that may prevent attempts for tree cutting and land conversion for crop cultivation. The trend of bird species richness was contrasting in the two rivers studied. There was an increasing trend in the number of bird species downstream in Layawan River. This may be attributed to the variety of habitats, like the presence of agricultural land, as well as riparian forest habitats.

River water quality and the quantity of its discharge to coastal areas were the factors that cut across and connect the aquatic ecosystems. These were determined through measurement of physico-chemical parameters (e.g. TSS, DO, nutrients, volumetric flow, etc.) and the use of bioindicators, such as macroinvertebrates.

Riparian zones, with the flora cover, may affect water quality in the river. Hypothetically, one particular parameter that would be affected by vegetation was the TSS. The observed decreasing trend of tree species and increasing TSS level downstream were possible indications of the relationship because absence of vegetation along the riverbanks would lead to soil erosion, thus contributing to the amount of TSS in the river water. Although, there were human activities, like quarrying, that could also increase TSS levels.

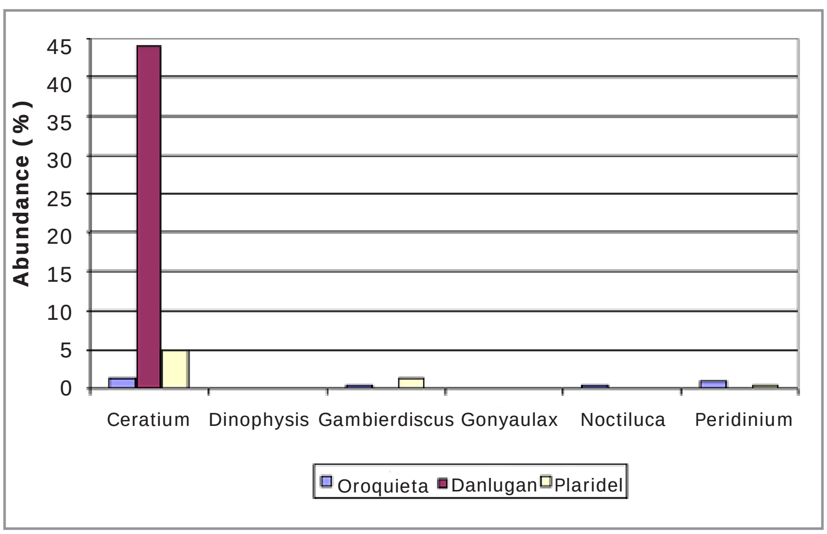

Figure 12. Relative abundance of red-tide causing organisms in the sampling sites.

Along the stretch of the river, TSS may also be related to macroinvertebrates. The trend established for macroinvertebrates, with decreasing number of families that are excellent water quality indicators downstream, likewise relate to the increasing TSS level downstream.

Considering the levels of concentration and load of TSS, as well as family composition of bioindicators, results of the study showed the healthy state of the aquatic zones of the river. The physico-chemical parameters (e.g., TSS, DO, and nutrients) were within the DENR standards, both in the river and in the vicinity near its mouth towards the coast, referred to as “impact area”. Moreover, macroinvertebrates present in the river were dominated by excellent and good water quality indicators, especially in the upstream portions, thus coming up with a “clean” and “rather clean” category based on the computed indices. Unlike the Lipadas-Talomo Rivers in Davao, where macroinvertebrates were non-existing in some portions, or if these were present, only those pollution-tolerant families were found. The macroinvertebrates were used as indicators of TSS, DO, and nutrients. River water quality may also be determined by looking at the coliform concentration. Usually, coliform easily die off, but during the sampling, their levels exceeded the DENR standards. Similar to other waters, like in Puerto Galera, coliform levels were already alarming yet the water was still classified as clean, maybe with other criteria.

Despite the acceptable levels of the important physico-chemical parameters transported to the coastal area, their impacts were still manifested in the state of the coastal biota. Hypothetically, whatever threatening activities done in the upper portion of a river may affect vegetation, water quality, and quantity of river discharge. This, in the long run, would have impacts downstream towards the coastal areas.

Threats (e.g., deforestation, quarrying, and irrigation dams) that affected the integrity of the two rivers studied had been identified even during the First Generation Research. Such threats may be attributed to the present pattern of biodiversity and the trends of physico-chemical parameters established in the project. Probably considering the long-term effects and not only the levels of concentration and loads measured *in situ* that were within the DENR standards, these may have created negative impacts on the coastal biota, such as the poor to fair coral cover (<50%) in the coastal sites, especially in Oroquieta (Layawan river mouth), and the absence of seagrass in the “impact area” (1 km north and south in Oroquieta and <400 m in Plaridel).

The state of coral reef and seagrass habitats that partly contributed to the poor state of fish stock in terms of biomass, size, and species richness, may also be affected by human destructive activities, like blast fishing that was well-documented in the coastal (coral reef) study. Furthermore, the reef fish profile, being generally small-sized, could be an indication of overfishing, as noted in the SECS project, which was also a socioeconomic-policy concern. Given the scenario, further increasing river discharge and transporting poorer water quality (e.g., higher TSS), with destructive human activities, both upstream and in the coastal zone, would widen impact areas, thereby degrading more coastal biota and depleting fish resources.

RECOMMENDATIONS

Based on the project results, the following points are recommended: 1) the relatively healthy state of the river aquatic zones had to be sustained by institutionalizing a community-based monitoring protocol generated during the BRP, using macroinvertebrates as bioindicators of river water quality and endemic birds as indicators of riparian health which would be readily adopted by the community; 2) rehabilitation of areas with diminishing tree species; 3) support action and management plan to protect the fauna, especially endemic birds, in the two rivers; 4) formulation of appropriate ordinances to address certain issues; 5) design of an integrated upland and coastal resource management program; 6) boosting of political will of *barangay* officials to enforce local ordinances to regulate quarrying and other destructive activities; and 7) implementation and pursuance of the unification of fisheries ordinances.

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People and Nature

RESOURCE UTILIZATION IN SELECTED TERRESTRIAL ECOSYSTEMS IN MT. MALINDANG AND ITS ENVIRONS[1]

Alita T. Roxas[2] and Leontine Visser[3]

Mt. Malindang Range is found in the eastern part of the Zamboanga Peninsula in Mindanao, Philippines. Its core is located within the Province of Misamis Occidental, occupying most of the area, and has a maximum elevation of 2,404 meters above sea level (masl). It is volcanic in origin but is now believed to be extinct. It has a rugged terrain, steep slopes, and dense forest cover. It also has several craters, the biggest of which is an 8-hectare (ha) crater lake at Barangay Lake Duminagat. The lake has been an outstanding attraction and believed to be sacred by the indigenous peoples in the area – the Subanens.

In 1971, some 53,262 ha of the Mt. Malindang Range was declared a national park and watershed reservation (Republic Act [RA] 6266); 45,000 ha of this is forested, the rest already opened and cultivated.

Pursuant to the law on the National Integrated Protected Areas System or NIPAS (RA 7586, 1 June 1992), the Mt. Malindang Range was declared a protected area[4], and its peripheral areas as a buffer zone[5], and is now known as the Mt. Malindang Range Natural Park (Presidential Proclamation 228, 2 August 2002). This had reduced the size of the core protected area to 34,694 ha, and the remaining area had been re-designated as buffer zone.

The park hosts diverse and rare species of flora and fauna. Two hundred twenty-three plant species in 89 families have recently been recorded in the park and a substantial number still requires scientific classification. Rare and endangered fauna found in the park were the Philippine eagle, Flying lemur, Philippine deer, tarsier, Rafona hornbill, and the Giant scops owl. Some 337 mammals, 158 birds, 11 reptiles, and 14 amphibians had also been recorded. The park's flora and fauna exhibit a high degree of endemism.

The park consist of around 33,700 ha of forested land (most of the core area), of which only 18,000 ha or less are primary growth forest. Open land and brush land comprise 5,800 ha of the park, and more than 10,000 ha are cultivated lands. The remaining areas are reforestation areas.

There are 65 barangays in 14 municipalities within the protected area (PA), supporting around 18,000 residents in the buffer zone and about 900 in the core area. Eighty percent of the PA's population are Subanens or with Subanen lineage, but the proportion of immigrant settlers is increasing.

THE SUBANENS

The Subanens (also called Subanun or Subanon) are indigenous people who settled before the 16th Century in the south and northwestern Mindanao region – the Zamboanga peninsula. Three provinces compose the peninsula: Misamis Occidental, Zamboanga del Sur, and Zamboanga del Norte. They are culturally distinct from recent immigrants as they have their own language and customs. The name Subanen originated from the Bisayan term *suba* which means river. These indigenous people lived near rivers and were called "river dwellers". Historical accounts point to the Subanens as occupying the coastal and lowland areas of the peninsula during the American colonial rule. Predominantly hunters, they were pushed into the hinterlands to avoid the marauding activities of Moros and Visayans. They were progressively pushed further to

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[4] A protected area refers to identified portions of land and water set aside by reason of their unique physical and biological significance, managed to enhance biodiversity, and protected against human exploitation (Sec 4[b], RA 7586)

[5] A buffer zone consists of identified areas outside the boundaries of and immediately adjacent to designated protected areas that need special development control in order to avoid or minimize harm to the protected area (Sec 4[c], RA 7586)

the mountains by the encroachment of settlers into their ancestral domain, eventually resulting into the assimilation of the Subanen culture into the culture of lowlanders. Western and Hispanic cultures, the schools, the media, as well as commerce and trade, exert influence on the Subanen indigenous culture. The Subanen cultural heritage include living harmoniously with nature, with the spirit world, and with men.

THE STUDY SITES

Don Victoriano Chongbian (also referred to as Don Vic) has a land area of 5,803 ha, which comprises 11.92 percent of Misamis Occidental's 486,723 ha of land area. Three of the Don Vic *barangays*[6] have strategic locations in the Mt. Malindang Range: Barangays Lake Duminagat, Gandawan, and Nueva Vista (formerly named Mansawan). These are logged-over areas which have been converted into agricultural lands and settlements.

Barangay Lake Duminagat is within the core protected area. It is located at the foothills of one of the prominent ranges of Mt. Malindang - the North Peak. It has a total land area of about 909 ha, 60 ha of which are forests, 48 ha are agricultural lands, and the rest are grasslands and residential areas. It is a crater valley surrounded by mountains with peaks of 1,678 masl, 1,865 masl, and 2,183 masl (North Peak). It is the most interior *barangay* and has the highest elevation among the three Don Vic *barangays* studied, with elevations ranging from 1,440-1,460 masl. This explains its low temperature which is an average of 15°C. Majority of the slopes are 35° (NIPAP-DENR 2000). It has a very rugged terrain and accessible only by horse-back ride or on foot. Survey results showed that it had around 313 residents composing 55 households, with an average household size of five members. It was gathered from scant and oral histories that the area had been settled in the 1930s when the Lake was discovered by a Subanen *surhano* (spirit medium), Pedro "Mali" Villameno. He originated from the lowlands, a place now called Buenas Suerte, Upper Mutia, Zamboanga del Norte. The mountain ranges of Malindang were said to be named after him, Mali, and his wife, Baindang (Hansel *et al.* 2003). A number of settlers in the Park today were his descendants, including four of his ten children. Almost all of the present settlers were Subanens. Survey respondents had stayed in the area for an average of 31 years, although some reported having settled there for the last 50 years.

Barangay Gandawan, used to be known as Gandawan Valley, is found in the buffer zone. It is adjacent to Barangay Lake Duminagat, with elevations ranging from 1,240-1,280 masl. It has a larger plain area compared to Duminagat, totaling to 101.9 ha. Surrounding mountains have peaks of 1,635 masl, 1,716 masl, and 1,678 masl (in common with Barangay Lake Duminagat) with majority of the slopes averaging 33° (NIPAP-DENR 2000).

One could either walk or ride a horse to go to Gandawan. Logging, which commenced in the early 1960s, opened the area to more settlers. There were 70 households in the area; mean household size was five. Due to a large percentage of recent non-Subanen settlers (about 70%), mean years of settlement in the area among respondents was 21 years.

Barangay Nueva Vista also lies in the buffer zone. It has an elevation of 1,269-1,303 masl, with undulating mountainous slopes (Nuñeza *et al.* 2004) and a land area of 1,606 ha (PALS 2002). Its first settlers were said to have arrived in the late 1940s from Ariosa, Zamboaga del Sur. Compared to the two other *barangays*, Nueva Vista is accessible to motorcycles and four-wheel drive vehicles and is the nearest to the poblacion which is about 10 km away; it serves as the center of the three Don Vic study sites. It has a secondary school, a *tabu-an* or public market, and hosts several microscale livelihood activities. About 263 households were found in the *barangay*; mean household size was five. Respondents reported an average of 23 years of residency in the area.

While there are no exact population figures in Gandawan and Nueva Vista, the reported number of households indicated that population decreases as the *barangay* becomes more interior. The three communities were net in-migration areas. In the last two intercensal periods (1990-1995 and 1995-2000), it was reported that Don Vic - the municipality where the three *barangays* belong - is a high growth area, growing by an average of 3.41 percent and 3.24 percent; the figures are high compared to the annual average national rates of 2.32 percent and 2.36 percent for the same period (NSO figures). Don Vic was declared a municipality only in 1990, as such, no other data on its population growth was available. There was a wide variation in the growth rates in the different municipalities of Misamis Occidental, but population growth was much higher in and around the Mt. Malindang Natural Park, where the marginalized still find abundant land to till. The three study sites in Don Vic were located in the core protected area or in the buffer zones of Mt. Malindang. These areas are priority areas for biodiversity conservation, but the presence of settlers there, and their livelihood

[6] The smallest unit of governance in the Philippines

activities, leads to deforestation and rapid biodiversity loss in the area.

Particularly in the study sites, settlements were established first in the highest elevation/most interior *barangay*. This was attributed to the migration there after the discovery of the Lake. Llikewise, illegal logging was also reported to have started around the Lake in the 1950s, where the forest was thickest. Logging concessions granted in the 1960s also started operations there; subsequent timber licensing agreements were granted for Gandawan, and then Nueva Vista.

BRIEF DESCRIPTION OF METHODS USED

Literature Review. A review of documents on the Mt. Malindang Range Natural Park, which were available at the offices of pertinent government and nongovernment organizations (NGOs) in Misamis Occidental, was done. This included reviewing data from the BRP First Generation Researches. A review of related literature was also made to familiarize researchers with the status of research in similar concerns.

Primary Data Collection. Primary data was obtained using direct observation, conversational interviews among household heads, key informant (KI) interviews, and focus group discussions (FGDs), each reinforcing and cross-checking each other. Interview guides and questionnaires were prepared.

Sampling. Purposive sampling was done in the selection of key informants and participants of FGDs. They came from the ranks of those competent and knowledgeable about the information being sought, such as the elders and the formal and traditional leaders. For the surveys, simple random sampling was done in Barangay Lake Duminagat as the *barangay* has only one *purok* and the number of households was only 55. The larger populations in the two other *barangays* of Gandawan and Nueva Vista led to the use of area sampling.

From the 388 households in the Don Victoriano study sites, a total of 93 households had been included in the sample for the survey on resource utilization. One hundred and thirteen households, however, had been included in the socio-demographic part of the survey. Respondents of surveys conducted were either the husband or the wife, with mean age of 41 years.

The socioeconomic profile of the respondents are shown in Appendix A.

RESULTS AND DISCUSSIONS

Ethnolinguistic Affiliation of Migrant Settlers. The Mt. Malindang Range Natural Park had always been associated with the Subanens. They comprised more than 90 percent of the settlers in the core area, but their number was smaller in the buffer zones. PALS (2002) data point to around 95 percent Subanen settlers in Barangay Lake Duminagat, 30 percent in Gandawan, and 71 percent in Nueva Vista. The rest were Subanen-mixed (lowlanders who have intermarried with Subanens) and Bisayan settlers from different areas in Mindanao. Subanens comprised 87.5 percent of the respondents in Barangay Lake Duminagat, 32.43 percent in Gandawan, and 75 percent in Nueva Vista. Mean years of settlement in the three Don Victoriano study sites among the respondents was 25 years.

Household Income, Sources, and Expenditures. Household income in the three study sites was not easy to obtain as income sources were unstable and difficult to estimate**.** Farming was the main source of income of the respondents. It consisted mainly of income from cash crops, like spring onions, chayote, and other vegetables of the temperate variety (cabbage, Chinese pechay, carrots, and bell pepper) and from occasional sale of livestock. Its mean monthly average was PHP 1,800. Livestock consisted of chickens, goats, pigs, and a few cattles. For Barangay Lake Duminagat residents, mean monthly farm income was only PHP 1,110. The figure hovered around PHP 2,489 in Gandawan, and PHP 1,783 for Nueva Vista.

Except for Gandawan, which - as mentioned earlier – is a valley, vegetable gardens were mainly on steep slopes. Gardening on steep slopes without the application of the sloping agriculture land technology (SALT) is difficult due to topsoil loss brought about by rains, which frequently visit the area. There is a higher incidence of crop failure in Barangay Lake Duminagat due to more frequent occurrence of strong winds and heavy rainfall (Bornales 2003).

Only about 18 percent of the respondents reported having off-farm income sources, i.e., from working for other farms. Such arrangement was called *panungha*. Other off-farm income sources included the occasional selling of woven mats and selling of ornamental plants (known locally as million flowers).

Around half of the respondents, meanwhile, reported having non-farm income sources. Estimates varied widely, from less than PHP 100/month to a very high PHP 41,000/month, the latter coming from near-monopoly microscale wholesaling and retailing. Non-farm income were commonly sourced from honoraria for holding positions in the local government, seasonal employment with NGOs, *sari-sari* store operations, renting out horses for carrying harvests to the market, and remittances from household members working in urban centers. Income from non-farm sources was higher than farm income; this was highest in Nueva Vista due to its location and access to poblacion markets.

Survey results indicated that mean monthly household income from all sources tend to be smaller the farther the *barangay* is from the *poblacion*. Thus, the mean household income for the most interior *barangay* of Lake Duminagat was PHP 2,138, followed by PHP 3,071 in Gandawan, and PHP 4,437 in Nueva Vista. The amount did not include consumptive income. Where forests products like firewood and wood for house construction and repair are neither sold nor purchased, they were not valued in cash by the settlers. The same was true for subsistence crops and cash crops consumed. Provincial estimates of consumptive income is PHP 800/month (CARE-AWESOME 2003).

Annual per capita income in Nueva Vista was around PHP 12,569. Taking the 2002 annual per capita poverty threshold for the country's rural areas of PHP 11,390 (NSO 2003) as benchmark, Nueva Vista, on the average, had an annual per capita income slightly above the poverty line. Annual per capita income in Barangays Gandawan and Lake Duminagat, meanwhile, were below the poverty line.

The estimated proportion of total income going to farm inputs was highest in Barangay Lake Duminagat. This was due to the greater difficulty of farming here, where slopes are most steep and where, as already cited, stonger wind and rains are frequent.

Assets Owned, Accessed, or Controlled. The other socio-demographic data lend themselves to analysis making use of Ellis' (2000) concept of assets in his framework for analyzing rural livelihood. The framework evolved from the "assets-mediating processes-activities" framework used by researchers in studying poverty-environment interactions (e.g., Reardon and Vosti 1995), sustainable rural livelihoods (Scoones 1998), and other similar themes.

Assets are the stocks of capital that can be utilized directly or indirectly, to generate the means of survival of the household or to maintain its material well-being at differing levels above survival (Ellis 2000). These assets refer to human, natural, physical, financial, and social capital. Access to and control of these assets enable people to translate them into livelihood strategies, which oftentimes conflict with the requirements of biodiversity conservation, especially when access and control are very limited vis-à-vis survival needs.

Financial capital and its substitutes are the stocks of money that households can accessed, referring mainly to savings and access to credit, and such substitutes as livestock and the marketable farm surplus, which can be converted to financial capital when sold.

Given the impoverished condition, only a very few households generated savings in the Don Vic study sites; the majority who had no savings also had no access to formal credit. Informal credit was at usurious rates of 10 to 15 percent per month, or even up to 10 percent over the weekend, as experienced by local *compradors*. *Compradors* in the Don Vic area were mainly residents there; they borrow funds from very few local usurers to purchase the local crops and sell them to nearby cities. Informal credit was also sought to purchase farm inputs, such as fertilizers and pesticides. The usurious rates resulted in the high cost of vegetable gardening and selling. Moreover, the farmers had to be paid low for their produce to enable *compradors* to earn profit.

Only relatively well-off households had livestock, either cattle or horses, which actually serve as store of value as they are intended to be sold only to meet emergency or contingency needs.

Foreign-funded programs, such as CARE-AWESOME (funded by CARE of the Netherlands) and the Philippines-Australia for Local Sustainability or PALS (funded by AusAID of Australia) were present in the communities, helping the settlers through the provision of livelihood projects aimed at poverty alleviation, and at the same time promote environmental conservation. These programs grant financial, technical, and marketing assistance. PALS also provide infrastructure assistance in the amount of PHP 300,000 per *barangay*. The CARE-AWESOME project, however, ended on 31 December 2004, while PALS had been in the area since 2002 and is still providing training to would-be beneficiaries to improve their capacity and ensure sustainability of projects.

Despite the general lack of financial capital, the foreign-funded programs were able to bring hope to beneficiaries and would-be beneficiaries. Assistance, however, continued to be farm-based due to the absence of essential infrastructure and utilities, such as electricity and power, which would make easy the diversification to non-farm activities.

Human Capital. Labor that is available to households is referred to as human capital. It includes its education, skills, and health. It is often the chief asset that the poor own to survive, yet it can be of low quality because of poverty itself.

Majority of the respondents had only elementary education. Women reported having more schooling than men, as the latter had to take more responsibility on the farm. Respondents in the lower elevation Nueva Vista had higher educational attainment. This was on account of the relative accessibity of the poblacion where schools were located. The general low level of education translated to low levels of skills that were applied on the farm; this level of skills, while matching the requirements of subsistence farming, hunting, and forest gathering, failed to catch up with commercial agriculture to which the settlers were increasingly drawn. It also explained why few engage in non-farm activities which yield higher returns. The lack of capability building among settlers in the area was a challenge now being addressed slowly by the government and NGOs.

The incidence of serious ailments was few in the study sites; primary health care was delivered by rural health units and *barangay* health centers. Hansel *et al.* (2003) and Arances *et al.* (2004) reported the widespread use of plants and herbs in the communities to cure illnesses.

Natural capital consists of land, water, air, and the biological resources that thrive on them. They are used by people to generate means of livelihood, and in the process they are either enhanced or degraded.

Land and Forests. The Mt. Malindang forest represented vast natural capital, which is being degraded by the activities of poor and landless migrants, regardless of ethnic affiliation, although the majority (up to 95%) were tribal people. Shively (2001) had mentioned a lot of research evidence in the Philippines and in other developing countries showing the strong correlation between levels of household poverty and the probability of forest use. The extent of poverty among the migrant settlers in Mt. Malindang suggested a similar phenomenon. This was not to absolve wealthy loggers who initially opened the Mt. Malindang forests and felled trees in the 1950s until the early 1980s. The survival activities of the landless poor and the profit-seeking loggers before they were banned from the forest were both the effects of earlier short-sighted policies. Historical data in the Philippines showed that such policies had put pressure on the forest by promoting growth at the forest margins (Coxhead *et al.* 2001). The landless, to diffuse unrest in the lowlands, were given the motivation to open and cultivate forested areas, as exemplified by homestead rights. The wealthy, meanwhile, were given timber licensing agreements and encouraged to produce for the export market to prop up the dollar-strapped economy.

Lands in the core area of Mt.Malindang and in the buffer zone are public lands, and hence, cannot be owned. The government, therefore, considered the land used by Subanen households and Bisaya migrants from the lowlands as encroached land (*inangkon*). To the Subanens, however, their claim of ownership over the lands they occupy was based on the customary system of traditional societies, or what had come to be known as ancestral domains. The land was cleared from the forest or inherited from parents who had earlier staked their claims on the forest. Male and female offspring have a right to “inherited” land. Key informants revealed that the earlier a family has migrated into the park the larger are the claimed lands due to the earlier abundance of land. Likewise, the larger the migrating family, the larger also is the land that is cleared from the forest as more people can do the laborious clearing of the forest. These two factors explained why land distribution now vary widely from less than 0.5-12 ha per household. Majority (60-75%) of the respondents, however, reported “their” land to be approximately within the range of less than 0.5 to 2 ha. It was significant to note that forest clearings had declined and land had grown scarce relative to the number of park settlers, as the earlier mentioned NIPAS Law had put a prohibition on the practice. Cultivation of land in the Don Vic study sites was by parcels and respondents had two parcels on the average, which they alternately use and fallow.

Natural capital includes the fertility of land. In these upland communities the soils were poor due to high rates of leaching and organic matter was generally low. A low pH (4.6-6.0) and a deficiency in potassium had been recorded. Increased soil acidity had also been observed owing to the use of chemical fertilizers. Erosion and landslides were common during heavy rains. Rainfall had not been measured but was expected to be two and a half to five times greater than that on the coastal communities and with much higher frequency of rainy days (NIPAP-DENR 2000).

Rivers and Lakes. The upland communities have abundant water resources; 17 major rivers and several small creeks arise from the park or its buffer zone. However, edible life in these water bodies, such as local fish species and freshwater shrimps and crabs, had been observed by respondents to be decreasing. Barangay Lake Duminagat, meanwhile, is oligotrophic resulting in its low productivity (Hansel *et al.* 2003), but its value to the settlers does not lie in its capacity to provide protein food but in its perceived ability to heal ailment and wash away sins.

*Physical Capital***.** Physical assets comprise of capital that is created by economic production processes. Infrastructure, tools, and machines form part of physical assets. They can substitute for natural capital in many circumstances. The substitution process can potentially help to take the pressure off natural resources that are being depleted in local communities. In the context of the three communities, this did not hold as physical assets were limited. Only an abaca threshing center, a *tabuan* or a small trading center, both in Nueva Vista, and a road network from Nueva Vista to the Poblacion could be found to be directly linked to production endeavors. The situation got worse with elevation, where the rugged terrain made the marketing of produce, purchase of basic supplies, infrastructure development, and other economic transactions costly. The communities had not yet been energized, too, and telecommunication access was difficult. This situation further inhibited the diversion into non-farm activities, where income generation is higher. Non-farm activities also minimize incursions on the remaining forests.

Social Capital directs attention to personal and family networks, typically comprising near and remote kin, as well as close family friends, that offer diverse means of support; it involves reciprocity ties (Ellis 2002). It may be vertical, such as those found in authority relationships (claims against kin or friends in the bureaucracy, for instance), or horizontal, such as membership in associations to pursue common goals.

Many of the respondents and key informants were related either by blood or by affinity, assuring them of support when necessary. The World Bank calls this bonding social capital (Winters *et al.* 2001). Vertical relations were nil as relatives holding positions in the municipal or *barangay* level did not have the necessary influence to open employment opportunities nor to facilitate delivery of social services due to the weak administrative link between the grassroots unit of governance and the provincial government. Horizontal relationships were common as indicated by the respondents' membership in local people's organizations (POs) and in religious groups.

NGOs have initiated the organization of POs to serve as channels for capacity enhancement and/or for getting livelihood assistance. This is a policy instrument for intervention to address environmental and livelihood security. More respondents were members of POs organized by NGOs with foreign funds. This was attributable to their capability to provide larger funding support for livelihood endeavors. Likewise, these NGOs were more immersed in the communities. In the same vein, the local officials that were interviewed showed more enthusiasm toward foreign-funded NGOs, as these were better able to fund infrastructure projects. Donor funds for livelihood have just recently started to reach the hinterland *barangays* such that their impact on biodiversity and livelihood sustainability still cannot be assessed.

Religious affiliations also create bonds among members. Key informants said that some religious groups, which have established themselves in the Don Vic study sites, had used the availability of land to entice followers to migrate and settle there. These religious groups combine Catholicism or Protestantism with traditional rituals. Membership in religious groups cultivates trust in a Supreme Being (in contrast to several deities, as is common in traditional societies) and balances the uncertainties of living under harsh weather conditions, possibilities of crop failures, and other unpleasant circumstances. In return, offerings in the form of crops, livestock, and even in cash are given to the Supreme Being through the religious leader.

The scarcity in the other forms of assets had made kinship ties, membership in POs, and religious affiliation valuable to the communities studied.

The asset approach to analyzing the communities of Mt. Malindang explains their survival strategies and provides insights to the type and focus of interventions that need to be in place. The low human, physical, and financial capitals have destined respondents to a life of poverty for so long and unless this is addressed, the situation will only grow worse.

RESOURCE UTILIZATION PRACTICES

On Land and Forests

Among the Don Vic study sites, Barangay Gandawan had the most number of floral species (about 300) consisting mainly of *Agathis* and *dipterocarps*. Barangay Lake Duminagat ranked second with 274 species, most of them were trees of the *Syzigium* and *podocarpus* genera. Barangay Nueva Vista had the least recorded number of species, or 244 (Tobias *et al.* 2004). More floral species were found in the first two *barangays* mentioned because natural forests still exist in the high and steep mountains surrounding them. In Nueva Vista, the natural forests had disappeared, and only secondary forests had been noted.

The forest flora provided the settlers in the study sites wood for fuel, for housing and repairs, and for fencing and support to some plants, such as the chayote. Some trees were fruit-bearing and several, together with herbs and grasses, were used for medicinal purposes.

Respondents' approximation of timber extraction for housing purposes per household yielded an estimated 37.31-66.57 board feet. This translates to 15 to 26 trees (at 15-20 cm diameter at breast height and 5 m long) per dwelling constructed. An on-going study by the BRP flora team had found that the Barangay Lake Duminagat forest contained an average of 877 trees per hectare, and the forest near Gandawan had an average of 504 trees per hectare; Nueva Vista was already devoid of trees. Considering the total number of households in the three communities studied - which was 388 - trees felled for housing totaled from around 5,820 to 10,088. This figure could easily mean a minimum of seven to a maximum of 20 ha of forest cleared, given the varying tree density in the different *barangay* forests. Moreover, trees cut for housing repairs, which occur from time to time, were not even considered yet in the estimates.

Kaingin is a traditional practice to clear the forest and to claim land for cultivation and settlement. This was often resorted to by Subanens and other settlers, as the Mt. Malindang forest provided open access. Subsistence crops were the earliest produce, which are still planted at present, alongside cash crops, and serve as staple food. These consisted of root crops, such as *gabi*, *kanaka* (local yam), and *kamote* (sweet potato). They were found to be resistant to pests; they were resilient and could withstand the harsh climate, and sometimes a marketable surplus was produced.

Cash crops started to be planted in the 1970s; potato was among the first cash crop planted, but the soil was found to be unsuitable for the crop. The Subanens learned of the steady market demand for spring onion in their interaction with relatives from the lowlands, which led them to start planting the crop. Spring onion had been found to grow well in the area, and they had been observed to command a good price. Thus, it had become the primary cash crop. However, since the 1980s, farmers had to apply fertilizers for the onions to grow well. Onions were supplemented by cabbage, carrots, Chinese pechay, and the sturdy chayote to augment income. The high value vegetables, however, became dependent on fertilizers. Pesticides also became necessary due to pest infestation. Poor soil and pest infestation, along with increasing in-migration, prompted further conversion of natural forest into agricultural lands.

Meanwhile, logging was also rampant and made further clearing of the forest less difficult. Recorded data (NIPAP-DENR 2000) point to the employment of the Subanens with logging companies as an alternative source of income. Further encroachments on the forest were prohibited with the declaration of the Mt. Malindang Range as a National Park and Watershed Reservation (RA 6266) on 19 June 1971, covering the entire 53,262 ha of the mountain range. However, presumably because of the political conditions of the country then (i.e., martial rule), it was only in 1982 that this declaration was made public. Timber licensing agreements (TLAs) were granted in 1972, and one decade of oversight - or hideous motives - heightened forest destruction. Pursuant to the law on NIPAS (RA 7586) enacted on 1 June 1992, Mt. Malindang was declared a protected area (PA) and its peripheral areas as buffer zones (Presidential Proclamation 228, 2 August 2002). With this, the Department of Environment and Natural Resources (DENR),local government units (LGUs), and the Protected Areas Management Board (PAMB) had been tasked to undertake the conservation and management of Mt. Malindang to ensure the sustainable development of the mountainous region.

While further encroachments on the forest are not allowed, the law has been wanting in enforcement. Logistical constraints, such as too few (totaling only 19), too ill-equipped, and underpaid forest guards could not effectively police 65 *barangays* existing in the park. Nevertheless, with the declaration of the Mt. Malindang Range Natural Park and the subsequent assistance offered by the European Union, several steps had been done to protect the park. Thus, the DENR Protected Area Superintendent (PASu) had mentioned that while *kaingin* claimed about 100 ha of forest per year before 1995, this had been reduced to 10 ha per year with NIPAS and done mainly on land allowed to fallow for some 10 to 15 years.

Supporting the PASu's statement were reports by key informants that the practice of *kaingin* in the Don Vic study sites was now infrequent and limited only to fallow areas. Fallow period, however, had progressively decreased from the previous 15-20 years to the present 1-3 years due to the increasing population in the Don Vic area and the declining access to unlimited land offered by the forest.

Today, land is generally used to grow high value vegetables and rootcrops. Considerations of crop-soil-climate-market compatibility, learned through years of experimentation, guide the settler migrants in their choice of crops. Minimal grazing takes place, but this is bound to increase as government organizations (GOs) and NGOs had started with cattle and horse dispersal as a form of livelihood. In addition, rituals are conducted to ask the spirits a bountiful harvests or to give thanks when the supplication is answered.

The use of organic fertilizers and contour farming as alternative means to ensure good harvests had been set aside by most. In Nueva Vista, a few practiced contour farming with assistance from the NGOs. Respondents said that the Department of Agriculture (DA) and DENR had made them aware of the long-term damage inorganic fertilizers create, i.e., rapidly degenerating the soil, reducing water quality, and making the produce hazardous to health. However, promptings of the DA and the DENR were often ignored, however, because inorganic fertilizers were readily available (i.e., supplied by *compradors* of vegetables on credit). The short-run utility of income derived from resulting harvests, obtained at increasing costs, often takes precedence over issues of sustainability of both the environment and livelihood.

Abaca and coffee were also being grown in the area. CARE-Philippines had been providing funds to farmers who planted these crops. It also funded the planting of reforestation species (*Pafaserianthes falcataria* and *Acacia mangium*) in Nueva Vista; efforts had been made to guarantee the species-soil compatibility. Support remained minimal and mainly came from the abaca planters due to the beneficial effects shading has on abaca. One reason why the community was lukewarm to reforestation was the undefined tenurial arrangement. Who stands to benefit from the harvest of the reforestation species several years from now? The NIPAS Law provided the answer: farmers who had settled in the area five years before the NIPAS Law shall be considered tenured migrants. This provision of the NIPAS applied to many migrant settlers in the Don Vic study sites, and the DENR had advised them to file for certificates of stewardship on the land.

Women worked on the farm and did most of the household chores and child rearing, necessitating fewer children. Moreover, there was an increasing shift in the marketing of farm produce from men to women. This could be interpreted as a conscious effort of women to take control of household income, as they were more closely involved with the provision of household food and other basic needs.

Utilization of Flora

The forest is a pool of resources that fulfills many household needs. Forest plant resources in the study sites were utilized for housing and repair, for firewood, for medicinal purposes, and as trellis to support vegetables, such as the chayote (*Sechium edule*) plant. Very few reported gathering non-timber forest products (NTFP), such as *pandan* and *tikog*, which were used in mat weaving. Oral histories cited the gathering of rattan in the 1970s to weave into huge baskets, which serve as containers for root crops.

Tree species commonly extracted for housing purposes included (in order of rank) *nilo*, pine, *igem*, *pulayo*, *gilon*, almaciga, and *gulayan*. Only a few species were selected, and they were specific for floors, walls, etc. Most respondents claimed to have cut trees only during the construction of their houses. A few said that they had to cut trees again for repairs.

Plant species commonly used for firewood included *gulayan*, *pulayo*, *baho-baho*, *hanagdong*, *abokado* (*Persia* sp.), falcatta, *kape*, *buungun*, *lipata*, *bayabas* (*Psidium guajava*), *gilon*, pine, *malabago*, *bayante*, *hamindang*, and *salumay*. Lesser-used species were also numerous. Estimates given by key informants yielded results of about 0.192 m^3 of wood per household per week that was being consumed. This translated to 2.18 trees, with an average diameter of 15 cm and length of 5 m. Projecting this estimated volume of firewood utilization into the total number of households within the Mt. Malindang Range would yield quite a scary quantity of trees felled. Respondents, however, stated preference for collecting dead trees, drop logs or branches, knowing that denudation destroys the watershed, causes flash floods, and erosion. Nevertheless, when firewood becomes scarce, they are forced to go to the forest interior to cut trees.

Extraction of forest plant resources was mostly done by male household members. Crude tools, such as the *machete*, were used in extraction; no mechanized tools were being used. The use of a chain saw was prohibited and penalized by the law.

Utilization of Wildlife Fauna

Majority (72%) of the respondents claimed that they no longer hunt nor trap fauna. The remaining 28 percent said that they do these activities to augment the household food supply and income.

Almost all of those engaged in hunting and trapping said that they were able to catch wild boar/pig, while the rest reported catching birds of various kinds (61.53 %). Others that were hunted were wild deer and wild chicken, monkeys, and giant lizards. The hunting of wild animals was infrequently done now. One reason was the decline in the quantity of wildlife observed. Key informants narrated the abundance of wildlife in the 1950s and how they were observed to decline in number through the years, such that in the 1990s, it was already difficult to hunt successfully. Another reason for the minimized hunting was the legislation prohibiting the act (RA 9147). What remained common was the trapping of wild animals using traditional ways, mainly as a defensive gesture. This was because wild animals feast on their crops, especially those that were planted very near forest fringes. Traditional methods included the *lit-ag* (traps installed in the periphery of farms to protect crops) and *ping-pong* (food bait with home made bomb).

Only male household members hunt and trap wild animals. In addition to wildlife hunting, respondents traced the decreasing number and species of wild animals to the destruction of their habitat due to logging and agricultural activities, and to the consequent creeping away of the forests from the communities.

Local Conservation Practices and Interventions

More than one-third of the respondents claimed to have practiced some conservation/management schemes for sustainability. These included timber stand improvement, assisted natural regeneration, and tree planting or reforestation. Others also credited their role as *Bantay Lasang* (forest guards) to have contributed to conservation. Moreover, the use of branches or “dropped logs” for firewood also contributed to the conservation of these resources. Conservation of fauna was done by refraining from hunting and/or by doing only defensive acts of trapping.

The support systems in conservation and management schemes emanated from external forces, mainly GOs and NGOs, as relayed by majority of the respondents. Internal forces (i.e., kinship) was not mentioned, which may be because household or community conservation and management schemes did not explicitly express sustainability as a goal. Moreover, conservation efforts aimed at long-term goals often give way to short-term fulfillment of needs, a situation arising from impoverished conditions.

CONCLUSIONS

The driving force to migrate to the Mt. Malindang Range was the availability of land. Open access made the clearing of the forest easy and attractive. The Subanens were the biggest group of migrant settlers in the area. Their low level of human capital made it difficult for them to work on non-farm ventures yielding higher returns and had made land a very valuable resource. Farm income sources were and remain to be the main sources of livelihood. This provided additional incentive to clear more forests. Policy intervention, however, had deterred this. The proclamation of the Mt. Malindang Range as a protected area and its periphery as buffer zone to protect and enhance the remaining biodiversity had created a host of efforts in an attempt to ensure environmental sustainability.

On the other hand, migrant settlers in the park were deficient in possessing and accessing other forms of assets that could give rise to livelihood security. There appeared to be a positive correlation between this deficiency and the elevation of the communities.

Farming practices were a mixture of traditional and modern means. The same was true with the hunting of fauna and harvesting of flora. Initial analysis showed that no true indigenous practice was applied in the use and management of the Mt. Malindang resources. This may be traceable to the different places of origins of the Subanens, intermarriages with the Bisaya, or constant interaction with them which had led to the assimilation of the Subanen culture into the culture of the lowlands. Moreover, mean years of stay in the Mt. Malindang study sites was only 25 years. There was, however, an apparent direct relationship between adherence to traditional farming practices and the elevation of the location of farms and residence.

The migrant settlers were found knowledgeable of the consequences emanating from unsound ecological practices. Interventions done by GOs and NGOs alike seemed to have been felt. This had somehow prevented more destruction of the environment. Poverty, however, forced them to revert to destructive practices.

RECOMMENDATIONS

The promotion of alternative livelihood activities that are not farm-based appeared to be the logical approach to avoid further degradation of the Mt. Malindang environment. An examination of the assets possessed and accessed by the migrant settlers could give insights on where interventions should be focused.

Efforts to inventory and study traditional practices that promote conservation and enhancement should continue, and their documentation should be made available to communities, especially since these practices appeared to be relegated into the background. The documentation could serve as guides to policy formulation and for designing technology packages that incorporate traditional practices, rendering them more context-based, and therefore more acceptable.

Policy-implementing bodies should be provided the logistical assistance needed to ensure effective enforcement of legislations for the protection of the environment. While national funding could be a good source, local resources and creativity could also be tapped, and the private sector drawn in. Moreover, and perhaps more importantly, the concerned migrant settlers should play an active role in designing policy measures that spring from their felt needs and informed judgment.

As NGOs had been found to play a significant role in making the migrant settlers aware of conservation management and in providing interventions that provide alternatives to farm-based livelihood, their continuing partnerships with GOs should be fostered. Their advocacy for environmental and livelihood sustainability should persists until this had taken deep roots among beneficiaries and could grow tall on its own.

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APPENDIX A. Socio-demographic survey results in Don Victoriano.

	Nueva Vista		Gandawan		Lake Duminagat		Don Victoriano Total	
	Frequency	Percent (%)	Frequency	Percent (%)	Frequency	Percent (%)	Frequency	Percent (%)
Number of Respondents	44	16.73*	37	52.85*	32	58.18*	113	29.12*
Household Size: Mean								
Nueva Vista : 5								
Gandawan : 5								
Lake Duminagat: 5								
Gender								
Male	34	77.27	25	67.57	24	75.00	83	73.45
Female	10	22.73	12	32.43	8	25.00	30	26.55
Age of Respondents								
below 25	3	6.82	1	2.70	1	3.13	5	4.42
26 - 35	17	38.64	11	29.73	12	37.50	40	35.40
36 - 45	12	27.27	16	43.24	7	21.87	35	30.97
46 - 55	9	20.45	4	10.81	7	21.87	20	17.70
56 - 65	2	4.55	4	10.81	3	9.38	9	7.96
above 65	1	2.27	1	2.70	2	6.25	4	3.54
Mean Age: 40.85 ~ 41								
Mean Years of Residency								
Nueva Vista : 23.02								
Gandawan : 21.22								
Lake Duminagat: 30.96								
Total Mean : 25.07								
Ethnicity								
Subanen	3	75.00	12	32.43	28	87.50	73	64.60
Mixed	7	15.90	6	16.22	2	6.25	15	13.30
Non–Subanen	4	9.10	19	51.35	2	6.25	25	22.10
Educational Attainment								
Some elementary	4	9.09	12	32.43	6	18.75	22	19.47
Elementary graduate	27	61.36	19	51.35	22	68.75	68	60.18
Some high school	4	9.09	3	8.11	4	12.50	11	9.73
High school graduate	3	6.82	2	5.41	0	-	5	4.42
Some college	2	4.55	1	2.70	0	-	3	2.65
College graduate	1	2.27	0	-	0	-	1	0.89
No formal education	2	4.55	0	-	0	-	2	1.77
Vocational	1	2.27	0	-	0	-	1	0.89

*As per cent of households

APPENDIX A. Continued...

	Nueva Vista		Gandawan		Lake Duminagat		Don Victoriano Total	
	Frequency	Percent (%)	Frequency	Percent (%)	Frequency	Percent (%)	Frequency	Percent (%)
Civil Status								
Married	38	86.36	36	7.30	29	90.63	103	91.15
Separated	4	9.09	0	-	0	-	4	3.53
Widow	1	2.27	1	2.70	1	3.12	3	2.66
Single	1	2.27	0	-	2	6.25	3	2.66
Main Source of Income								
Farm	42	95.45	37	100.00	32	100.00	111	98.23
Off-Farm	12	27.27	3	8.11	6	18.75	21	18.58
Non-Farm	23	52.27	16	43.24	21	65.63	60	53.10
Mean Household Income								
Nueva Vista : 4437.33								
Gandawan : 3071.08								
Lake Duminagat : 2138.60								
Expenditures								
Mean % of income spent on food		36.86		42.86		75.58		49.01
Mean % of income spent on farm		18.52		23.62		32.34		24.83
Inputs		15.12		8.97		13.19		12.43
Other purposes								
Sources of Credit								
a. Relatives	12	27.27	7	18.92	3	9.38	22	19.47
b. Friends	2	4.55	-	-	-	-	2	1.77
c. *Barangay* officials	10	22.72	4	10.81	-	-	14	12.39
d. Neighbors	2	4.55	2	5.41	1	3.13	5	4.42
e. Others:	3	6.82	-	-	2	6.25	5	4.42
Pamorsyento sa Mansawan	2	4.55	4	10.81	1	3.13	7	6.19
Sari-Sari store (in dry goods)	-	-	-	-	1	3.13	1	0.88
Bubu system	-	-	1	2.70	-	-	1	0.88
CAFGU	1	2.27	1	2.70	-	-	2	1.77
Womens Association	1	2.27	-	-	-	-	1	0.88
Labor Association	11	25.00	18	48.65	24	75.00	53	49.90
Farm Lot "Ownership"								
a. Tax declaration	-	-	1	3.13	-	-	1	0.88
b. Usufruct	31	70.45	32	86.49	26	81.25	89	78.76
c. Inheritance	2	4.55	-	-	3	9.37	5	4.42
d. *Hulam* (borrowed)	5	11.36	3	8.10	1	3.13	9	7.96
e. *Kaugalingong Bungkag* (initiative	1	2.27	-	-	2	6.25	3	2.65
to clear forest for cultivation	5	11.36	1	3.13	-	-	6	5.31
f. Gratis (transfer of rights)								

APPENDIX A. Continued...

	Nueva Vista		**Gandawan**		**Lake Duminagat**		**Don Victoriano Total**	
	Frequency	Percent (%)	Frequency	Percent (%)	Frequency	Percent (%)	Frequency	Percent (%)
Land Holdings								
less than 1	15	34.09	13	35.14	8	25.00	36	31.86
1 – 2	11	25.00	9	24.32	16	50.00	36	31.86
3 – 7	9	20.45	8	21.62	3	9.38	20	17.70
8 – 11	4	9.09	-	-	1	3.13	5	4.42
12 and above	2	4.55	3	8.11	-	-	5	4.42
cannot quantify	3	6.81	4	10.81	4	12.50	11	9.73
Mean Size of Land Holdings								
Nueva Vista : 2.7385 ha								
Gandawan : 2.4828 ha								
Lake Duminagat: 1.3398 ha								
Respondents with Positions in								
a. LGU/*barangay*	5	11.36	12	32.43	10	31.25	27	23.89
b. Traditional organization/*barangay*	0	-	3	8.11	3	9.38	6	18.75
c. No position	39	88.64	22	59.46	19	59.38	80	70.79
Membership in POs/NGOs								
a. POs/NGOs organized by NGOs with foreign funding	16	36.36	28	75.68	20	62.50	64	56.64
b. POs/NGOs organized by NGOs without foreign funding	3	6.82	0	-	0	-	3	2.65
c. No membership with any POs/NGOs	25	56.82	9	24.32	12	37.50	46	40.71

"WILL THE TWAIN EVER MEET?": A METHODOLOGICAL DIALOGUE IN A SOUTH-NORTH PARTNERSHIP ON RESEARCH AND DEVELOPMENT[1]

Levita A. Duhaylungsod[2]

For several decades, a great deal of effort has gone into strategic approaches to South-North development cooperation. From simply having the Northern partner take the donor role and development assistance to the South, development collaborations have evolved into "partnership" relationship. Underlying this notion is the view that the S-N partnership is also a learning challenge for both partners that provides opportunities for new concepts, values, methods, and behavior. Alongside this view is the emphasis on participation and the awareness of the social context in which the development partnership is located.

One area of such partnerships is capacity enhancement on research, where Northern and Southern scientists collaborate for knowledge production and endeavor to produce researches with development agenda. This partnership dialogue is a challenging social process because the wealth of S-N partnership experiences has been mainly development projects in nature, with sprinkling of development research projects with funding support from the North. The premise of research for development is an innovation that resulted in the search for evolving science-based and interdisciplinary approaches that similarly take into account developing community-based researchers within the context of cultural and institutional complexities. This challenge comes at a time when the epistemology of science and production of knowledge have also been subjected to a critical review. Hence, together with the concept of participation, the Kuhnian phrase "paradigm shift" also became a buzzword.

Within the above context, the paper focuses on a methodological development that particularly addresses the concern for systematically assessing the capacity development efforts being promoted in a North-South research partnership. Largely drawn from a process and experiential learning from the Biodiversity Research Programme (BRP) in the Philippines, the paper proposes a methodological framework and argues that such framework can have a wider application in the field of participatory research with multi-stakeholder involvement across cultures and environment. While the case Programme involves Northern and Southern partner-participants, the scope of the paper covers mostly the experiential learnings derived from the Southern partnership.

PARTICIPATION AND MODES OF KNOWLEDGE PRODUCTION

Development paradigm in the 80s was marked by a realization that new approaches and strategies were needed in order to meet the challenges of societal processes. This led to a proliferation of strategies that were purportedly participatory and people-centered, interpreted by development organizations in a variety of ways. Eventually, "participation" was widely endorsed, notwithstanding the lack of consensus on what it means and how to achieve it. The terms 'people's participation' and 'popular participation', originally appropriated by nongovernment organizations (NGOs), became part of the language of international development agencies, government departments, and even banks (Adnan *et al.*1992). North-South development cooperation are similarly premised on this assumption, such that Northern partners are expected to be not just donors but active participants as well in the implementation of projects.

The International Institute for Environment and Development (IIED) in UK is one of the earliest proponents of participatory approaches to development. Apart from publishing discussion papers on wide areas of participatory work, it also regularly publishes *PLA Notes* that contain case studies of participatory experiences ranging from health to environment and gender development. Most of these experiences are methodologies and tools drawn from practical engagements in cross-cultural settings and a variety of field locations and programs. Largely, these documents are rich experiences of NGOs, government agencies, project donors, and community organizations, not to mention research institutions. Pretty, together with

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a number of colleagues, has been doing substantial work on the issue of participation and has, in fact, come out with a typology of participation as shown in Table 1.

Parallel to the shift in development strategies and approaches, assumptions of the conventional research paradigm of disciplinary sciences, particularly social sciences, were also challenged. Traditionally, development research was classified as action research but following the eventual ascendancy of what came to be known as critical research pioneered by the Frankfurt School, alternative paradigms (Eisner 1990, Guba 1990) were asserted and discourses in the production of knowledge through research were examined (Long and Long 1992). Social development and research have, henceforth, come a long way and have covered a wide array of concerns (Booth 1994). In particular, the area of agricultural research and development has tremendously demonstrated that research partnerships with farmers produce more substantial knowledge in agriculture sciences resulting in new agricultural professionalism (Chambers 1993, Pretty and Chambers 1993).

The convergence of development and research has been marked by interdisciplinary or multidisciplinary approaches. A people-centered approach, which utilizes participatory methods, is viewed as essential in these approaches.

However, it is commonly argued that participatory methods lack discipline and are sloppy, and thereby fail to meet the established criteria of internal validity, external validity, reliability, and objectivity. These four criteria, however, are generally used to evaluate conventional research inquiry and are dependent on the core assumptions of positivist science (Lincoln and Guba 1985, Guba and Lincoln 1989, Kirk and Miller 1986).

With the creative ingenuity of practitioners and drawing from established methods in the field of anthropology, criteria for the trustworthiness of the findings of an inquiry that make use of participatory methods have also been developed. Guba (1981) had developed trustworthiness criteria for methodological soundness - credibility, transferability, dependability, and conformability - but Lincoln (1990) had argued that these are similarly grounded on conventional positivist science and fail to capture the impact of the process of inquiry on the people involved. It is therefore necessary to come up with 'authenticity' criteria that include an appreciation of the research participants' own constructed realities and concomitant changes that they undergo in the process of inquiry. Drawing from these criticisms and other suggestions, Pretty (1994) proposed a set of 12 criteria for establishing trustworthiness of an inquiry anchored on participatory principle:

Table 1. A typology of participation: how people participate in development programmes and projects.

Typology	Characteristics of Each Type
1. Manipulative participation	Simply a pretence, with people's representatives on official boards but are not elected and have no power.
2. Passive participation	Unilateral decision by project management and people simply informed of decision. Information shared with external professionals only.
3. Participation by consultation	People participation is through answering questions. External agents control problems' definitions, information gathering, and analysis. Professionals are not obligated to take peoples' views.
4. Participation for material incentives	People contribute resources, like labor or farms, in return for food, cash or other material incentives but they have no other stake when the incentives end.
5. Functional participation	External agencies see participation as means to achieve project goals; people's groups formed to meet predetermined project objectives. May have interactive and shared decision-making but external agents make major decisions.
6. Interactive participation	Joint analysis, action plans, and formation or strengthening of groups and local institutions. Participation is viewed as right, not just means to achieve project goals. Multidisciplinary roles and perspectives through use of systemic and structured learning processes. Eventually, local groups take control.
7. Self-mobilization	People take initiatives independent of external institutions; contact with external institutions for needed resources and advice but people retain control of use of resources. Self-mobilization can happen if NGOs and government are enabling. This type may or may not challenge existing distributions of wealth and power.

Adapted from Pretty 1995

1. Prolonged and/or intense engagement between the various actors
2. Persistent and parallel observation
3. Triangulation by multiple sources, methods, and investigators
4. Analysis and expression of difference
5. Negative case analysis
6. Peer or colleague checking
7. Participant checking
8. Reports with working hypotheses, contextual descriptions, and visualizations
9. Parallel investigations and team communications
10. Reflexive journals
11. Inquiry audit
12. Impact on stakeholders' capacity to know and act

Pretty (1995) had cautioned, though, that these criteria are themselves value-bound and should be used to "identify what has been part of the process of gathering information and whether elements have been omitted". In this context, the results of an inquiry will be judged as trustworthy "because certain things happened during and after the investigation".

Innovative research projects with development and social relevance involving Southern and Northern scientists have emerged in the recent decades. Traditionally, international researches, like those undertaken by the Consultative Group on International Agriculture Research (CGIAR), International Service for National Agriculture Research (ISNAR), and Canada's International Development Centre (IDRC), among others, are conducted by working closely with national programs and governments. Some of the efforts are directed towards research capacity enhancement of national research institutions and researchers. New types of South-North research partnerships have also been experimented on, and one interesting endeavor is research programs that are more process-oriented even as they aim at production of knowledge.

THE BIODIVERSITY RESEARCH PROGRAMME (BRP): AN INNOVATIVE SOUTH-NORTH PARTNERSHIP

Propelled by international commitments in the Rio Summit of 1992, the Department of Environment and Natural Resources (DENR) in the mid-90s set up two banner programmes that dwelt on the sustainability issues of environment and natural resources (ENR) development and conservation efforts. One was on sustainable development (DENR-UNDP 1995), while the other was on biodiversity (DENR 1995). The former produced the "Operational Framework on Sustainable Development" in 1996, which proposed a system of generating indicators of sustainable development. The latter published the most comprehensive picture of the biodiversity status of the country to date, alongside a proposed action agenda, to include biodiversity research. The publication came out of press in 2000, although work started in 1995.

Towards the tail end of the 90s, the Netherlands Development Assistance Research Council (RAWOO) and the Southeast Asian Regional Center for Graduate Study and Research in Agriculture (SEARCA) embarked on a collaborative biodiversity research, which may be assumed to have taken off from the then on-going biodiversity country project. A synopsis of the biodiversity issues in the Philippines ranging from resource loss and destruction, rehabilitation to policy concerns were discussed. Significantly, a general description on the biodiversity research environment in the Philippines was noted as "mostly fragmented, uncoordinated, reactive and donor-driven, and will not be self-sustaining unless they are linked to a strategic national programme of conservation". The SEARCA-RAWOO collaboration is premised on the "principles of joint responsibility, mutual trust, sharing of experiences and expertise, and a two-way learning process" (Saguiguit *et al.* 2003).

A multi-stakeholder group of researchers, government, and non-government organizations defined four tenets of biodiversity research in the Philippines that served as the guideposts in evolving the five-year BRP in Mindanao, which commenced in July 2001(RAWOO-SEAMEO 1999). Firstly, it must be "location-derived and development-oriented", implying that the research relevance and usefulness are to be measured in terms of the response to the needs and local ecology of communities where the research is located. Researchable areas are scoped from the people's identification of problems and solutions. Secondly, it must be "promoting multi-stakeholder participation". Community representation from the local government unit, NGO, and other stakeholders should have constant interaction with the scientific research community. Moreover, effective feedback mechanisms enhance research inputs into policy, programmes, and practices on biodiversity conservation and utilization.

Thirdly, it must be "system-oriented and interdisciplinary" in order to understand comprehensively the interconnections and interactions occurring between and among the components of the biodiversity system. Natural and social scientific disciplines should converge to a common goal of establishing approaches, methods, and models of biodiversity research. Fourthly, by "using an integrated ecosystems or landscape approach" in the research, the up-scaled appreciation of the interactive elements in the spectrum of ecosystems will be systematic, with options to define integrative measures of interventions. In effect, the micro and macro influences on biodiversity conservation are placed in proper perspectives.

Research Areas

A set of priority researchable areas under the BRP is shown in Table 2. These were defined taking into account the requisite multidisciplinary or interdisciplinary approaches and methodologies. The need to rigorously conduct the research itself and the development orientation of the Programme are therefore a challenge to the researcher. This set of research concerns guided the evolution of specific research projects on site, classified as First and Second Generations.

THE PARTICIPATORY PROGRAMME MONITORING SYSTEM (PPMS)

Generally, development projects and institutions have mechanisms to check departures or consistencies in their project implementations, usually referred to as monitoring and evaluation or M&E, but used in varying contexts and projects. An external evaluation committee indicated that RAWOO's innovative research partnerships (which included the Ghana Health Research Programme [HRP]) are highly interesting experiences and thus, it recommended, among others, setting up a Joint Monitoring and Evaluation Project (JM&E). RAWOO took up this recommendation, and both its Philippine and Ghana partners agreed to jointly undertake it. In principle, the M&E of the BRP and HRP should be anchored on the principles of multi-stakeholder perspective, collective learning by doing, and the yardstick of performance is more the expectations of stakeholders than the Programme plan (JM&E Project Document). Facilitators were contracted for each of the Programme. For the BRP, designing the monitoring system phase began in October 2003, 30 months after project implementation.

Monitoring and evaluation have always been viewed as inseparable activities in any project, hence the more popular term "M&E". In the JM&E Project Document, these two sets of activities have been clearly differentiated by describing the Phase 2 work as "designing and testing of methods, tools, and indicators for Programme monitoring", and Phase 3 as "designing and testing of methods, tools, and indicators for Programme evaluation". Furthermore, the document provided the framework for the joint M&E which categorized Phase 2 as the process evaluation portion, while Phase 3 as the performance evaluation of the Programme. The delineation indicates that the two systems are to be evolved separately, however, they must be intricately related. This paper is a schema for Programme monitoring.

There is a dearth of literature on methodologies or approaches appropriate for monitoring researches with a development slant. However, the increasing experiences on a variety of participatory development processes across different cultures and environments provide rich methodological insights to develop a monitoring and evaluation scheme applicable to research and development programs like the BRP. The designing of the PPMS took off from these, as well as the JM&E Project Document, particularly its literature review.

BRP Vision, Mission, and Goals

A very important and relevant variable in setting up the participatory monitoring system of the BRP is the hierarchy of what it planned to attain within the 5-year life cycle of the Programme expressed as vision, mission, and goals (VMG). The assumption that these concerns are realistic is well articulated by the Programme (RAWOO-SEARCA 1999). The Programme is not explicit on the attainment

Table 2. Generic research areas and support needed.

Research Areas	Support Programmes
(1) Validation and standardization of methodologies for biodiversity research and conservation	Human resource development
(2) Increased knowledge of: Biology (genes, species, and ecosystem) Methods for rehabilitation and restoration Socioeconomic and cultural factors (indigenous knowledge systems, resource valuation, and gender concerns)	• Development and production of materials for informative and educational purposes • Establishment of databases and directories
(3) Policy-oriented research on: Land and resource use Stakeholder analysis Conflict resolution	Networking

timeframes, but the facilitator extracted an approximate appreciation of the correspondence, vis-à-vis the timeline of concerns as presented in Table 3.

The table implies that, in the immediate term, the PPMS could provide sufficient information to gauge the feasibility of reaching the objectives by the end of Programme life, and whether there are necessary adjustments in approaches and strategies so that goals are attained within the timeframe. However, there may be Programme changes even while the projects are implemented, but these are mainly managerial. In the long term, the PPMS documentation will be the solid basis for *post facto* evaluation of the Research Programme impacts vis-à-vis mission and vision.

Engaging Participation in the PPMS

Participation of BRP players is vital in the development of the PPMS, as outlined in the JM&E and the terms of reference of the facilitator. However, the specialist input of the facilitator-consultant proved critical in the eventual evolution of the PPMS. This is expected in any sub-contracted project similar to the current situation, more so on account of the limited literature relevant to the monitoring process of research programmes. In effect, the JM&E "prescribed" the bounds of the PPMS even if it only provided a general framework as theoretical foundation in a S-N research partnership on development. It demanded the facilitator to provide the analysis and conceptualization of the operational framework of the PPMS, and thereafter

Table 3. Hierarchy of Programme concerns.

Areas	Description and Assumed Scale	Programme Timeline
Vision and mission	The vision of the Programme is "economically and culturally prosperous communities living harmoniously in a sustainable environment where biodiversity conservation is founded on an integrative and participatory research model" and its mission is that "the BRP in Mindanao is committed to undertake and promote collaborative, participatory, and multidisciplinary research that will enable sustainable use of biological resources, and effective decision-making on biodiversity conservation, to improve livelihood and cultural opportunities". It may be implied that these claims could be attained partially in five years as planned, but a clearer picture would be known thereafter, that is if the Programme had created impact in the researchers, community, and Programme managers. In this case, the attainables are long-term.	Assumed that by the end of the Programme life, which is five years, a momentum was gained for the vision and mission to be attained thereafter.
Goals	1) To generate research results that provide fundamental understanding of biodiversity and its interaction with human systems 2) To generate and disseminate biodiversity research results and processes 3) To strengthen the capacity of both human and institutional resources for planning, conducting, and managing biodiversity research at all levels 4) To promote balanced and genuine partnership for biodiversity research among Filipino and Dutch researchers and local communities On cursory assessment, their attainment could be assumed as realizable by the end of Programme life, either in full or partial. In the minimum, the Programme mission was substantially felt by the partners through achievement of goals.	Five years
Project objectives	The objectives vary depending on the particular needs of localities where the research projects were conducted (refer to individual projects and the clusters of thematic researches).	Every closure of the First and Second Generation Researches; on the average every two years

the formulation of the PPMS Instrument. Other inputs came handy from the researchers who are recognized biodiversity scientists, but these were mostly Filipinos based in Mindanao. Ideally, Northern research partners should have been covered, but Programme pragmatics posed constraints. Overall, the participatory technique was utilized in facilitating the series of convergence of various inputs including those coming as feedbacks.

The entire process of the PPMS development was therefore an approach that combines 'prescription' and participation. Central to the process is the synthesis or crafting of the facilitator of the eventual design that served as the main input-material for a participatory process of formulation, otherwise known as feedback.

FRAMEWORKING PARTICIPATORY PROCESS MONITORING

Developing the framework took the perspective that a capability building research for development Programme such as BRP (whether this means as knowledge stocking or skills improvement of key partners) is a management function. Logically, therefore, a Participatory Programme Monitoring Scheme should be tailor-fitted from a development-oriented management cycle. In this context, the Programme Cycle Management for Sustainable Development, which was principally designed for development projects, was utilized as base material for evolving the PPMS.

Research Programme Cycle Management

Figure 1 illustrates that the Programme Cycle Management is segmented into four, namely, (1) Development Research Programme Preparation, (2) Implementation through Research Projects, and assessment for adjusting on-going projects, (3) Infobase development and management, and (4) Evaluation for impact determination.

The connections of these segments were generated, including the presumed activities under each segment of the management cycle. For example, in segment 1, the level of the thinking process is programmatic, which, understandably, is macro, such as the efforts to set the "vision, mission, and goal" of BRP. Where information is available, the discussion may be thematic as when the BRP started to cull insights and lessons from the Participatory Rapid Appraisals (PRAs) in 1998. Ideally, the process could have been monitored and documented so that framework questions like, "was the logical framework model adopted for the Programme planning?" may be answered comfortably. As it is, "recall monitoring" may have been done for this section.

The presumed activities, also shown in Figure 1, are the assumed points of the monitoring function. These need to be cross-checked with activity outputs apart from knowing the process that went into reaching the outputs. Even as every segment will require some kind of monitoring, the main focus of the PPMS is the monitoring function associated with the continuum of project activities. This includes, (a) actual research conduct, (b) assessment of approach, method, and sometimes instrument, (c) adjustment of processes as called for, and (d) project termination (segment 2). The expected iteration in this segment epitomizes the innovation in managing Research Programmes, specifically outlining the purposive adjustment of processes in the on-going implementation to ensure that Project objectives are attained, subsequently ascertaining that Programme goals are addressed. The timely delivery of documentation from the monitoring activity remains the most crucial in this management segment.

The conscientiously documented processes, effects, and outcomes of projects, which must be stored and managed in an infobase (segment 3), provide adequate material for evaluating whether the Programme goals are satisfied. At the point where reflection is on policy formulation or reform, institutional development, and methodological modification, it maybe said that the impacts of the Research Programme are unearthed (segment 4). To say the least, the monitoring activity must still be very active on this part of the cycle. Thereafter, the management cycle continues, although it is dependent on many realities like readiness of partners to pursue, funding, and priorities.

Parameters and Indicators

The parameters of success were interpreted from the statement that the "main aim of the North-South research partnerships is to help solve development problems through knowledge development and capacity enhancement". Knowledge development and capacity enhancement, by their nature, are processes, although, these may be considered as outcomes (success parameters) of research approaches oriented at finding solutions to problems created from the continuing interplay of society, environment, and development. In other literature, these success parameters are broadly lumped as knowledge management and skills development resulting from a capability building-focused Programme, such as the BRP. From this set of parameters, the process indicators for participatory monitoring could then be evolved for each of the parameter. It is possible that a

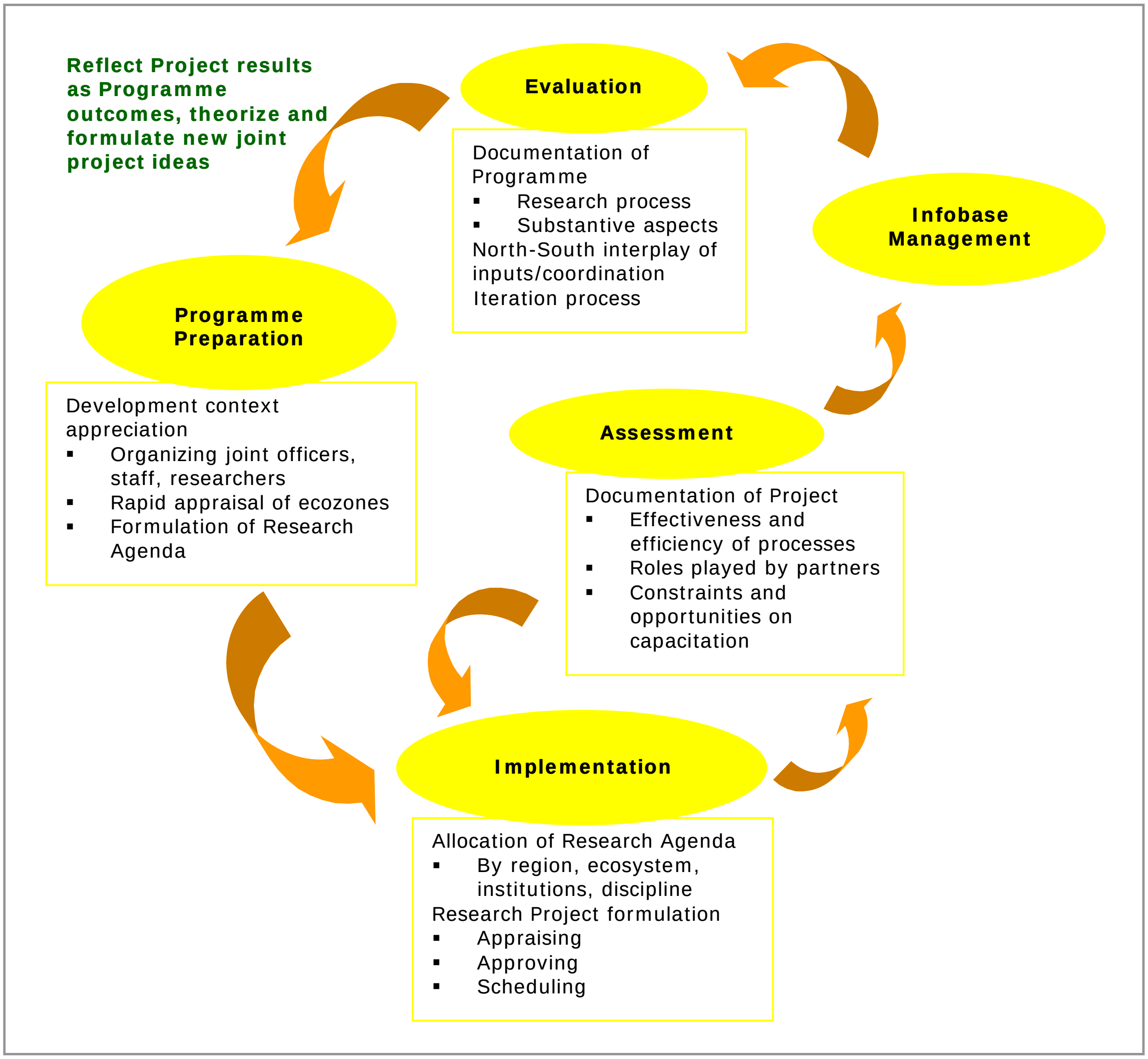

Figure 1. Major activities cum monitoring in the Programme cycle management stages.

parameter will have more than one indicator, that is, if a parameter requires sub-steps for its attainment.

Conceptually, the hierarchical logic of the monitoring system has been cascaded as follows, although, primarily focused on the monitoring of the Programme process:

PROGRAMME VISION >> MISSION >> GOALS >> PARAMETERS >> (OBJECTIVES) >> PROCESS INDICATORS

Another way of looking at this hierarchy is that when the parameters are indicated, the objectives are assumed to "carry" the goals of the Programme. The indicators are project-level, thus, what will be monitored are project processes leading to the attainment of the objectives, and in effect, goals in a long-term view.

To assess the soundness of the PPMS Framework, the system was examined on the basis of the following criteria, in decreasing order of importance: (1) relevance to the BRP in terms of its contribution to attain the goals; (2) hierarchical logic of ideas; (3) workability-flexibility under varying conditions of biodiversity; (4) iterability or its openness to modification.

Feedback on PPMS Framework

The PPMS Framework was subjected to a Round Table Discussion (RTD) with the researchers, Programme officers, and staff. To ensure efficiency of the RTDs, prospective RTD participants were provided with copies of the Framework well ahead of schedule. Three successive RTD sessions were conducted for Programme participants from Central Mindanao, Northern Mindanao, and Southern Mindanao university campuses.

After sieving through the proceedings, the facilitator incorporated the agreed modifications on the manuscript to produce the draft final document.

Instrumentation and User Handbook

PPMS Forms were subsequently drawn from the RTD-endorsed conceptual framework. This phase required substantial time for analytical thinking and juxtaposing with exposures to similar cases and expert stock knowledge, bearing in mind the need to strike a balance between quantifying the monitoring of the Programme process and capturing the nuances of the process.

The cascading nature of the PPMS forms creates a three-dimensional perspective as shown in Figure 2, that is, at the x-plane is the individual descriptors of the parameters-indicators-effectiveness, at the y-plane is the succession of parameters, indicators and effectiveness, and at the z-plane is the frequency of occurrence and the quality of the occurrence. The explanation on the observation further pictures the quality of the answers.

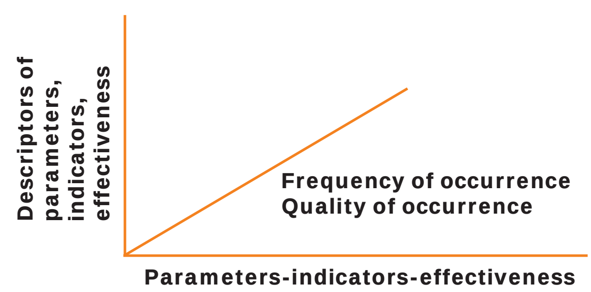

Figure 2. Three-dimensional perspective of the cascading nature of the PPMS forms.

A complex portion in the development of the instrument is the translation of the parameters of success and process indicators into a setup that objectively elicits possible answers from users-respondents on simple and understandable Programme situations and concepts. The concern is whether the situations or concepts have universal meaning regardless of whoever uses the Form. Guided by the immediate aim that the monitoring system must probe the research Programme process, the process indicators should be measured at varying levels of effectiveness even as efficiency may have to be taken from a collective measurement of effectiveness, specifically referring to the frequency of answers. The meticulous application of indices (measures of the process indicators) reflects the magnitude of the attempt to measure the levels of effectiveness of the process.

To complete the task, a step-wise procedure was given as instruction on the most practicable and scientific use of the PPMS Form. Some simulation exercises were conducted by the facilitator to detect weak spots and the usability of the proposed PPMS Instrument.

Following the process of the previous RTDs, the PPMS Instrument was thoroughly scrutinized for theoretical soundness, relevance, and workability by the researchers, officers, and staff of the BRP. For greater effectiveness, copies of the instrument were distributed at least a week before the actual conduct of the series of RTDs. The draft final document in the form of a User's Handbook, containing both background and framework, was again subjected to a series of RTDs.

In summary, the entire PPMS development process maybe viewed as a research inquiry that engaged a grounded theorizing and methodological approach. In this sense, participants, including the facilitator, arrived at a joint learning and produced a collective form of innovative contribution in the monitoring of research programme process. The User Handbook itself captures the process. Table 4, which was lifted from the Handbook, illustrates a sample output of this particular kind of inquiry.

PROSPECTS

Systematic and thorough monitoring of capacity development programs has been a relatively new agenda in development partnership. The case experience of developing a programme-dedicated monitoring system of the BRP offers a process prototype that has potential for wider application, despite the lack of Northern partners in the PPMS designing process. It should be noted, however, that the general takeoff of the PPMS (i.e., the JM&E Project Document) was largely a Northern input. Specifically, the manner by which the PPMS was evolved illustrates how a monitoring instrument could be tailored to programme goals. It could be particularly useful for researchers in search of methods and instruments. The meticulous indexing of the process indicators and the latitude of qualitative and quantitative measures may be further explored. In its novelty, the requisite further testing and application is deemed in order but it is argued that the methodology and framework may serve as alternative to conventional modes of programme monitoring that is generally donor-driven.

At another level, the PPMS is illustrative of the possibility of institutionalizing approaches and structures that encourage learning even as a program may have defined goals to achieve. The series of leveling off and interactive involvement of people within the entire process of the PPMS maybe tedious, but within the context of emerging new types of S-N or multi-stakeholder partnerships that asserts participatory philosophy, the experience demonstrates a possible translation of the rhetorics of participation.

Table 4. Monitoring form for Programme goal 1: To generate research results that provide fundamental understanding of biodiversity and its interactions with human systems.

Parameters of Success	Process Indicators	Extent of Effectiveness	Observation[1] (0-4) F*	Q*	Explanation on the Observations
Knowledge development: deepened understanding on society-environment-development (SED) nexus	Participation: ensuring participation of partners in the analysis of the connectivities and interactions	Researchers actively participate in the analysis			
		Local Researchers[2] actively participate in the analysis			
		Community actively participate in the analysis			
		LGU actively participate in the analysis			
	Capacity building: using clear analytical methods and tools	Write ups of methods and tools are being distributed to all partners			
		Methods and tools are thoroughly and collectively discussed with Local Researchers			
		Capacity building trainings on methods and tools for Local Researchers are conducted			
	Interdisciplinary: integrating social and biophysical disciplines	Both social and biophysical ideas are being encouraged			
		Social and biophysical ideas complement			
		Social and biophysical sciences contribute to a universal SED framework			

*F = frequency Q = quality
[1] Options for frequency 0 = not applicable; 1 = never; 2 = seldom (sometimes); 3 = often (most of the time); 4 = always (all the time)
Options for quality 0 = not applicable; 1 = poor; 2 = fair; 3 = good; 4 = excellent
[2] Local Researchers are residents of the community who are partners of researchers from institutions like the university

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LANDSCAPING AND LOCATING IDENTITY IN THE MT. MALINDANG "DIASPORA"[1]

Alita T. Roxas[2] and Levita A. Duhaylungsod[3]

The paper examines the Subanen communities in the Mt. Malindang environs in the province of Misamis Occidental as they have been historically establishing their ancestral domain. It is argued that ethnicity, as basis of identity, cannot be understood in isolation from concrete historical and ecological processes. Drawing on an on-going research on resource utilization and biodiversity, it focuses on the landscaping of four Subanen communities, taking into account their dynamic interaction with migrant settlers. Patterns of in-migration, nature of inter-ethnic relations, and the socioeconomic processes are described in the context of how these have implications to the creation of their landscape and identity claim or assertion.

ETHNICITY AND THE MT. MALINDANG RANGE

Ethnic-cultural issues have remained latent and unresolved in contemporary times. Particularly in the context of the cultural diversity and the inter-ethnic dynamic in Mindanao, ethnicity has become an ambiguous basis of identity. Early anthropological approaches view ethnies as something given and permanent. Language, religion, tribe, territoriality, and social organization are commonly used as distinguishing elements of an ethnie or ethnic group. These are, in fact, the very same stipulations in the Indigenous Peoples' Rights Act (IPRA). However, in the reality of the Mindanao diaspora, such distinctions are not heuristic, if not nebulous. Historically, ethnicity in Mindanao has been in constant flux.

Nothwithstanding what seems to be the fluidity of the concept of ethnicity and identity, the question of resource sovereignty is undeniably a fundamental basis of cultural distinction. Indigenous peoples have acquired such distinction in the global political order of the '90s largely because of their historical claim to their homelands and experiences of marginalization and territorial disenfranchisement. The location and nature of the resource itself condition the appropriation or claim of particular local or regional groups. The Mt. Malindang Range is one of the early regions that served as crossroads of resource invasion.

During the period of Spanish rule, there was a persistent drift of Bisayan in-migrants to the northern coasts of Mindanao, including Misamis Occidental, largely prompted by a search for better farming opportunities. Some historical accounts indicated that in 1903, half of the Bisayan-speaking settlers in Mindanao live in the northern provinces, and around 70,000 have arrived in Misamis via Dapitan around 1900 (Noorduyn *et al.* 2002). Similarly, the arrival of the first Muslims in the region forced the Subanens to retreat into the hinterlands. As early as this historical period, therefore, the Subanens had already been victims of incursions into their traditional homelands. As Christie (1909, pp. 12-13) wrote, "As the Christian Filipinos hem in the Subanuns from the sea on the north, north-east and south-west, so a line of Mohameddan villages borders the sea on practically all the south coast of the Subanun country and part of the west".

The US colonial administration initiated 'pioneer settlement' in the entire island of Mindanao (Pelzer 1945). The immediate post-war period of the 1950s witnessed a massive exodus of both Bisayans and Ilocanos across Mindanao, following the post-colonial government's transmigration programs. As a consequence, the Subanen were further forced to move to the interior as Bisayans from Bohol, Negros, and Siquijor and a sprinkling of Luzon migrants progressively dominated the coastal and lowland areas of Zamboanga Peninsula. The Subanen had been reported to yield land they used to till to the migrant settlers. As in the ancestral domains of other indigenous peoples in Mindanao, lands being cultivated or left to fallow were exchanged for what the Subanen had in scarce quantities - salt, kerosene, cigars, etc. Logging concessions further exacerbated the loss of ancestral lands of the Subanen.

[1] Abridged version of the paper presented to the Philippine Studies Association, 17-19 September 2004, Baguio City
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CLOSING THE FRONTIER AND THE MT. MALINDANG NATIONAL PARK

In 1971, Republic Act (RA) 6266 declared 53,262 hectares (ha) of the Mt. Malindang Range a national park and watershed reservation, of which 45,000 ha was still forested, the rest already opened and cultivated. It has several craters, the biggest of which is an 8-ha crater lake at Barangay Lake Duminagat. The lake has been an outstanding attraction and is believed to be sacred, particularly to the Subanen. The park was one of the original components of the National Integrated Protected Area System (NIPAS), declared under RA 7586 of 1992. Pursuant to the law on the NIPAS, the Mt. Malindang Range was declared a protected area (PA) and its peripheral areas as a buffer zone, and was, thereafter, known as the Mt. Malindang Range Natural Park (Presidential Proclamation 228, 2 August 2002) (NIPAP-DENR 2000). This had reduced the size of the core protected area to 34,694 ha, and the remaining area had been re-designated as buffer zone.

Protected areas are established to protect biodiversity. Mt. Malindang became a full-pledged protected area with the very recent approval of the Mt. Malindang Range Natural Park Act of 2004 (RA 9304, approved 30 July 2004). Eighty percent of the PA's population are Subanens or with Subanen lineage, but the proportion of in-migrant settlers is still increasing. Such is the current landscape of the ethnic dynamics in the remaining forest resource in the Mt. Malindang Range, as seen in the three upland *barangays* in the Municipality of Don Victoriano (more popularly called Don Vic) and a *barangay* in Oroquieta City within this region.

THE SUBANEN COMMUNITIES AND HISTORY

The 1990 population of Misamis Occidental was 424,365, of which 60,224 were Subanen. The coastal and lowland areas were dominated by migrant Bisaya, and further inland, in the foothills and mountains, Subanen communities were to found. The name Subanen (also known as Subanun, Subanon, Subanu, or Suban'on) means "river dwellers". This comes from the root word *suba*, which means "river" to both the Bisaya, as well as to Muslims in Sulu. "-Nen" or "-nun" is an adjective suffix indicating origin. The Subanens were given their name by the Moros and the early Christian missionaries. The Subanens considered themselves as *Tau bukid* or "people of the hills". Early researchers on the Subanens pointed to their well-developed swidden agriculture, alternatively called shifting cultivation (Christie 1909, Finley and Churchill 1913, Frake 1957), where they select a forest land, clear it, plant crops on it, and after two harvests, abandon it in favor of another forest land. The Subanens, however, were frequently seen using the rivers to go from place to place, and this may have created an image of them as river dwellers. Their perception of themselves as *Tau bukid* apparently remains, as some key informants well into their '60s said that their children prohibit them from speaking and acting like they came from the hills ("*ayaw pag-binukid*"). Historical accounts, however, point to the Subanens as dominantly occupying the coastal and lowland areas of the Peninsula during the Spanish time and the American colonial rule. They were forced to move to the hinterlands to avoid the marauding activities of some Moros, and eventually, the Bisaya from across different provinces in the Visayan region. As settler in-migration progressed, they were pushed further into the mountains, maintaining their traditional swidden cultivation system.

From scant and oral history accounts, the four *barangays* - Lake Duminagat, Gandawan, Mansawan, and Mialen - are originally Subanen communities. Of the four Subanen *barangays*, Mialen is the closest to the relatively more urban Oroquieta City. The migrant Bisayan culture appears to have crept into that of the Subanen, even as the Subanen dominated the area. The lake was initially referred to as *danao,* or *tubig sa tiwala sa kagulangan* (water in the midst of the forest), but the Bisaya equivalent was said to be *duminagat*, which, accordingly, was how the early Bisaya loggers originating from the lowlands would call the lake. Eventually, the community was referred to as Lake Duminagat.

The migrating Subanens, like other indigenous peoples in the Philippines, are traditionally swidden cultivators. They take into account several factors when they identify specific settlement sites in the park region. These include the suitability of the land for farming, the availability of nearby sources of water, trees and even herbs to cure ailments, as well as accessible sites for hunting and fishing. As spirits are believed to be guardians of nature, *pamuhat* or *kano* (rituals) are performed to call on these spirits for guidance in determining the sufficiently endowed site. These spirits are also believed to have found their abode among trees, mountains, lakes, and rivers. It is customary, therefore, to perform rituals, such as the *pailis* and *diwata,* before cutting big trees, before commencing *kaingin* and the farming cycle, and even before fishing and hunting. The rituals seek permission for resource use and supplications for a bountiful yield. Likewise, these are performed for thanksgiving. These rituals are previously often accompanied by lavish offerings (*paghalad*) consisting of boiled rice, unsalted and half-cooked pork or chicken meat, eggs, local bottled wine, and some cigars. Performance of rituals are led by a spirit medium known locally as *baylan* or *suruhano*, who could either be a male or female. The *baylan* or *suruhano* is placed in high esteem by the Subanens as he/she is believed to be capable of visiting the spirit world and contacting the spirits and deities to intercede for favors being asked. He or she is therefore seen as possessing the wisdom and the character that befits the role. To facilitate planting and harvesting crops, *hunglos*, a form of labor exchange, is practiced among the Subanens.

LOGGING AND THE INTENSIFICATION OF CROSS-CULTURAL EXCHANGES

The Subanen communities inhabit logged-over areas that had been converted into agricultural lands and settlements. Around the lake where the forest was thickest, timber poaching started in the 1950s. The Bisayan migrants, who were more entrepreneurial than the Subanen, initiated timber trading. Eventually, logging concessions within the Lake Duminagat area was granted in the late 1950s. Subsequent timber licensing agreements (TLAs) were approved for Gandawan and Mansawan in the early '60s. The logging companies hired some Subanens, together with the Bisaya, for their labor requirement.

The logging operations necessitated the opening of pilot roads to allow the transport of equipment and the hauling of logs. These called for the massive clearing of primary forests that paved the way for migrants from neighboring towns and provinces. Subanen in-migration substantially increased in the '60s. The income earned from employment in logging companies was supplemented by the planting of root crops such as *kamote* and *kanaka*. These served mainly as subsistence crops. As rice did not grow well in Don Victoriano, this had to be purchased from the cash income earned. The Subanens had been reported to have preference for rice over corn as staple food. Some enterprising women narrated picking leftovers of palay harvest in nearby Molave, Zamboanga del Norte to ensure that rice could be served, even if only occasionally, during meals. Extraction of non-timber forest products for cash and harvesting of forest-based resources supported their subsistence requirements.

Additional TLAs were granted in 1973, resulting in the employment of more Subanens and Bisaya in logging companies, which ultimately led to more settlers around the park and more deforestation. This took place despite a legislated prohibition, embodied in RA 6266 that was approved on 19 June 1971. TLAs in the park were cancelled in 1982, but the logging companies were given a year to wind up their operations and to haul down previously cut trees.

Meanwhile, the communities begun planting cash crops in the Don Vic sites in the late 1970s. The relatively small population of settlers then, and the absence of information about RA 6266, made the practice of *kaingin* widespread. Farm lots then were fertile, and inorganic fertilizers were unheard of. The cash crops were mainly vegetables of the temperate variety, such as cabbage, carrots, Chinese pechay, and bell pepper. These vegetables were introduced by the Bisaya in the lower elevation areas and were found by Subanen settlers in the park, through their relatives in the lowlands, to suit the cool Malindang climate. These were also found to command a high price in the market. The planting of these high value crops changed the Don Vic landscape. The *uma* was slowly replaced by gardens. Production processes, previously foreign to the Subanen, took place. New relations of production, and even the value attached to land, changed. RA 6266 could be said to have hastened the process.

The employees lost cash income with the closure of the logging companies. Such was replaced by further cash cropping, which meant additional garden plots, and inevitably, additional forest clearings. Spring onions started to be planted as well, and this provided good income, enabling the Subanens to repair their houses, using wood from the forest (*linaksi* or manually cut into slabs) for the floors and walls, and to replace the nipa or cogon roofing with galvanized iron sheets. Since the demand for timber did not wane, illegal timber poaching became rampant. Taking their cue from the loggers, the Subanens began selling their forest resources. While further encroachments into the forest have been banned, its enforceability had been constrained by the lack of logistics and manpower. The few (numbering only 19), ill equipped, and underpaid forest guards could not effectively police 65 *barangays* in the vicinity of the park.

A number of Subanens who previously worked in the logging companies chose to move to the lowlands to seek other forms of employment. Lacking the requisites for employment in the urban sector, they ended up as hired labor in some small establishments. The low pay forced them to go back to the park to cultivate their own gardens. Women who tried their luck in the nearby cities and municipalities became sales ladies and domestic helpers. Some of those who were married to non-Subanen lowlanders returned to the Park with their spouses to also plant high-value crops.

It was also during this period that the peace and order situation in the lowlands became critical. Skirmishes between the military and rebels, identified by key informants as members of the New People's Army or NPA, had triggered evacuations - which eventually became additional in-migration - of Subanens or Subanen-mixed, also referred to as *libog* (children of intermarriages) to the park.

CONTINUITIES AND TRANSFORMATIONS

Don Vic from, the 1990s to the present, is characterized by the intensification of agricultural production that radically resulted in changes in the production system and social structure and relationships, particularly among the Subanen. Reciprocity between and among Subanen and Bisaya still persists, as evidenced by the continued practice of sharing of seedlings and onion bulbs for cash cropping. However, what used to be distinctly Subanen communities were replaced by an ethnic mix of population. It was only in Barangays Lake Duminagat and Mansawan that a Subanen cultural identity is still distinguishable. The relatively high density of households in Nueva Vista was one reason why new migrants preferred Gandawan to the more accessible Mansawan; the other reason was the relative abundance of cultivable lands in Gandawan. The difficulty in accessing Barangay Lake Duminagat, as well as its cooler weather and stronger winds, made it a poor choice for settlement to new in-migrants.

The population growth had resulted in the decrease of traditional size of cultivated lands, from 4-6 ha to the current average of 2 ha per household, further constrained by the legislations pertaining to the Mt. Malindang Range Natural Park. Majority, though, had less land to till. Lands in the park are state-appropriated. Lands cultivated by households are therefore usufruct. To the Subanen, however, the lands are *inangkon*, i.e., "inherited" from parents who were early settlers in the area. Male and female offsprings have a right to "inherited" land. Families who have settled earlier in the Mt. Malindang Park have larger usufruct lands.

Swidden farming had been replaced with sedentary and monocrop farming system, and the Subanens had begun to treat land as individual property, as they could no longer open new frontiers. This outlook is also being strengthened by the NIPAS Act, which stipulates that those who have been using the land five years prior to its approval shall be regarded as tenured migrants. Local *compradors* and loans operations, previously alien to the Subanen culture, prop the current agriculture production system.

The *pamuhat* or rituals are seldom resorted to, nowadays. Rare performances skip the previous practice of offering sacrifices (*paghalad*), or tone this down due to the increasing difficulty of accessing these offerings. There were a few who reported using inorganic fertilizers and pesticides and yet perform rituals, saying that nothing would be lost in combining the modern ways with the traditional. This, they said, would ensure a good harvest, as they believed that success of crop production could not be attributed solely to the soil or the absence of pests. The spirits were still believed to take care of unforeseen factors. Others fear retribution if the *pamuhat* was completely set aside. The once functional and meaningful cooperative system, *hunglos,* was perceived now to be impractical, as compared to getting hired labor when necessary. They attributed the impracticality of the *hunglos* to the unpredictability of the weather and not necessarily to the changed production system.

In the mid-'90s, there emerged in Mansawan a Bisaya-based religious group called *Piniling Nasud*, which recruited more Bisaya to Gandawan and Mansawan, enticing them with abundant and fertile land in the area. Rock Christ, another religious group scattered across Zamboanga del Norte, similarly engaged in recruitment of more migrants into the area. Local Subanen were also drawn into these groups. Subanen who had been brought to these sects had, therefore, shifted to a monotheistic religious belief that contrasts with their traditional beliefs in several deities. There was also the practice of folk Catholicism or the combining of prayers and rituals, as is being done by members of the *Katolikano*, another religious group coined from "Catholic" and *kano,* which means ritual.

Cebuano had replaced Subanen as the lingua franca. Even the Subanens in Barangay Lake Duminagat, who understood but did not speak Cebuano in the past, had also shifted their lingua franca to Cebuano. The use of Subanen language today is generally confined to the *baylan* during the *pamuhat*. It is not uncommon now for the third generation members of Don Vic communities to ask their parents not to speak Subanen, especially in the presence of Bisaya. This is not out of respect for the Bisaya, however, but out of the apparent lack of cultural identification with Subanen dialect, *"ulaw mag-istorya'g binukid"* (It is shameful to speak using the dialect of the mountains).

Wearing of the Subanen traditional attire had been confined to the holding of the *pamuhat*, and only by the *baylan*. It had become a "costume" in the sense that it is worn only during festivities, for the purpose of dancing. A claimant of the Certificate of Ancestral Domain Claim from Mialen even referred to the Subanen traditional attire as their "uniform" when they attend CADC meetings or Subanen gatherings, adding that, "*Maayo mi tan-awon ana sa litrato"* (It is good to see us in that attire in pictures). Clothes are now commonly *ukay-ukay* or used clothing from abroad, which are sold in the Mansawan *tabo-an* and in the streets of Oroquieta. The *ukay-ukay* clothing, with its affordable cost, somehow reduces the discomfort associated with keeping the Don Vic settlers warm. It is quite a sight to see Subanens wearing the *Amerikana* or western coat, as well as winter apparel during the cooler or rainy days.

Despite the apparent weakening of the Subanen tradition, there persists a determined effort to claim their ancestral domain. The Subanens in Mialen had filed for a CADC with the DENR in 1998. The Subanens from Don Vic had filed a similar claim with the NCIP. As in many indigenous communities who have parallel experiences with the Subanen, contemporary claims on territory are made through their claims of ancestry (Resurreccion 1998).

CONCLUSION

Territoriality, as a focal basis for establishing and maintaining cultural identity, and from which resources for physical survival are drawn, has been historically tenuous for the Subanen of Mt. Malindang. Their land-based aspirations have been continuously linked with confrontations with invaders to their traditional homelands, including the State. While there is recognition of their ancestral domain surrounding and within the state-declared national park, they remain in a marginalized position vis-à-vis their resources. Even within the more interior Subanen communities, the state declaration of Malindang as a national park has rendered their hold on their lands precarious, given the defined prohibitions and guidelines. As a consequence, their indigeneity and cultural identity as Subanen that presumably should have distinctively separated them from the other ethnies that settled in their traditional homelands, have been progressively weakened. Cultural differences and the sense of cultural distinctiveness appear to be eroding fast, especially amidst current realities where new forms of threats to their culture are continuously emerging.

Given the contemporary context of the Subanen communities described in this paper, the enshrinement of indigeneity and all the identity symbols and culture markers through the IPRA is, in all likelihood, resting on an “alleged community of culture” when put against its operationalization. The on-going cultural “reawakenings” or “revivals” of indigenous communities and the claims of identity and assertion of indigenous peoples like the Subanen, in effect, may be taken as vindication for the historic years of disenfranchisement and deprivation of control of their traditional homelands.

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GOVERNMENT POLICY AND LOCAL PARTICIPATION: MANAGING MT. MALINDANG NATURAL PARK, PHILIPPINES[1]

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This paper presents results of a policy research conducted in Mt. Malindang Range Natural Park (MMRNP) in the island of Mindanao, southern Philippines. MMRNP is one of the priority protected areas under the National Integrated Protected Area System (NIPAS), which was set up by legislation in 1992. Research results indicated that while local participation in management of the protected area was one of the main objectives of the NIPAS Act, the major indigenous populace presently inhabiting the surroundings of the park generally lacked awareness of its status as a protected area. Furthermore, while the community generally acknowledged the value of not cutting trees for environmental protection against soil erosion, landslides, and flooding, timber poaching continues due to lack of alternative livelihood. Based on the results of this study, a number of recommendations are presented. First is a review of the existing policy with regard to the roles of various stakeholders of the park: the multi-sectoral Protected Area Management Board (PAMB) as a policy-making body, the local community as a major partner in park protection, and the Department of Environment and Natural Resources (DENR) as the government agency mainly responsible for the management of the protected area. Second, there should be effective information, education, and communication (IEC) regarding the protected area and the importance of local participation in its management. Finally, it is strongly recommended that alternative livelihood opportunities for the communities dependent on the park be considered in the implementation of policies aimed at conserving biodiversity.

INTRODUCTION

Government Policy on Environmental Conservation

The country has a long history of environment-related legislations and is very rich in laws intended to protect, conserve, and manage natural resources. The first legislation on biodiversity conservation in the country is the Protection of Game and Fish Act in 1916. The first significant law governing protected areas is Republic Act (RA) 3915 of 1932. This legislation also provided for the establishment of national parks (Bugna and Blastique 2001).

The existing environment-related laws range from very broad to very specific. The broadest legislations are embodied in the Philippine Constitution, which provides the legal framework upon which all laws should be formulated. For example, Section 16, Article II declares that “the State shall protect and advance the right of the people to a balanced and healthful ecology in accord with the rhythm and harmony of nature”. Section 2, Article XII further states that “all lands of the public domain…and other natural resources …shall be under the full control and supervision of the State…” (Philippine Constitution 1987).

RA 7160, also known as the Local Government Code of 1991, is relatively specific as it defines the functions of the various local government units in environmental protection. For example, the code states that the duties of the *Sangguniang Bayan* (the legislative body of the municipality), include, among others, the protection of the environment and imposition of appropriate penalties for acts which endanger the environment, such as…illegal logging and smuggling of logs, smuggling of natural resources products and endangered species of flora and fauna, slash and burn farming… (Sec. 447, par. 1[vi]). This is complementary with Sec. 2, Art. XII of the Philippine Constitution, which is a general statement of the role of the State in the management of the country’s natural environment.

Establishment of protected areas in the Philippines is mainly intended to conserve biological diversity. In a natural park, extractive resource use is not allowed. Thus, the livelihood of those who mainly depend on the park can be seriously affected.

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The National Integrated Protected Area System (NIPAS) Act

The Philippines is one country in the world where relatively stronger co-management models of protected areas are found (Borrini-Feyerabend *et al.* 2004). An important indicator of protected area co-management in the country is the NIPAS Act, which was passed into law in 1 June 1992. It is a result of the concerted effort of the Philippine Department of Environment and Natural Resources (DENR), nongovernment organizations (NGOs), the World Bank, and the Philippine Congress. The passage of the NIPAS Act was a response to the growing demand from the public for laws that address the issues of biological diversity conservation, protected area management, and sustainable development (PAWB-DENR 1992).

The NIPAS Act provides for the establishment and management of protected areas as a key strategy for *in situ* conservation of the country's rich biodiversity. The Act primarily aims to ensure the conservation of the country's biological diversity and stipulates that the "use and enjoyment of protected areas" should be in accordance with this overall goal. At the same time, it is an extraordinary legislation because it recognizes local participation as an important component of biodiversity conservation, at a time when it was not the prevailing practice. Traditionally, the dominant approach in conventional protected area management considered people and nature as separate entities, where human concerns are incompatible with conservation (Borrini-Feyerabend *et al.* 2004).

The NIPAS Act prescribes 13 steps in the establishment of protected areas in the Philippines. These steps are: (1) compilation of maps and technical descriptions; (2) initial screening or protected area suitability assessment; (3) public notification to inform the various stakeholders about relevant documents pertaining to the NIPAS Act; (4) conduct initial consultations on such issues as the role of the Protected Area Management Board (PAMB) and the relationship of biodiversity conservation and livelihood in protected areas; (5) conduct census and registration of protected area occupants; (6) resource profiling of the biophysical features of the area; (7) preparation of the initial protected area plan; (8) conduct public hearings to further inform the various stakeholders and solicit their views about the inclusion of the area in the NIPAS; (9) conduct of regional review and recommendation about boundary modifications; (10) conduct of national review and recommendation; (11) issuance of presidential proclamation designating the protected area; (12) passage of a congressional action; and (13) demarcation of protected area boundaries.

The active participation of the various stakeholders of a protected area should not stop in the accomplishment of the above steps. A more active participation is required in actual protected area management, which also necessarily requires a certain degree of flexibility. This is addressed by the NIPAS Act through its provision on zoning, not only of the protected areas, but also of its buffer zone. This zoning is supposed to take into account biodiversity conservation in the light of the rights of local communities to their traditional source of livelihood. This will then make it possible for the local communities (including indigenous cultural communities or ICCs) to be part of the decision-making process on the best possible means of managing the forests, from where they have been mostly dependent for their livelihood.

Mt. Malindang Natural Park

The Mt. Malindang Range is situated in the province of Misamis Occidental and is the central feature of the eastern part of the Zamboanga peninsula, in the island of Mindanao, southern Philippines. Mt. Malindang was declared a national park and watershed area by virtue of RA 6266, which was approved on 19 June 1971. About 45,000 hectares (ha) of the total land area (53,262 ha) are covered with forest, while the remaining portions are already being cultivated. At the time of the passage of RA 6266, the government had already granted 25-year timber license agreements (TLAs) to three commercial logging companies. These companies operated in various parts of the Mt. Malindang Range from the early 1960's until the TLAs were cancelled in the early 1980s.

The park includes 65 barangays in 16 municipalities, but the watershed feeds about a million people in 31 municipalities from three provinces. An estimated 18,000 people inhabit the buffer zone, and about 900 inhabitants in limited portions of the core area. The people inhabiting the close vicinity of the park are mainly of the Suban'n Subanen tribe, whose livelihood largely depends on subsistence farming (DENR-EU 2000).

In accordance with Sec 5, par.(a) of the NIPAS Act, Mt. Malindang became an original component of the NIPAS. As part of the procedures stipulated in the NIPAS Act, the boundaries of the park were re-surveyed and revised. The revisions were made official with the passage of Proclamation 228 on 2 August 2002, declaring the mountain range as a natural park. Henceforth, the mountain range has been referred to as the Mt. Malindang Range Natural Park (MMRNP). RA 9304, which was passed on 30 July 2004, is the legislation that declares Mt. Malindang as a full-fledged natural park. The core protection zone of the park covers 34,964 ha, while the remaining portion of the original area has been re-designated as buffer zone. No human activity is allowed within the core protection zone, while limited non-extractive human activities are allowed in the buffer zone.

A strict protection zone consists of "areas with high biodiversity value which shall be closed to all human activity, except for scientific studies and/or ceremonial or religious use by indigenous communities" [par (a), Sec 10, DAO 25, S. 1992]. On the other hand, buffer zones are identified as "areas outside the boundaries of and immediately adjacent to designated protected areas, pursuant to Section 8 [of NIPAS] that need special development control in order to avoid or minimize harm to the protected area" [par (c), Sec 4, RA 7586].

The management of the park is administered by a multi-sectoral Protected Area Management Board (PAMB). Currently, the PAMB membership is composed of 16 municipal mayors, 65 *barangay* captains, five representatives of indigenous communities, representatives from government agencies at the regional and provincial levels, and representatives from nongovernment organizations (NGOs) who are working in the Mt. Malindang area.

METHODOLOGY

The data used for this paper were obtained from respondents and key informants in six *barangays*: four terrestrial and two riverine. The four terrestrial *barangays* were Barangays Lake Duminagat, Gandawan, and Nueva Vista (in the Municipality of Don Victoriano), and Peniel (in the Municipality of Lopez Jaena). The two riverine *barangays* were Barangays Mamalad (in the Municipality of Calamba) and Mialen (part of Oroquieta City). Only Barangay Lake Duminagat is within the protected area; the other *barangays* are within the buffer zone.

Data on environmental policy assessment were obtained from a combination of simple random, multi-stage simple random, and stratified random sampling survey techniques, key informant interviews, focus group discussions, and direct observations. Additional information on policy enforcement and issues were gathered from interviews with key personnel of NGOs and implementing agencies. Attendance to PAMB meetings and some activities organized by the PAMB were also done to enrich data analysis. Key informant interviews were also conducted with those involved in policy implementation, including the Governor of Misamis Occidental, the Provincial Environment and Natural Resource Officer (PENRO), the Protected Area Superintendent (PASu), and forest guards.

RESULTS

The passage of the Mt. Malindang Range Natural Park Act is the second to the last of the 13 steps prescribed by the NIPAS Act in the establishment of a protected area. As such, it can be inferred that the affected communities should have been well-informed of and actively involved in the establishment of park. The PAMB membership also indicates a certain degree of awareness among local communities about the park, as well as participation in its management. However, results of this study indicated that local awareness and participation are not as impressive as they seem.

Awareness of the Protected Area and the NIPAS Act

For the communities included in the study, the most commonly known policy was the prohibition on the cutting of trees for commercial purposes. This was the policy mentioned first by the majority of the respondents in both the terrestrial and riverine sites. The other prohibited acts mentioned by the respondents and informants were poisoning of fish, hunting of animals, *kaingin* (slash-and-burn farming), and polluting bodies of water. There appeared to be an inverse relationship between awareness of the prohibition on the cutting of trees and the geographic proximity of the community to the core zone of the park. In general, however, more prohibited acts were known to people in the riverine communities than those in the terrestrial communities.

Awareness of Mt. Malindang as a Protected Area

Majority of the respondents and key informants indicated that they were aware that Mt. Malindang had been declared a protected area. However, their perception about a protected area showed very limited understanding; majority believed that a protected area is a place where cutting of trees is prohibited. Few believed that a protected area is where the forest is preserved or where both people and animals are protected. However, a few had the notion that a protected area is a tourist spot!

In the riverine communities (which are geographically farther from the core zone of the park), the awareness of a protected area was limited to it being a place where cutting of trees is prohibited. Thus, the perception about a protected area appeared to be directly influenced by the geographic distance of the community from the core zone of the park. That is, the farther away the community is from the core zone, the more limited is the people's idea about a protected area.

Awareness of the NIPAS Act

Majority of the respondents and key informants in all the terrestrial and riverine sites were not aware about the NIPAS Act. Of those who were aware about the Act, their awareness was limited to it being the law that prohibits cutting of trees. Other respondents' perceptions vary from extremely general (law for the environment) to very specific (law that protects the areas of Mt. Malindang and law about the forest guards). More significantly, many indicated that they have heard about the NIPAS Act but actually had no idea what it was about. This indicated that at best, awareness was very limited and fragmented, which might partly explain the low level of the acceptability of the law.

Source of Information

In all the terrestrial and riverine sites, the most commonly cited sources of information on the prohibited acts were the Department of Environment and Natural Resources (DENR) personnel and *barangay* officials. According to the respondents and key informants, the dissemination of information was either done through community assemblies in the *barangays*, or through meetings of *barangay* officials (usually *barangay* captains) in the city; who were then expected to relay the information to the community. However, many respondents and key informants complained that the latter strategy was not effective in disseminating information because the *barangay* officials were not sharing or explaining to the community the information they got from the meetings. This may partly explain the limited awareness of the communities about the policies directly affecting them.

The limited level of awareness of the respondents concerning the various aspects of the policies indicated that much remains to be done in how policies are communicated to the local communities. Three critical steps of the NIPAS Act are public notification, initial consultation, and public hearing, all of which are intended to inform the affected communities about the establishment of the protected area. While this was reported to have been done during the implementation of the National Integrated Protected Areas Programme (DENR-PAWB 2003), results of this study indicated that the activities undertaken or approaches used were not effective in informing the communities.

Acceptability of the NIPAS Act to the Local Communities

The acceptability of the NIPAS Act was analyzed in terms of its perceived effect on the environment and livelihood, together with the communities' compliance or defiance of the prohibitions set by the Act and related ordinances.

The respondents generally acknowledged that prohibiting the cutting of trees and declaring Mt. Malindang as a protected area have a positive effect on the environment. There was a general perception that the environment is improving and that the forest is preserved, partly because landslides had stopped. On the other hand, some still believed that the NIPAS did not help because many people are still cutting trees, particularly in the riverine communities. It was emphasized, though, that most of the violators were from other communities.

As with awareness, the geographic distance of the community from the core protection zone of the park appeared to influence the perceived effect of the protected area on the environment. A greater proportion of the respondents in the communities near the core protection zone perceived that the protected area has a positive impact on the environment. On the other hand, a greater proportion of the key informants in the communities that are relatively far from the core zone and close to the seat of provincial government perceived that the declaration of the protected area negatively affect the environment. These were also communities where cutting of trees continue despite the prohibition.

The respondents were divided in their perception with regard to the impact on livelihood of the declaration of Mt. Malindang as a protected area. In Barangay Lake Duminagat, majority of those who were aware of the declaration indicated that their livelihood was negatively affected. This was because the demarcation greatly limited their major livelihood activity, which is vegetable gardening. This was not surprising considering that Barangay Lake Duminagat is within the core protection zone and the farm lots of many residents are within what they referred to as "demarcation" or the boundary of the protected area. In fact, some respondents from that *barangay* lamented that after the setting of boundaries, only a quarter of their original farm lots were left outside the boundaries.

Some informants from the riverine areas indicated that their livelihood was negatively affected by the declaration, mainly because of the prohibition on the cutting of trees. This was the main source of livelihood of some residents, the ones paid by "contractors" from the city to cut trees. Thus, the protected area, which they equate as the place where cutting of trees is prohibited, was naturally perceived as detrimental to their livelihood.

There were also reports of non-compliance with the prohibition on the cutting of trees, which were attributed mainly to lack of alternative livelihood, dependence on wood as fuel for home consumption, and on the communities' belief that cutting of trees was allowed for house construction and repair. Others emphasized that violators were from other areas, and that apprehension was risky because the violators were armed. Others claimed that violators send death threats to local forest guards who attempt to apprehend them.

The availability of market for wood and wood products, for varying purposes, was also another reason cited for defiance of the prohibition on cutting of trees. This was especially true in the riverine communities, where people cut trees because there were "orders for wood" from contractors in the city. In other communities, another reason was the demand for fuel wood within the locality. Those who have money to spend prefer to buy fuel wood instead of actually going to the forest to gather firewood. The presence of internal demand for fuel wood led some enterprising residents to gather fuel wood not only for household consumption, but also for commercial purposes.

Enforcement of the NIPAS Act

The DENR is the lead agency in the implementation of the NIPAS Act. Other agencies involved include the Department of Interior and Local Government (DILG), the Department of Trade and Industry (DTI), and the Philippine National Police (PNP). Enforcement also requires the active participation of the various local government units of the province of Misamis Occidental, from the provincial to the *barangay* levels. The other stakeholders involved are the indigenous peoples and the NGOs operating in the area. The involvement of the various agencies and various stakeholders is formally reflected in their membership in the PAMB.

Monitoring and surveillance of the entire Mt. Malindang Range requires forest guards (ideally trained in protected area management) and logistical support, such as binoculars and horses, which are necessary to patrol the interior portions of the park. However, the DENR lacks the manpower and equipment required to monitor the park. There were a total of 19 forest guards patrolling the entire Mt. Malindang Range; nine were employees of the DENR, while 10 were volunteers who were provided only with meal and transportation allowance. The PASu had requested the municipalities that have jurisdiction over certain portions of the park to allocate funds for the payment of salary of one forest guard per mountain *barangay*. However, no favorable action had been taken by the local government units. Thus, by March 2005, only the nine forest guards employed by the DENR were left to patrol the entire mountain range.

Policy implementation is severely hampered by lack of necessary manpower and logistics. Enforcement is made more challenging by non-compliance of known prohibitions. This is particularly true when compliance with policies means compromising the more immediate concern of livelihood. As pointed out by Worms *et al.* (2004), protected areas can be managed with the involvement of resident communities only when their basic interests are at stake. For example, the payment received for cutting of trees had been admitted as the major source of income for some people, thus, cutting of trees continue and will continue provided that demand exists, even though cutting of trees is known as prohibited.

Community participation in monitoring and surveillance was mainly through the involvement of *barangay* forest guards, known as *Bantay Lasang*. They are assigned by the *barangay* captain, but are deputized by the DENR to monitor their area and report any violator. They are considered as volunteers and are not compensated for their work. The presence of these local forest guards had not been effective in preventing illegal activities, such as timber poaching. They did not report violators to the DENR due to fear of retaliation from the violators. Some violators had firearms and threatened the *Bantay Lasang* against reporting to the DENR.

Another problem that recently surfaced for policy implementors is the unauthorized removal of bamboos planted as vegetative fence along the peripheries of the core protection zone. These bamboos are intended to make the boundaries of the protected area more visible, and at a later stage, provide alternative livelihood to those living around the vicinity of the park. However, the Protected Area Office (PAO) had received reports of cases wherein some of the bamboos planted were taken by some residents and transferred to their farm lots. Again, the lack of sufficient manpower makes it difficult to monitor these kinds of activities. Concrete actions have yet to be taken by the DENR.

Extent of Effectiveness of the NIPAS Act in Managing the Mt. Malindang Natural Park

Policies are implemented to achieve some positive results. Thus, the implementation of the NIPAS Act is expected to ensure that the management and utilization of protected areas are "consistent with the principles of biological diversity and sustainable development" (NIPAS Act, Sec. 2). In the context of this study, the effectiveness of the NIPAS Act was viewed according to its impact on the management of forests, agroecosystems, and river basins of Mt. Malindang. Results indicated that the full potential of the Act in conserving and maintaining biodiversity in Mt. Malindang is yet to be realized.

Undoubtedly, the implementation of the NIPAS Act had some positive impact on the management of the forests of the Mt. Malindang Range, especially since no commercial logging has happened in the area since the implementation of the Act. The NIPAS Act could also be considered effective because of the passage of RA 9304. However, some data indicated that the implementation of the NIPAS Act failed to halt the destruction of some forested areas of Mt. Malindang. During the operation of logging companies (1971-1982), the total forest cover lost due to logging and *kaingin* was estimated at 6,000 (approximately 545 ha/year); an estimated 10,000 ha of forest cover was lost in 1982-1995. That is, deforestation increased to approximately 769 ha/year (MMRNP-PAO 2004). The increase in deforestation may have been caused by a number of factors, including in-migration that resulted to clearing up of forest areas for cultivation and timber poaching that may have replaced commercial logging. Unemployment of some residents due to the cessation of operations of the logging companies, coupled with their familiarity with the areas, had led them to conduct timber poaching.

Satellite images provided by ALTERRA showed an estimated forest cover loss of 14,546 ha during the period of 1992-2000. This implied that deforestation indeed increased even during the implementation of the NIPAS Act. The absence of exact figures on forest cover of Mt. Malindang Range made it impossible to determine the extent of deforestation that occurred during the implementation of the NIPAS Act. However, the formation of the multi-sectoral Misamis Occidental Anti-Illegal Logging Task Force on 10 September 2004 could be considered as confirmation that despite the implementation of the NIPAS Act, much remains to be done for the conservation and management of biodiversity in Mt. Malindang and its environs.

SUMMARY AND CONCLUSION

A number of conclusions could be drawn from the results of this study. First, there was a generally low level of awareness about the NIPAS Act, which was almost limited to it being the law that prohibits the cutting of trees. The extremely low level of policy awareness in the terrestrial and riverine could be attributed to the minimal and ineffective information dissemination campaign.

Another significant finding of the study was that awareness of the positive impact of certain policies does not necessarily translate to acceptability of those policies; acceptability was influenced by the perceived impact of the policies on livelihood, as well as the perception on how the policies were implemented. Thus, an acknowledgement that a policy will have a positive impact on the environment does not necessarily mean that there will be compliance with that policy. This was particularly true if compliance is perceived to have a negative impact on livelihood. Thus, alternative livelihood should be an important consideration in the enforcement of environmental policies.

Finally, enforcement of the NIPAS Act was largely dependent on the availability of manpower and logistics, as well as the effective coordination of all agencies and organizations involved in the implementation, and more importantly, the active participation of the local communities within and around the park. While policy implementation was hampered by severe lack of manpower and insufficient logistical support, the major challenge was the non-compliance of the policies because of the general lack of understanding of the long-term negative consequence of illegal activities, and the people's more immediate concern for livelihood. Furthermore, policy enforcement was not helped by apparent lack of demonstrated local government commitment and weak political will.

RECOMMENDATIONS

Based on the results of the study, a number of recommendations are presented. The first set of recommendations addresses the issue of awareness. The apparent limited awareness of the communities on the long-term significance of protecting and conserving the environment requires intensive and sustained information, education, and communication (IEC) campaign. Effective communication is critical in the entire conservation and development process (Worms *et al.* 2004). Thus, IEC should be done at different levels and should address the concern of various stakeholders. A critical requirement would be the translation of the policies into local dialects. The IEC should not be limited to the *barangay* officials and tribal leaders, but should include the community. However, *barangay* officials, tribal leaders, and officers of people's organization should be equipped with a working knowledge of the policies since they are the most common sources of information for the community. Visual aids would be very useful IEC materials, especially in areas where the literacy level of the community is rather low. It would also be more effective to have separate sessions for different groups in the community, such as children, young adults, and women. The media to be used should be tailor-made to ensure its appropriateness to the concerns of a particular group. It should, however, be ensured that the same information is passed to these different groups in order to have a common understanding of the policies.

The acceptability of policies was found to be influenced by the perceived impact on livelihood, as well as the community's perception on how the policies were implemented. This calls for a policy awareness campaign that would be able to convince the communities that protecting and conserving the environment could actually improve their livelihood conditions. However, simply explaining this will not work. Thus, it would be necessary to actually present some possible alternative livelihood activities to address the perception that protecting the environment necessarily means sacrificing livelihood. Furthermore, environmental groups have increasingly acknowledged that conservation strategies require more than just "raising awareness" and necessitate the development of income-generating options (van Helden 2004). This would require close coordination with other government agencies, such as the DTI, and NGOs that have the capability to assist in the development of alternative livelihood strategies.

Policy enforcement is largely dependent on the availability of qualified manpower and logistics, which no single government institution possess. Thus, sustained policy enforcement would only be possible with the collaboration of various agencies. However, government agencies alone could not have all the required resources for effective policy enforcement. In this regard, NGOs may fill the gap and be effective partners in policy implementation. The involvement of NGOs may also be strengthened through their membership in the PAMB, which is the vehicle for the active involvement of the local government units, other government agencies, the local communities, and other significant stakeholders in Mt. Malindang and its environs.

The management and conservation of biodiversity in Mt. Malindang and its environs would also require a review of the PAMB as a policy-making body, especially the approaches and strategies adopted by the Board as it carries out its functions. Currently, the executive committee regularly meets once a month, while there are only two *en banc* meetings a year (as mandated by the NIPAS Act). Thus, *barangay* captains, who are the representatives of local communities, are required to attend PAMB meetings only twice a year. A mechanism should be devised for more active participation of *barangay* captains in PAMB deliberations. This would give them a greater sense of responsibility for protecting and conserving Mt. Malindang and its environs, and empower them to be true agents of effective co-management, an approach that has been accepted and recognized in various parts of the world as effective in protected area management (Borrini-Feyerabend *et al.* 2004).

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THE INDIGENOUS CULTURAL COMMUNITY OF THE SUBANEN AS CO-MANAGERS OF MT. MALINDANG NATURAL PARK, PHILIPPINES[1]

Alita T. Roxas[2]

Protected area management in developing economies like the Philippines is challenging as it is daunting, as protected areas are generally inhabited by impoverished populations who are dependent on natural resources therein for their subsistence and livelihood. Most of the human populations found within protected areas are indigenous peoples who have lived there for many generations and whose patterns of claiming and using land are based on cultural specificities.

Protected areas are established to protect and enhance biodiversity for the future generations. The realization of this objective is being operationalized in various management styles that have evolved - from the traditional exclusionary approach, which puts all the responsibility in the agency in charge, but which, due to ensuing conflicts, had led to the call for local communities' participation; in certain protected areas this participation had matured into partnerships and collaboration, involving all the main stakeholders, i.e., indigenous peoples and other local residents, resource users, and other institutions and agencies.

This paper presents prospects for Subanen co-management of Mt. Malindang Range Natural Park (MMRNP), a protected area in Misamis Occidental, based on data and insights from a biodiversity research conducted under the Philippines-Netherlands Biodiversity Research Programme (BRP) for Development in Mindanao: Focus on Mt. Malindang and its Environs.

OBJECTIVES

This paper seeks to characterize the livelihood strategies among the Subanen in the core protected area and buffer zones of the MMRNP as influenced by culture, historical land use, market demand, and environmental legislations, and how these livelihood strategies impact on their livelihood security and on the biodiversity of Mt. Malindang. It also looks into the salient features of Subanen culture and social relations which could be harnessed for Subanen co-management of the MMRNP .

METHODOLOGY

Prior informed consent of the communities to be studied were obtained through entry protocols and consultative community assemblies. Both quantitative and qualitative research methods were used to obtain a meaningful description of the nature of evolving resource expropriation and use, and responses to market demand and environmental policy. A combination of simple random and area sampling were done in choosing sample households. Additional information on policy enforcement/ intervention, resource utilization, and livelihood strategies were gathered through focus group discussions, key informant interviews, direct observations, and interviews with key personnel of agencies/bodies involved in the management of the park, such as the Department of Environment and Natural Resources (DENR) and the Protected Area Management Board (PAMB), to enrich data and analysis. The study was conducted in November 2003 to April 2004.

THE MT. MALINDANG RANGE

The Mt. Malindang Range is located in parts of Zamboanga del Norte and Zamboanga del Sur in Region XI and much of Misamis Occidental in Region X. It is the only representative natural forest in the Zamboanga Peninsula Biogeographic Zone (Myers 1988) in Mindanao. Some 53,262 hectares (ha) of the mountain range was proclaimed a national park and watershed reservation area by Republic Act (RA) 6266 on 19 June 1971. It was after ten years, however, that the proclamation became public. This may be due to oversight or because timber licensing agreements already granted prior to the approval of RA 6266 included a top official of the province. The Mt. Malindang National Park became one of the protected

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areas established under the NIPAS Act of 1992 under RA 7586. The NIPAS Act required a re-survey and revision of the boundaries of the park. Its new boundaries became official under Proclamation 228, dated 2 August 2002, which declared it as the Mt. Malindang Range Natural Park (MMRNP), with a core protected area covering 34,964 ha; the remaining portion was designated as buffer zone. MMRNP became a full-fledged protected area on 30 July 2004 with the passage of RA 9304. This status allows the park to have its own annual budget allocation for its protection and enhancement.

The MMRNP occupies most of the provincial land area and has a maximum elevation of 2,404 masl. Arances *et. al.* (2004) described its forest vegetation types as follows: mossy forest, characterized by the *Ascarina-Elaeocarpus-Macaranga* community; montane forest, by the *Lithocarpus-Magnolia-Paraserianthes* community; dipterocarp forest, by the *Shorea-Anisoptera* community; almaciga forest, by the *Agathis-Syzygium* community; mixed dipterocarp forest, by the *Shorea-Lithocarpus-Cananga* community; and agroecosystem, characterized by communities of vegetables such as cabbage (*Brassica oleracea* var. *capitata*), carrots (*Daucus carota*), chayote (*Sechium edule*), and spring onion (*Allium fistulosum* L.); cereals (rice, *Oryza sativa* and corn, *Zea mays*), agroforestry (coconut, *Cocos nucifera* and lanzones, *Lansium domesticum*), and grass-dominated fallowed areas (*Cyathea* spp.-*Imperata-Saccharum*).

The mountain range is volcanic in origin. It has a rugged terrain, steep slopes, and dense forest cover and has several craters, the biggest of which is the 8-ha crater-lake at Barangay LakeDuminagat. The mountain range is characterized by a mild humid climate. The temperature is lower (about 12-16°C) and rain is more frequent at higher altitudes (NIPAP-DENR 2000). Fauna found in the park included the critically endangered *agila* or Philippine eagle (*Pithecophaga jeffeyri*); the vulnerable *kagwang* or Flying lemur (*Cynophalus volans*) and *pungak,* locally referring to both the Giant scops owl (*Mimizuki gurneyi*) or Grass owl (*Tyto capensis*); the locally-threatened *binaw* or Philippine deer (*Cervus mariannus*), and tarsier (*Tarsius syrichta*); and the near-threatened *kalaw* or Rufus hornbill (*Buceros hydrocorax*). Some 39 species of mammals (22 endemic), 162 species of birds (66 endemic), 34 species of reptiles (12 endemic), 24 species of amphibians (12 endemic), and 1,171 species of plants (138 endemic) had also been recorded (Arances *et al.* 2004).

There are 65 *barangays* and 14 municipalities within the park, supporting around 19,000 residents in the buffer zone and about 900 in the core area, but the entire Mt. Malindang watershed feeds about a million people living in 31 municipalities from three provinces - Misamis Occidental, Zamboanga del Sur, and Zamboanga del Norte (NIPAP-DENR 2000). Eighty percent of the protected area's population was Subanen or with Subanen lineage (offsprings of mixed marriages), but the proportion of immigrant Bisaya settlers was increasing.

THE INDIGENOUS PEOPLE OF MT. MALINDANG: THE SUBANEN

The Subanen are indigenous people believed to be the first occupants of the Zamboanga Peninsula. Pigafetta's chronicle of his 1519-1522 journeys, as mentioned by Christie (1909), narrated the Subanen occupancy of the lowland and coastal zones of the peninsula. Scott (1994) was also convinced by the Pigafetta chronicle that the Subanens had settlements scattered along rivers. Suminguit (1989) also noted that the Subanen inhabit the mountain ranges that cross the provinces of the Zamboanga peninsula, and specifically pinpointed to the Subanen settlements in Mt. Malindang in Misamis Occidental. In a recent exploratory study of the enthno-history of the Subanen, where a group of 51 Subanen tribal leaders gathered for interviews in Zamboanga del Sur on 16-17 August 2000 (Rodil *et al.* 2002), the historical claim that the Subanen were the first inhabitants of the Zamboanga Peninsula was validated. Oral histories narrated by Subanen key informants in the Socioeconomic and Cultural Studies (SECS) Master Project of the BRP also pointed to the earlier Subanen habitation of the coasts and lowlands of the peninsula of their current territories.

Suminguit (1989), citing several references, also described the cultural heritage of the Subanen, which included the characterization of the Subanen as river dwellers as they lived near rivers, resulting to their being called as such (also, as Subanun, Subanon, Subanu, Suban'on). Subanen came from the root word *suba*, which means "river" to both the Bisaya, as well as to Muslims in Sulu. "-Nen" or "-nun" is an adjective suffix indicating origin. Several authors pointed to the Subanen as having been given their name by the Moros and the early Christian missionaries but that they called themselves *Tau Bukid* or "hill people". These authors (Lebar 1975, Hall 1987, Christie 1909, Finley and Churchill 1913) also characterized the well-developed Subanen practice of shifting cultivation, where the Subanens choose and clear a forestland and then plant crops, and when the soil fertility was deemed to have declined, abandon it in favor of another forestland. The Subanen used rivers to move from place to place, thereby creating an image of themselves as river dwellers.

Sevidal Castro *et al.* (2005), using various references (Pelzer 1945, Suminguit 1989, Rodil 1994, Scott 1994, Alegre 2004, etc.), described factors that brought about the Subanens' movement away from the coasts, their settlement along rivers, and progressive movement into the hinterlands of Mt. Malindang. These consisted mainly of efforts to escape: the pre-Hispanic subjugation by co-inhabitants of Mindanao; the conquest of the Bisayans; the conquest by the Moros; the subjugation of the coastal villages by the Spanish government; the evangelization attempts of Jesuit and Agustinian missionaries even in their inland territories; and the encroachment of in-migrants from Luzon and the Visayas into their ancestral domain, facilitated by settlement programs of the US colonial administration.

Subanen key informants also narrated that migrants from the Visayas and Mindanao had with them supplies, such as whetstone, salt, and cigars, which were offered in exchange for Subanen lowland farms. Apparently relying on open access to fertile lands in the mountains, the Subanen accepted the barter and moved to the uplands. Sevidal Castro *et al.* (2005) and Rodil *et al.* (2002) also found that the Subanen were evicted from their lowland farms because the migrants obtained legal documents for the land. Migrants from Cebu, Bohol, Negros, Siquijor, and Luzon, therefore, progressively dominated the coasts and lowlands of Misamis Occidental. They were collectively called Bisaya, owing to similarities in dialects. The Subanen called them *dumagats* or settlers from across the seas.

By the year 2000, the Subanen comprised 4.66 percent of the population of indigenous peoples in the Philippines (NSO Special Release No. 086 as cited by Sevidal Castro *et al.* 2005). In Misamis Occidental, the Subanen constitute 4.38 percent of the population according to ethnolinguistic grouping (NIPAP-DENR 2000). The same source points to the Bisaya as comprising 41.78 percent, the largest ethno-linguistic group in the province and found mainly in cities and municipalities along the coasts and in the outer lowlands. The Subanen, meanwhile, were clustered in the interior lowland and in upland communities in and around the MMRNP.

THE STUDY SITES

Three upland *barangays* in the municipality of Don Victoriano (more popularly called Don Vic) and a lowland *barangay* in Lopez Jaena, all within Misamis Occidental, comprised the study sites. These four communities cut across the different management zones established within the park, namely, Barangay Lake Duminagat, located within the protected area, Barangays Gandawan, Mansawan, and Peniel, found within the buffer zone.

The Don Victoriano study sites are logged-over areas. These are contiguous *barangays* with varying elevations. Barangay Lake Duminagat has the highest elevation, with elevations ranging from 1,440-1,460 masl; its mountain slopes vary from 19° to 35°. It is a crater valley and has a land area of 909 ha, 60 ha of which are mossy forest. Adjacent to it is Barangay Gandawan, a lower crater valley, with elevations ranging from 1,240-1,280 masl; its surrounding mountains have slopes from 22° to 26°. Its plains measure about 102 ha. Barangay Mansawan lies next to Gandawan, possessing an elevation range of 1,269-1,303 masl, with undulating mountainous slopes of 12° to 35°.

Mansawan is accessible to motorized vehicles and is the entry point to the two interior *barangays*. One could reach Gandawan and Duminagat either on foot or on horseback. The usual means of transportation in going to the lowlands is the *habal-habal* or motorcycles without sidecars carrying as many as four passengers.

Peniel in Lopez Jaena has elevations that range from 300-600 masl, with slopes ranging from 18° to 30°. It is accessible to motorized vehicle but due to its steep slopes and rugged terrain, the residents only rely on the *habal-habal* to commute to neighboring *barangays* or to the *poblacion*.

The study sites were all initially settled by the Subanen: Peniel in 1928, Lake Duminagat in the early 1930s, and Gandawan and Mansawan in the 1940s. Peniel, owing to its lower elevation, now has only 15 percent Subanen population from about 300 residents; the rest are Bisaya. Barangay Lake Duminagat is almost solely Subanen territory; only two of its 57 households are headed by non-Subanen, a result of intermarriages between the Subanen and the Bisaya. In Gandawan, Bisaya in-migration started in the 1950s and 1960s, triggered by the opening of roads due to large-scale commercial logging, and an invitation of a religious leader to his followers to "partake of God's gift of abundant land". Gandawan has only 30 percent Subanen household population out of its 70 households. In Mansawan, similar reasons attracted settlers. Open access to land and the community's relative accessibility to vehicles soon attracted other in-migrants from the surrounding Mindanao provinces, and even those from the Visayas. Mansawan today has 276 households, 70 percent of which are Subanen.

Houses commonly cluster around each community's *centro*, although some houses are also dispersed in several *puroks*. Most farms are located at the base of mountains, on slopes, and in forest fringes (particularly in Barangay Lake Duminagat), although similar farms in Gandawan are situated mainly in flat lands, the *barangay* being a valley. Grasslands and some forest patches can also be found; these are previously cultivated land left to fallow, however, they are getting smaller due to the influx of migrants.

EARLY PATTERNS OF RESOURCE USE

The Subanen, like other indigenous peoples in the Philippines, were traditionally swidden cultivators. The *kaingin* was their way of clearing lands. The pioneer settlers made small clearings from the forests and converted these into settlements and subsistence farms that were planted to root crops such as *kamote* or sweet potato (*Ipomoea batatas*), *gabi* or taro (*Colocassa esculenta*), and *kanaka* (*Xanthosoma* sp.), which are known as the traditional crops of the Subanen and serve as staple food.

From the forest, trees were cut to provide materials for dwellings; these were also used for firewood. Resin tapping from adult almaciga trees was common; the resin aided in building fire and serve as illuminant and sealant to roof holes. Herbs were also extracted for treating ailments; wild berries and rootcrops were additional food. *Pandan* (*Pandanus multiflora*) was woven into mats and rattan (*Calamus usitatus)*, the Subanen's early cash crop, was sold as baskets rather than as strips to generate higher income. Income earned from the trade helped the household buy rice or corn, which were difficult to cultivate in the Don Victoriano altitude and weather, as well as other basic needs.

Hunting wild game from the dense forests and fishing in rivers that traverse the communities ensured the addition of protein in the diet. Both hunting and fishing were for subsistence. Lake Duminagat was a sacred site to the Subanen and was believed to heal ailments and wash away sins; the Subanen refrain from fishing in the lake.

The early Subanen utilized family labor on the farm but the *hunglos* or *pahina,* a type of cooperative community labor similar to the *bayanihan,* was summoned when clearing the forest, planting, or harvesting crops. This activity requires reciprocal actions from community members (Roxas *et al.* 2005).

Resource use by the initial Subanen settlers was dominated by a belief system. They revere a Supreme Being, Apo Gumulang, who is believed to have created heaven and earth. Deities are believed to dwell in the natural resources or guard over them. This belief requires the performance of *pamuhat* or *kano* (rituals) to ask for guidance in determining forestland suitable for farming, to seek permission for resource use, and to make supplications for abundant harvests (Roxas and Duhaylungsod 2004, Roxas *et al.* 2005). Rituals known as the *pailis* and *diwata* are performed before trees are cut, before doing the *kaingin*, and before planting. Sevidal Castro *et al.* (2005) also cited other rituals gathered from focus group discussions among Subanen elders, such as the *paggasa* or *paghalad*, an offering made to invoke the spirits to keep watch over the crops and ensure productive yield; when the supplication is answered, the *pasungkò* is performed to thank the spirits. Hunters perform the *apal* in order to be led to where hunting of wild game is allowed by the deities. *Apal* is also performed before fishing. In deference to the deities, the mating and birthing season is respected when hunting, which is during the rainy months. Similarly, gravid fish or young catch are returned to the river. Rituals are led by a male or female spirit medium known locally as *balyan* or *suruhano*. Non-performance of rituals is seen as offending the spirits who may impose such sanctions to the offender as poor harvests, sickness, or even death.

The Subanen belief in the guardianship of the deities over natural resources, manifesting itself in rituals asking permission for resource use or in respecting their abodes, serve as a social mechanism that call for the proper use of resources and their conservation, thereby sustaining the subsistence livelihood, and in the process defining the relationship between the Mt. Malindang Subanen and nature. Lake Duminagat is a testimony to this belief. The Subanen inhibit themselves, as well as others, from bathing, washing clothes, or littering in the lake. Its immediate vicinity is kept clean and the lush vegetation surrounding it is conserved. Also, the forests of Mt. Guinlajan, as well as in Barangay Lake Duminagat, are left undisturbed due to its cultural importance to the Subanen. It is held sacred as it serves as burial grounds of former Subanen *timuays* and chieftains. The Subanen elders felt the need to guard their natural resources and ensure its sustainability; this led to the organization of the *Magalong* or the Subanen volunteer forest guards.

LOGGING, THE OPENING OF ROADS, AND CROSS-CULTURAL INFLUENCES

The Mt. Malindang Range was not spared from the large-scale commercial logging that characterized the different forests of Mindanao in the late 1950s up to the early 1980s. It left an imprint that altered the physical and socioeconomic milieu of the communities studied. Timber licensing agreements led to the denudation of forests and destruction of natural habitat. About 40 road networks leading to highways and urban areas were built to transport heavy equipment, to haul logs, and to support the industry in various ways. Only a very few Subanen were hired by logging companies, as the more skillful Bisaya filled up most of the labor requirement.

The roads contributed to deforestation and changed the Mt. Malindang landscape, bringing in new migrants, new crops, and new orientations. They caused increased in-migration by both Subanen and Bisaya to the Don Victoriano communities, attracted by the presence of huge logged-over areas which would make easier the clearing of land for farms and settlements. Information pertaining to new crops suitable to high elevation areas and cool climate was obtained through increased interaction with Bisaya migrants and with Subanen relatives in the lowlands. The Mt. Malindang Subanen learned that these crops fetched a good price and had a good market, prompting them to diversify on their farms. The experimentation of the Subanen with the new crops revealed the dynamism of their culture.

Cash cropping started to co-exist with subsistence farming and soon became the dominant feature of the landscape. Spring onions were cultivated in the 1970s and have since become the primary cash crop. High-value vegetables of the semi-temperate variety, such as cabbage, carrots, and chayote, also started to be produced for the market and became widespread in the 1980s. The settlers in what are now the core and buffer zones of Mt. Malindang, Subanen and Bisaya alike, resorted to more *kaingin,* this time in logged-over areas, and started to cultivate slopes to obtain bigger farms. Sevidal Castro *et al.* (2005) recorded indigenous knowledge applied to ensure good harvests. This included the decomposing of grass and cuttings, and leaving or burning them (*pagsilab*) over farm lots to nourish the soil; and crop rotation, or the alternate planting of *kamote* (sweet potato) or cabbage in lieu of spring onions, after two years of continuously harvesting the latter to replenish soil nutrients. The spring onions were replanted when the soil was observed to have gained fertility. When even the sturdy *kamote* could not grow well, the plot was left to fallow (*paanutan*). When pests infested the monocrop garden plots, the Subanen experimented on the use of various concoctions of plants, or resorted to *kaingin* in the middle of the forest, where no pests are initially found. *Kaingin,* therefore, is a form of managing soil fertility and pest infestation by the Subanen. The continued cultivation of traditional crops, i.e., *kamote* and other root crops, meanwhile, is a way of hedging against possible cash crop failure, as the traditional crops are not prone to pest infestation and require no fertilizers. Also, the traditional crops remain as staple food when there is not enough cash to buy rice or corn. The income generated from cash crops allowed house repairs and extensions (which again require the cutting of trees from the forest). Nipa or cogon roofs were replaced with galvanized iron sheets bought from the lowlands to better withstand the rains.

The opening of roads also allowed the construction and opening of elementary schools in the communities studied. A secondary school was even established in Mansawan. While it was previously held by the Subanen that one only has to till the land to gain a living and that education is not important for survival (Rodil *et al.* 2002), the opening of schools brought about a change in the outlook towards education; Subanen parents now prod their children to attend classes. They now see education as a means to improve skills, giving the educated better chances of responding to opportunities. Stories by lowland relatives, as well as by the Bisaya migrants, of better pay and lighter work in urban employment was a good enough reason to pursue formal education.

In addition to kinship and friendship ties in the initial settlement period, membership in religious groups that migrated to the sites provided a good source of social capital, as members give each other solace and assistance as they face the challenges of living with very minimal government support and access to social services. The Subanen practice of religion is syncretic in nature - it cultivates trust in an Almighty God, even while it seeks for intercessions by nature spirits. An example is the practice of folk Catholicism or *Katolikano* among a group of Subanen. This religious group, whose name had been coined from "Catholic" and "*kano*", combines prayers and rituals. Similar to rituals, religion balances the uncertainties of living under unpredictable weather conditions, possibilities of crop failures, and other unpleasant circumstances.

THE NIPAS ACT: CLOSING THE FRONTIER

When the proclamation of Mt. Malindang as a national park was announced ten years after its promulgation, the loggers were given a year by the DENR to wind up their operations (NIPAP-DENR 2000). Subanen and Bisayan settlers who were rendered jobless turned to cash cropping, or as some key informants reported, to illegal logging. Selling logs proved to be difficult, however, due to the distance of the mountains to the lowlands and the absence of means of transportation.

The decade of the 1990s witnessed more changes in the park's landscape. The passing of the NIPAS Act in 1992 to address issues on biodiversity conservation, protected area management, and sustainable development attracted attention to Mt. Malindang, which has been converted from a forest reservation area to a protected area. It was in the mid-90s, however, when enforcement of the NIPAS Act in the park commenced. By account of the Protected Area Superintendent (PASu) Rolando Dingal (2004, personal communication), about 100 ha of Mt. Malindang forest were lost to *kaingin* annually prior to 1995; this was drastically reduced to less than 10 ha per year after 1995. The PASu attributed this to information campaigns, involvement of *barangay* officials in implementing the NIPAS, the entry of nongovernment organizations (NGOs), and the five-year European Union-funded National Integrated Protected Areas Project (NIPAP). European funds allowed the Department of Environment and Natural Resources (DENR) to deputize forest guards to monitor activities in the park. Only 19 forest guards were deputized, however; this was obviously a small number considering that the core protected area was about 35,000 ha. The *barangays* also organized their own *Bantay Lasang* or forest guards.

The delineation of the strict protection zone under the NIPAS Act reduced farm sizes in the forest fringes of Barangay Lake Duminagat to only a quarter of the original. Thus, the NIPAS Act was perceived negatively as it denied access to natural resources and sought to end the Subanen practice of *kaingin*, which has characterized the way they lay claim to land since time immemorial. The DENR, unable to give alternative sources of livelihood to compensate for the diminution of farms, conceded to allow affected families to continue farming inside the delineated boundary, but warned against further expansion into the forests. Vegetative fencing by planting bamboo supplemented the concrete markers in the perimeter of the core zone. Mansawan, Gandawan, and Peniel farms, being in the buffer zone, were not affected by the delineation.

The DENR also compromised in allowing the cutting of forest trees to build or repair houses of settlers, but only naturally-fallen trees were allowed for firewood. While the Subanen collected branches and dead trees (“drop logs”) for firewood, they admitted to cutting forest trees when sources become scarce. In Mansawan, which was already devoid of forests, firewood was purchased from enterprising Subanen living near forest fringes. The rate of extraction of trees for firewood and the absence of reforestation had caused tree species being used as firewood, such as *gulayan (Lithocarpus* spp.) and *pulayo* (*Syzygium* spp.), to be locally threatened. As shifting cultivators, the Subanen were not predisposed to plant trees nor to reforest. Now that the NIPAS Act had closed the forest to further encroachment, implying that the Subanen have to stay where they are, the Subanen have generally remained lukewarm to reforestation. They explained that this was due to to their undefined tenurial arrangement in the park. To address this concern, the DENR and the CARE-AWESOME project helped the Subanens, who have resided in the park five years prior to NIPAS, in applying for their certificates of stewardship. Those who applied participated in the planting of *gulayan* and *pulayo*, which the CARE-AWESOME funded, to avert the depletion of the population of these tree species. The funds, which paid for the labor time spent, provided participating farmers with additional income. Moreover, the current commercial growing of an endemic variety of abaca, which was also supported by CARE-AWESOME, had also encouraged tree planting or more appropriately “tree parenting”, as the participants were required to nurture what they planted.

The prohibitions to clear forest resulted in the substitution of swidden farming with sedentary farming, a practice completely alien to Subanen agriculture. This, and the commercialization of agriculture, which was venturing toward permanent cropping with the planting of abaca, represented what Reardon and Vosti (1995) referred to as “exogenous trend and shock factors” that put considerable stress on the Subanen way of life. Cross-cultural influences weakened some Subanen cultural practices; with NIPAS, the performance of rituals to identify and open new farm sites has waned. The resulting shift to intensive land use with shorter fallow period (six months to a year) had become widespread. Those with smaller farm lots had to continuously cultivate the same plots.

Diminishing harvests of cash crops were observed as soils started losing their fertility due to overuse. Pest infestation became common in monocrop gardens, which were usually planted to cabbage or spring onions.

The resiliency and dynamism of the Subanen culture was again demonstrated when the Subanen combined introduced technology in the form of inorganic fertilizers and pesticides with their indigenous practices to combat decline in soil fertility and infestation of pests. Lacking knowledge in the use of inorganic farm inputs, the initial boost in yield was not sustained. Nevertheless, the initial increase in income, as well as greater time spent on the farm, generated demand for other goods. This presented opportunities for rural business and other non-farm activities among those with bigger farms, such as operating *sari-sari* stores, bakeries, eateries, even entertainment joints for betamax showing and “sing-a-long”.

As the crops were already commodified, rendering labor on another farm also required payment, referred to as *panungha*. This had replaced *hunglos* or *pahina*. *Panungha* had become a good source of supplemental income for those with small farm lots and have surplus labor time. It had formed part of the emerging trend towards diversification of income sources. Honoraria from serving as *barangay* official or from temporary engagements in programs of government agencies and NGOs had also augmented income.

PARK MANAGEMENT

The late 1990s was marked by the presence of local and foreign-funded programs in the MMRNP, such as the EU-NIPAP and CARE-AWESOME (both had just terminated operations at the time the study was being conducted). The programs served as intervention mechanisms to meet the requisites of a full protected area that the core of Mt. Malindang had become. These included formulating a protected area general management plan, putting markers on core zone delineations, environmental awareness campaigns, capability building for biodiversity conservation, and alternative livelihood for park residents, infrastructure, logistics, and personnel support. The Philippine-Australian Local Sustainability (PALS) program was yet another project in the park and the communities around it. In its second phase, the project has been contributing huge funds to the province of Misamis Occidental. It provided both alternative livelihood and infrastructure support. The BRP, meanwhile, provided collaborative and interdisciplinary research efforts to inventory plant and animal species found in the park, to determine their conservation status, and to better understand the park's ecological functions, as well as the complexities of people-environment interactions. Findings were expected to serve as take off points for action and policy intervention.

The sloping agriculture land technology (SALT) was introduced in the communities studied, but it failed to gain ground due to the intensive labor and high initial financial capital that it requires. The BRP, meanwhile, established model cabbage farms in Barangay Lake Duminagat and Gandawan showcasing the combined use of inorganic and organic fertilizer (chicken dung), cabbage polyculture, and integrated pest management (IPM). The Subanen and Bisayan farmers that were chosen as local partners were trained on the techniques. The project gained widespread acceptance due to the increased yield of cabbage at lower cost. The BRP had also undertaken a mass propagation of endemic, rare, and economically important plants collected from the three Don Victoriano communities by establishing a nursery and greenhouse in Mansawan. Teachers and students of the Mansawan High School, together with the Mansawan *barangay* council, led the planting of seedlings in the identified sites. The nursery is now being managed by the school and the *barangay* council. BRP researchers continue to visit the communities even after the project ended in December 2005 to monitor progress and to continue providing technical assistance. New funding sources are being tapped by these researchers to implement some recommendations made.

The linkages formed with NGOs, academic institutions, and international organizations implementing conservation and development programs represent enormous social capital for the development of Mt. Malindang communities. These linkages serve as a powerful tool to address vulnerabilities, such as low income and lack of skills, which, hopefully, will result in alternative livelihood and wean people away from further impinging on the forests and the massive use of inorganic fertilizers and pesticides, which also adversely impact on the fragile Mt. Malindang ecosystem.

Alternative livelihoods are those that reduce pressure on the forests and on land, given the protected area status of the communities. Cheap credit for alternative livelihood appeared to be the assistance of greatest utility and provides the initial attraction to development programs. Skills enhancement, such as business planning and bookkeeping, as well as team building and values clarification, preceded the granting of loans. Alternative livelihood programs in the sites followed the scheme of recycling loan repayments to the next group of borrowers. The initial beneficiaries were those belonging to women's club and farmers' associations, both Subanen and Bisaya, who participated in capability building and values clarification workshops. However, it takes time before loans are granted to those interested given the limited funds available.

Marketing assistance and equipment were also provided. From these efforts, coffee and abaca are now growing in areas outside the delineated strict protection zone. A recent project involves goat and cattle dispersal in grasslands in the buffer zone, one which drew some criticism due to the steep slopes and conservation status of the park, especially since cattle requires a large area for grazing.

Infrastructure development assistance, meanwhile, comes in the form of construction or repair of the *barangay* hall, health center, or day care center, and the installation of community water systems.

The communities, meanwhile, are represented in the Protected Area Management Board (PAMB) by their *barangay* chair. The municipal mayors of Misamis Occidental also sits in the PAMB. Other members are the provincial planning officer, the provincial director of the Department of Interior and Local Government (DILG), the regional executive director of the DENR, a representative of the DENR, five representatives of the Subanen, and seven NGO representatives. Issues, activities, policies, and decisions affecting the park are tackled in the PAMB. The *barangay* leaders in the Don Victoriano communities and Peniel do not always attend the PAMB meetings, which are held in far away Oroquieta, when they did, key informants revealed that information regarding what were tackled or planned for the core and buffer zones were not relayed to the communities, thereby depriving these communities participation in the management of their affairs. The crafting of the Mt. Malindang Management Plan, nor its recent revision, did not also involve the *barangay* leaders in the core and buffer zone areas.

There were no developments related to the applications for certificates of stewardship of land, however. Meanwhile, a congregation of nuns assisted the Subanen of MMRNP to file for ancestral domain claims with the DENR as embodied in DENR Administrative Order No. 2, series of 1993. This was overtaken by events with the promulgation of the Indigenous People's Rights Act or IPRA in 1997.

IPRA is another landmark legislation affecting the Mt. Malindang communities. Aimed at promoting and protecting the rights of indigenous cultural communities, while at the same time making them partners in resource management. It is particularly important to the MMRNP, being home of the Subanen. Under IPRA, ancestral domain claims have to be filed with a newly created agency, the National Commission for Indigenous Peoples (NCIP). Generally, however, the Subanen in the study sites have not been reached by the information dissemination on IPRA, neither by the efforts of government agencies nor by other Subanen groups (Gomez *et al.* 2005).

CONTINUING VULNERABILITIES AND ADAPTIVE RESPONSES

Despite existing prohibitions, hunting occasionally takes place in Barangay Lake Duminagat and in Peniel where there are still forests. The activity was mainly for subsistence, although a portion of wild game meat was sometimes sold to neighbors. The conduct of *apal* has waned as wild game had become scarce or moved into more interior forests. The Subanen attributed this to the destruction of wildlife habitat, primarily due to large-scale commercial logging. Hunting is prohibited during the mating and birthing periods of wild game; in addition, hunting of wild boar that is less than 40 kg is avoided. Wild animals are observed to forage on farms near forest fringes during the harvest season, traceable to dwindling food resources in their disturbed habitat. The Subanen protect their farms by setting up traps.

Fish and other aquatic life in the rivers, which, even in the earlier days were not plenty, became scarce. Some settlers said this could be due to the lower water level brought about by the decline in forest cover. Others said this could be due to the construction of irrigation dams in the lowlands; the dams were said to trap fish downstream during the spawning season. Fishponds established in the mid-90s did not withstand heavy rainfall. Fish now comes almost solely from the lowland markets.

Medicinal herbs continue to be gathered from the forest and there is increasing interest in the gathering of ornamentals (e.g., wild orchids). As the forests have grown distant, some Subanen have planted herbs and ornamentals near their homes, and have started selling them in lowland markets. Honey, when collected in abundant quantity, is bottled and sold in the upland market; otherwise, it serves as a source of additional nutrition for children.

Key informants revealed that some park residents conduct timber poaching in the core zone due to the demand for timber generated by the housing needs of growing communities nearby. The use of chainsaw, though prohibited, was sometimes detected through the distinct sound it produced. The few DENR-deputized forest guards patrolling the huge area of the park could not effectively stop the illegal activity; they also received death threats for their interference. The *barangay Bantay Lasang* was also rendered helpless by these threats.

Rough estimates of the number of trees felled for building a modest dwelling ranged from15 to 26 (average of 15-20 cm diameter at breast height and 5 m long). The cutting of trees for building a house was done once, but was repeated after some time for repair and maintenance (about once in 10 to 20 years, indicating the good quality of wood used). Average extraction of trees for fuel per week per household, meanwhile, was estimated to be 0.192 m^3 or 2.20 trees (also with individual average measurement of 15-20 cm diameter and height of 5 m). Sources said that it takes five years for a tree to grow this size. The average number of trees extracted per week for fuel for the three Don Victoriano *barangays* was 295.53 trees (Roxas *et. al.* 2005). This was around 38 percent of the average total number of trees per hectare, which was estimated by Arances *et al.* (2004) to be around 781-794 trees. This implied that for the fuel needs of the three *barangays*, a little more than a third of a hectare of forest was cleared every week. In a month's time, more than a hectare was cleared, adversely affecting biodiversity.

At the time the study was conducted, there was no alternative source of timber for house construction/repair and for fuelwood in the three sites. Thus, if left unchecked, forest cover would continue to decrease over time. ALTERRA's satellite image analysis of Mt. Malindang for 1992-2000 bared a deforested area of about 12,651 ha for the 9-year period. This exhibited a rate of 1,405.67 ha per year. The CARE-AWESOME estimate of average deforestation per year for Mt. Malindang in the last five years was 800 ha.

On the other hand, the number of non-Subanen population in the Don Victoriano study sites had increased despite IPRA. Constant interactions of the Subanen with the non-Subanen hastened the process of their acculturation, weakening, in the process, the Subanen culture, including those elements which nurture the environment. Though IPRA provides for the right of indigenous people to regulate the entry of migrants and other entities, lack of awareness of the legislation by the Don Victoriano and Peniel Subanen, and the lack of cohesiveness of their tribal association, had inhibited them from benefiting from the IPRA provision. Direct observation and results of focus group discussions had led the researchers to characterize the Subanen as harmonious and generous, lending land for farming and for settlement to new inmigrants until they are able to claim their own land. The generosity may have its roots in the Subanen psyche that land is a common resource which provides means to gain a living.

Farm lots have been fragmented with the increase in population and now generally range only from about half a hectare to two hectares, and as the prospect of "claiming" more land is nil due to the NIPAS Act, these farm lots are increasingly being viewed as private property. Fruit trees now serve as boundary markers to usufructuary land; their fruits supplement the settlers' diet, replacing wild fruits which used to be harvested from the forests.

The continuing land intensification resulted in poorer natural capital for the Subanen, as the soil loses its fertility. Additional funds for farm inputs for the impoverished Subanen households in the study sites could only come from informal loans due to the absence of formal financial intermediaries. The few households in Mansawan with savings (it is significant to note that these were those involved in non-farm livelihood activities) saw this as an opportunity to sustain the increases engendered from non-farm earnings by reinvesting these in money lending. Informal credit, previously unknown to the Subanen, had its uses despite certain disadvantageous terms, such as high interest rates (10-20% a month).

Aside from new relationships found in debtor-creditor arrangements, the farmer-*comprador* (trader) relationships also emerged. *Compradors* were either from the lowlands or were Subanen residing in Mansawan who borrowed funds from local moneylenders to buy vegetables produced in the park and sell them to bigger *compradors* in the lowland markets of Misamis Occidental, who would then sell them there or to neighboring provinces. Women, meanwhile, are increasingly drawn to the trading of produce, compelled by the need to better secure proceeds of loans from moneylenders as well as income from sales. Many local *compradors* were women.

The diverse set of activities that were increasingly employed to improve livelihood suggested that households use multiple paths to get out of poverty. Compromising these efforts, however, was the continuing degradation of the environment which made livelihood unsustainable. Wanting in exposure and training, the farming skills of the Subanen failed to catch up with the requirements of commercial crop growing. The application of fertilizers, generally without guidance from a farm technician, resulted in continuous soil degradation, together with low crop yields, as nutritional imbalances occur when nutrients required by crops are not matched by those supplied by the soil and fertilizers. Pest infestations increased, owing to pest-pesticide mismatch. The on-going extraction of trees from the forests for timber and firewood further destroy wildlife habitat, several of which are already classified either as locally threatened, rare, or endangered. The ill effects of large-scale commercial logging continue to be felt and further aggravated by current practices.

Since the 90s, various government agencies, like the DENR and the Department of Agriculture (DA), as well as other foreign or locally funded NGOs, such as the PIPULI and Bukagan Ecological Association (BEA), had been doing consciousness-raising projects on the environment. In information and education campaigns, people were made aware of the value of the forests, the natural resources, and the environment. They were informed of the role of the Mt. Malindang Range watershed, and the interconnectivities and interdependencies of the different ecosystems from the uplands to the lowlands unto the coasts. Deforestation and degradation of the environment, the role played by people in bringing these about, and their adverse affects, were extensively discussed. While these environmental campaigns were not forgotten, the park settlers, given their limited options, had set the message aside. Their economic condition prevented them from taking the long-term view of a sustainable environment as the basis for livelihood and food security.

A more efficient governance is needed in the core and buffer zones. Government efficacy could be improved through better relationships and frequent communication between *barangay* officials and municipal/provincial officials, as well as with agencies directly and indirectly tasked with protected area management, such as the DENR and the DA.

The municipal and provincial governments and the agencies referred to become more responsive to the needs of its grassroots constituents when relationships are stronger. The presence of these relationships allows for better monitoring of government provision of services and, thus is likely to improve the delivery of public services. This has been observed by Winters *et al.* (2000) in several rural development projects. In the communities studied, however, only the *barangay* government was active. This severely limited the mechanism through which social capital could potentially benefit the communities.

The quality of administrative, economic, and political governance depended greatly on the skills and capabilities of the elected *barangay* officials to deliver the services needed by their constituents, and at the same time befitting the conservation status of their communities' ecology in the most efficient, effective, and economical way. An analysis of the *barangay* leadership in the area showed that most *barangay* officials had either finished elementary or high school education levels, which are essentially considered inadequate for governance, given the lack of capability building for this purpose. This would not only deter them from optimizing the performance of power attached to their positions as mandated by the Local Government Code of 1991, but could also affect the quality of administration they could carry out during their term of office. In addition, other important activities necessary to respond to development issues as poverty and environmental concerns, such as resource generation and mobilization through creation of linkages and networking with private/business, public and civil society organizations in the local, national, and international levels could not possibly be done well, if at all. The same was true in the prioritization of the funding allocation out of their Internal Revenue Allocation (IRA) and other resource generation activities for development purposes. The lack of skills in governance may seriously limit their options due to the lack of understanding of the relationships of the various aspects affecting development.

Interviews with key informants and focus group discussions, meanwhile, surfaced a perception that government programs and projects - including research undertakings conducted in the area - were lopsidedly pro-environment rather than pro-people. Environmental protection, conservation, and management were seen as taking precedence over the alleviation of poverty.

Focus group discussions conducted in the area showed that participants had knowledge on people and environment relations, as indicated by their ability to identify the consequences that could befall to nature due to anthropogenic activities. However, they considered survival needs more immediate than environmental care, given their lack of options. The issue was how to strike a balance between utilization of natural resources and conservation.

CO-MANAGEMENT OF THE PARK

Efforts aimed at raising awareness on the need to protect biodiversity and protect the MMRNP ecosystem had been mentioned. These undertakings are continuing and make use of multi-media approaches, which include a regular radio program, flyers, newsletters, comics, film-showing, exposure trips, and curricular intervention in the elementary and high school levels. A solid organizational work for community-based environmental co-management schemes could have capped the environmental consciousness-raising activities, however.

Joint NGO-government efforts to partner with the communities to manage and enhance the latter's fragile ecological resources – which was what the CARE-AWESOME project envisioned to do – seemed to bear fruit as the Mansawan and Gandawan planters organizations formed the Protected Area Community-Based Resource Management Association (PACBRMA) and had applied for its recognition by the DENR. PACBRMA is a scheme where the community co-manages resources with the government, represented by the DENR, for a period of 25 years. Eligible for this scheme are people's organizations whose members are qualified tenured migrants and interested indigenous people who commit themselves to participate in community-based projects within the protected area. The application of the Mansawan Planters' Association is for 667 ha of land to co-manage, while that of the Gandawan Planters' Association, which is joined by some settlers of Barangay Lake Duminagat, covers 331 ha. Nothing has happened to this application as of the last visit of the research team to the communities. Sadly, CARE Philippines, which was at the forefront of the AWESOME project, had already packed up in December 2005.

Prior to IPRA, the Subanen community in Peniel in the buffer zones had been granted its Certificate of Ancestral Domain Claim, but this had to be converted to Certificate of Ancestral Domain Certificate of Ancestral Domain Title (CADT) under IPRA. The provincial NCIP has reported (June2004) that the Subanen communities in the Don Victoriano core and buffer zones had applied for CADT. The Ancestral Domain Sustainable Development and

Protection Plan (ADSDPP) for both Peniel and the Don Victoriano communities have yet to be prepared, however.

The ADSDPP is an instrument promoting the fulfillment of the well-being of the current generation of indigenous cultural communities or indigenous peoples without compromising the needs of the future generation. It shall, among other responsibilities, ensure the compliance of ICCs/IPs to their responsibilities to maintain ecological balance, restore denuded areas, and provide a checklist of prioritized development projects and programs, which would serve as ready reference for collaborative efforts with development partners and/or grants of assistance to ICCs/IPs in an ancestral domain.

The process of establishing community co-management scheme is usually part of a broad community-based resource management program within thelocal government unit (LGU), given the generally low level of human capital in the community applying for co-management. This is often facilitated by an outside organization, such as a local or national NGO or a local university as in the case of Siliman University and the formation of Apo Island reserve. In the absence of CARE Philippines, the PALS program in Misamis Occidental and a Misamis Occidental university – or a consortium of the universities from where the BRP researchers are based – may provide the much needed assistance.

The case of the co-management of the Sibuyan Mangyan Tagabukid of Sibuyan, Romblon of their resources proved effective in the campaign against illegal logging and in the protection and enhancement of biodiversity (Tongson and McShane 2004). Co-management of the Apo Island Reserve, meanwhile, has deter the destruction of coastal habitats and the decline of fishery resources (Green and White 1996).

CONCLUSIONS

If the Subanen were to serve as an effective social fence against further destruction and degradation of the MMNRP, their security of tenure, land, and usufruct rights in relation to the park, and the promotion of their general well-being should be addressed. Moreover, empowering them to co-manage their resources, albeit requiring the heavy assistance of external parties advocating the twin goals of livelihood security and environmental sustainability, builds their confidence and encourages outcomes that are long lasting. This promise has found fulfillment in co-management models now existing in the country and in the rest of the world.

Conservationist elements in the culture of the Mt. Malindang Subanen are many, but current developments surrounding their survival have either relegated these into the background or have been supplanted by efforts to try to cope with their changing environment, which, unfortunately, consisted also of activities detrimental to biodiversity and the environment. Co-management involves identifying the Subanen interests and concerns in relation to the protected area; jointly developing a vision for the protected area rather than imposing this on the communities involved; negotiating an agreement to achieve that vision with roles and responsibilities and benefits and rights clearly defined; then implementing, monitoring, and reviewing the agreement. Co-management is basically a process of consultation and seeking consensus on identified issues of mutual concern to the Subanen communities, the LGU, the DENR, and other stakeholders.

While political leadership in these Subanen communities are weak, cooperation and help that are often relied upon in facing the adversities of life in an impoverished context have developed strong social cohesiveness among the Subanen. This is evident among members of religious organizations, among members of women's and farmers' organizations, and among the elders. This social capital could be tapped to support the co-management process.

NGO and government support, meanwhile, could build the capability of the barangay government which, when left to itself, could be powerless to alleviate the plight of its constituents and/or protect the immediate environment.

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FROM *PAILIS* TO *PASUNGKÔ*: NEGOTIATING THE PRESENT, ASCERTAINING THE FUTURE (Indigenous Knowledge Systems and Opportunities for Biodiversity Management and Conservation)[1]

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Many indigenous peoples in the Philippines have lived with the vicissitudes of their biophysical environment for ages, moving through river systems, across hills and over mountains that punctuate the landscape of their ecosystem. Historically, they have nurtured this intricate coexistence with the biophysical environment that provides the resources from which they derive their sustenance, at the same time, limits their activities. Nurturing this co-existence has, in the recent past, been marked by laboriousness of work, occurrence of poor harvests, lack of social services, and conditions of poor health (ESSC 1998, Kamlian *et al.* 2001). These render them vulnerable to extreme circumstances of exposure to physical difficulties (Beauclerk and Narby1988) and other non-physical problems.

Indigenous knowledge systems are those that pertain to the environments and the people's perceptions of their relationships with them. It is the systematic body of knowledge acquired by local people through the accumulation of experiences, informal experiments, and intimate understanding of the environment in a given culture. This is generated and transformed "through a systematic process of observing local conditions, experimenting with solutions, and readapting previously identified solutions to modified environmental, socioeconomic technological situations" (Brouwers 1993). Religious and traditional beliefs, practices, and rituals have evolved out of the people's relationship with the land, the forest, and other natural resources. Socio-political institutions function effectively in the control, use, and management of land.

Similar to many indigenous peoples in the Philippines, the Subanun in Misamis Occidental have indigenous knowledge systems that reflect the culture-ecosystem relationships. Their IKS has transformed over time, adapting to the changes, acquiring a syncretic nature.

REVIEW OF RELATED LITERATURE

The literature in the Philippines and elsewhere on indigenous knowledge systems and on the components thereof is vast. A good number describe the importance of indigenous knowledge for natural resource management and sustainable development. Others consist of research undertaken on traditional knowledge, gender, and conservation of bio-cultural diversity. Then there are studies on ancestral domain, land ownership, ancestral domain, and land use and management.

Among the materials intimating about the perspectives which underlie studies on indigenous knowledge and sustainable development are ethnographic literature. Some of these are found in UGAT, Inc. (1996). The papers articulate how indigenous peoples continue to struggle to "redefine themselves, to adapt to changing circumstances without the loss of identities and their sense of place that renders meaning to existence".

These materials instruct us about the continuing deterioration of the natural habitat and culture in many traditional territories of indigenous peoples. Such literature assert that the indigenous peoples have a wealth of traditional knowledge and belief systems whose efficaciousness in maintaining biological and cultural diversity is unquestionable, albeit unknown to many.

A compendium of conference papers on environment and development by Masipiqueña (2003) acknowledges that long-term studies in indigenous knowledge is important in improving sustainable management of biodiversity.

While Chambers, Pacey, and Thrupp (1991) recognize the values of local knowledge and practices, they warn against romanticizing indigenous belief systems and urge exertion of efforts to strike a balance between asserting the values

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and advantages of indigenous knowledge, as well as their limitations and potential. The theme in the essays of Resurreccion and Sajor (1998) is the assertion of the need to reassess the discourse about upland societies and the imperative to situate them in their complex histories and contemporary desires.

Other readings confirm the gender differentiations in the various roles involved in biodiversity conservation, including those that have largely remained unexplored by policy makers. Several researches underscore the urgency of action, from the state to institutions and groups that assume the responsibility of developing the land and its remaining resources and the restoration of the ecological balance. They assert that it is crucial for these bodies to recognize the essential connection between biological and cultural diversity and to acknowledge the need to integrate gender issues and environmental issues in sustainable development efforts. A number may be mentioned here, like Braidotti *et al.* (1997), Levy (1992), and Appleton (1993).

There are researches about the efforts of several groups of tribal organizations that are strengthening their capability to protect their remaining territories and manage their resources with efficiency and effectivity, and reassert the integrity of their culture. These groups seek means to create relationships with other institutions including the academic and religious and nongovernment organizations. Some of these studies are found in UNDP, TCDC, and TWN (n.d.).

Among the reference on ancestral domain, land ownership, land use and management are the researches of Burton (2002), Regpala (1996), Rodil, Sevidal Castro, and Tangian (1999), and Suminguit (1989).

RATIONALE

This study recognizes that the indigenous people possess an immense knowledge of their environments. The people's knowledge and perceptions of and their relationships with the environment are important elements of cultural diversity. Such knowledge includes systems of classification of plants and animals, sets of empirical observations about the local environment, how ecosystems function, and systems of self-management that govern resource use. As asserted by past researches, this wealth of knowledge and the belief systems are efficacious in maintaining biological and cultural diversity. Their efficiency lies in the capacity to adapt to changing circumstances, as such, achieving a syncretic nature.

The thesis of this paper is that certain elements in the Subanun indigenous knowledge systems do, in fact, exercise regulatory functions in resource use, thus, bear potentials for biodiversity management. These elements can very well synergize with modern technology-based approaches to biodiversity conservation. (Modern technology-based approaches include, among others, introduced technologies whose knowledge, processes, skills, and practices require the use of power-driven machines, or are the products of knowledge, processes, skills, and practices in the use of such machines.)

This report briefly tackles certain aspects of the Subanun cultural system, particularly their belief system, one of the basic Subanun institutions that set order to the relationship between the community and the biophysical environment. It also tackles the Subanun adaptive strategies in farming.

OBJECTIVES

This report has the following objectives:

1. to describe certain elements of indigenous knowledge systems (IKS) of the Subanun in the research sites;
2. to describe the adaptive strategies of the Subanun in the research sites and the cultural and belief system underlying these strategies; and
3. to identify the practices in Subanun traditional resource use patterns that have the potential for biodiversity management and conservation.

METHODOLOGY

Largely qualitative in design, the study benefited from a triangulation of information sources, as well as, of data-gathering techniques. The main tools used were key informant (KI) interviews and testimonies, focus group discussions (FGD), documentary review, secondary data gathering, and participant and non-participant observations.

SIGNIFICANCE OF THE STUDY

Understanding Subanun practices and adaptive strategies and the belief system underlying them sets the stage for viewing the general stability of cultures and ecosystems and the context in which to discuss the impact of traditional resource use and management schemes on the culture-ecosystem relation. Of greater importance is engendering an appreciation for how certain elements of the belief system prevent overexploitation or deterioration, sustain or conserve these ecosystems. Appreciation of these broadens the perspectives in the formulation of development policy and in the planning and implementation of development plans not only of government authorities, but also of civil society. In addition, this provides the opportunity for grounding theory on the empirical experience of the people in the study sites

STUDY SITES

The sites of this study were communities in Misamis Occidental where research had been done over the past two years since June 2003 under the Biodiversity Research Programme (BRP) for Development in Mindanao, a program jointly undertaken by the governments of the Netherlands and the Philippines, through the Southeast Asian Regional Center for Graduate Study and Research in Agriculture (SEARCA). The study from which the data for this paper was derived was conducted in the upland *barangays* of Lake Duminagat, Gandawan, and Mansawan, in the Municipality of Don Victoriano Chiongbian; the upland *barangay* of Small Potongan in the Municipality of Concepcion; the lowland *barangay* of Peniel in the Municipality of Lopez Jaena; and the lowland *barangay* of Mamalad in the Municipality of Calamba.

Barangay Lake Duminagat has the highest elevation at 1,500 to 2,200 meters above sea level (masl). There are study sites with elevation above 1,000 masl, namely Barangays Gandawan and Mansawan in Don Victoriano, and Barangay Small Potongan in Concepcion. It is these *barangays* with altitudes between 1,000 masl to 1,700 masl where the type of ecosystem is the montane forest. The study sites with elevations below 1,000 masl are Barangay Peniel in Lopez Jaena and Barangay Mamalad in Calamba whose type of forest ecosystem is colline and lowland.

RESULTS AND DISCUSSION

Cultural System and Traditional Resource Use Patterns

Indigenous knowledge system has enabled the people in Mt. Malindang to face the vicissitudes of the environment. Based on experience and tested over time, such knowledge system is user-derived and undergoes a continuing process of adaptation to culture, society, and the environment.

Subanun Belief System and Traditional Adaptive Strategies

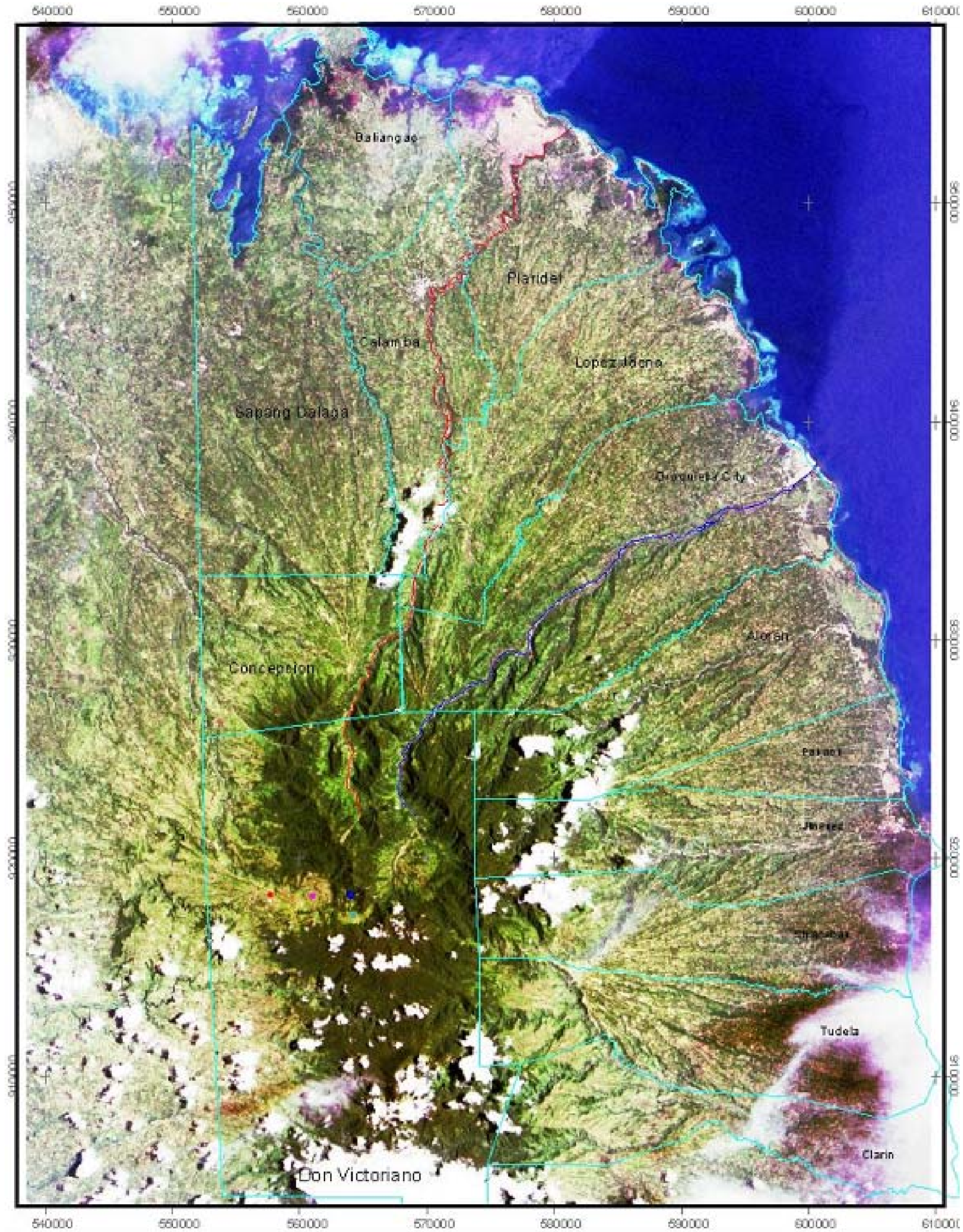
Besides information consisting of extensive and detailed knowledge of the natural environment, certain indigenous knowledge is based on customs governing resource use. Many of these customs are closely related to the belief in spirits. This belief system underlies the practices in utilizing the environment. Technologies (equipment, tools, and implements) and adaptive skills of the people, materials, experimentation, biologicals (local crop, tree species, etc.), human resources (specialists such as healers, ritualists, local organizations, council of elders, etc.), traditional instruction methods, etc., also form components of indigenous knowledge system.

The central principles of the Subanun belief system are impermanence of the world and the guardianship of the spirits over natural resources. The functions of the belief system include reinforcing people's identification with the group, enabling the Subanun to relate with the biophysical environment, and providing a sense of security in the face of uncertainties and the demands of living.

The vast expanse of what the Subanun informants in the *barangays* of Lake Duminagat, Gandawan, Mansawan, Small Potongan, Peniel, and Mamalad recognized to be natural resources were *tinubdan sa kinaiyahan*, consisting of the forests, the lake, rolling hills, mountains, streams, etc. Many of these resources, the Subanun believed, served as abode of supernatural beings (*mga tawo nga dili ingon natò*), over which they exercise guardianship. Certain other natural resources were believed to be the domain of or owned (*guipanag-iya*) by the spirits. These beliefs place some restraint on the open access to and control over such resources by Subanun farmers. The use of those resources that were believed to be the dwelling place of nature spirits is subject to the limitations imposed by these supernatural beings. On the other hand, the natural resources which were deemed to be owned by the supernatural beings set limitations on the choices among the Subanun farmers as to location, area size, and soil type of the land which they may cultivate. Thus, these areas were rendered inaccessible for use or control by the Subanun farmers without permission of the owners or guardians, while those that are neither subject to the guardianship nor ownership by immortals inevitably become potential areas for overutilization.

This regulatory function of the belief system, especially over resource access and utilization, compels the practice of rituals and ceremonies in observance of such beliefs.

In adapting to the environment, the people in the six *barangays* had identified resources according to the function derived therefrom (Appendix A). Numerous floral resources, for example, were used for food, timber, fuel, medicine or health, ornament, materials for pest control, for rituals, for *palihí* (insurance for success or safeguard against adversities).



Landsat True Color Map
September 2000 UTM Zone 51
Mt. Malindang Range Natural Park
Province of Misamis Occidental
Zamboanga del Norte and del Sur
Philippines

Figure 1. Map showing the municipalities of the province of Misamis Occidental.

Lands cleared in the forests were planted to food-producing plants. Some were traditional crops. Others were introduced cash crops. Some traditional crops had, over time, become also cash crops. Food from farming was supplemented by fish from the lake and other freshwater sources. At times, it was supplemented by meat of wild boar from the forest.

Constituting the people's responses to situations and changes in the environment, these adaptive strategies clearly presented an intertwining of resource use patterns that are traditional to Subanuns in the study sites and those that may have been sourced from non-Subanun in-migrant settlers who claim ethnic group identities such as Boholano, Cebuano, and other Visayan groups, even groups from Luzon.

Farming

The vast tracts of agricultural land in the research sites, whether in the core area or buffer zone of the Mt. Malindang Natural Park, were generally utilized for small-scale swidden farming. This was done at the base of the mountains, on slopes of or atop hills, and in the fringes of present-day forests, particularly those that had been logged over. In the case of Barangay Small Potongan in the uplands, and the lowland *barangays* of Peniel and Mamalad, farms were mainly located on plain (*napô*) areas, although slightly sloping terrain (*hanayhay*) was likewise cultivated.

Most of the farms (*ba-úl*) of Subanun informants, usually as small as below 1 hectare (ha) and as big as 2-3 ha, were located approximately 1-2 km away from their residential houses.

In selecting an area for clearing, the Subanun take into consideration their own time-tested system of identifying the area. Soil quality (according to their own assessed suitability to crops to be planted), availability of the area, and approval of the spirits were just some of the major bases for the choice of location of the farm lots. Soil quality was determined by its physical attributes which, to them, demonstrate soil fertility, like its dark earth brown color and spongy texture (not coarse, sticky, nor hard - *dili balason ug dili pilit*), with a balanced proportion of sand, silt, clay, and humus. These were among the characteristics which determine soil desirability. For Subanun in the upland *barangay* of Small Potongan, and the lowland *barangays* of Peniel and Mamalad, soil contour was the main determinant of a good farm area, that is, plain or *napô*. Their secondary choice was slightly sloping terrain or *hanayhay*. Subanuns in Barangay Small Potongan, however, considered uncultivated area within the forest as best for farming. Moreover, Subanuns in Barangay Peniel classified soil as unhealthy when it is reddish in color, clayish, and does not make plants grow well.

The availability of the area was indicated by the prolonged period of abandonment of the area or by the extended time during which trees are growing on the area. The other consideration taken into account was the traditional belief system. A few seek permission to use the area through performing traditional rituals (e.g., *pamuhat, kano-kano, pagdiwata, padugò, pa-ilis,* and *tugbong tubig*) before starting to make a clearing, to be sure that no *engkantos* or spirits will be offended or maligned in the process. In this regard, the observance of customs regarding the conduct of rituals provided a system of relating with the supernaturals, of securing acceptance by the spirits, for self-protection and self-preservation.

The choice of crops was dictated by considerations of climate, soil suitability (and in the case of cash crops, the marketability of the produce as well).

Farming involves several phases requiring knowledge, skills, materials, the performance of rituals, the observance of certain norms, etc., which are important in ensuring productive crop yield and protection of crop against pest infestation. This indigenous knowledge was articulated in the farming phases, which included, among others, clearing and plot preparation, preparation of seedlings, planting, crop care and maintenance, and harvesting.

<u>Clearing and Plot Preparation</u>. For informants in the research sites, whether Subanun, non-Subanun, or mixed Subanun, areas that were cleared for cultivation may either be *kagulangan* (forest) or lands that had been previously cultivated, or lands which had been left to fallow.

In areas that were considered *kagulangan,* clearing is locally known as *kaingin.* It is a process that involves cutting of grass and vines with the use of scythe (*lampas*), and small trees using ax (*atsa*).

Among Subanun farmers, clearing requires performance of a ritual known as *pailis* (exchange). Underlying this ceremony is the belief that supernatural beings own the forests. The ceremony is performed in supplication for use of the forest. Observing this ensures that no spirits are maligned (*dilì masalakan*) by the clearing activities.

It is the *balyan* who officiates at the ceremony, being the specialist on rituals and the expert in communicating with the spirits.

Pailis was still observed in the upland *barangay* of Small Potongan, where the collective activity still retains its dynamism among the Subanun, particularly those whose livelihood is threatened by vicissitudes of the environment. It was no longer practiced in the upland *barangays* of Lake Duminagat, Gandawan, or Mansawan, where numerous cash crop producers live and farm, who find little to relate with in the spiritual world. In the lowland *barangay* of Peniel, *pailis* was done only when the first forest clearings were made.

Meanwhile, in the lowland *barangay* of Mamalad, the pre-clearing ritual is called *tugda* or *bagti.* The ritual, now performed only by a few, is officiated by any person who is familiar with the procedures. In preparing the land for use as *basakan* (rice paddies for wet rice farming), the *padugò* is done when irrigating the fields requires diverting the river flow. This practice had declined at present time as religious ministers discourage its converts among Subanun families from continuing observance thereof.

After the conduct of the pre-clearing rituals, the task of cutting trees (*pagtagâ*) and cutting grass (*lampas*) are done. *Pagtagâ* is usually done by men; cutting small trees and shrubs requires using the bolo (*sundang*); cutting (*lampas*) grass uses the scythe. The size and location of the area that may be cleared, however, were subject to what they believed are allowed by the supernatural stewards or owners.

In sunny weather, the cuttings are set to dry for three to four days before burning (*silaban*), usually among farmers in the upland *barangays* of Mansawan, Gandawan, Small Potongan, and in the lowland *barangay* of Peniel. However, because it constantly rains in Barangay Lake Duminagat, drying seems impossible, so the cuttings are usually laid along the perimeter of the clearing to decompose as the next steps in the land preparation proceed, and planting can ensue even as the cut grass and branches are not yet set to burn. Farmers believed that decomposed material act as soil fertilizers.

Following *pagtagâ* and *lampas* is *bunglay* (weeding) with the use of *guna* (trowel). *Bunglay* is a technique for clearing in which shorter grasses are uprooted, then piled or lined along the edges of the cleared area either to be burned (*silaban*) when these are withered after a few days, or left to decompose and serve as fertilizers.

If the area had already been previously cultivated or left to fallow, clearing mainly involves *paglampas* (cutting of grasses) using the scythe, and/or *pagbunglay* (uprooting the weeds) with the use of *guna* (trowel). Cut grasses are then set along the sides of the cleared area, and then burned or left to decompose.

The establishment of new clearings in the forest through *kaingin,* however, had now been prohibited by the government, thus compelling the people to burn grass in areas which had lain fallow to clear these of weeds, grass, etc., returning to them even before the ideal fallow time is up. This had also underscored, for many research sites, the compulsion to engage in mixed farming, given the prohibition against making new clearings.

For rice, land preparation may be any of these three different types - one for upland rice and the other two for wetland rice, particularly in Barangay Small Potongan and Barangay Mamalad, respectively. Upland rice (*humay sa kamad-an*) land preparation was mainly through *paglampas* and *silab* (slash and burn) consisting of the same set of activities involved in land preparation for corn, usually done by men. For wetland rice, land preparation may take on either of these two methods, terracing or construction of rice paddies. Practised in Sitio Migubay in the upland *barangay* of Small Potongan, terracing involved the construction of earthen embankment, or surface drains or channels, across sloping land or steep mountain sides. In Barangay Mamalad on the other hand, many practised the construction of rice paddies (*basakan*), as large as 25 m x 60-70 m rectangular plots.

Rice paddies are rain-fed and/or irrigated through springs or rivers. The task involved in land preparation, being physically heavy and strenuous, was mainly done by men.

The activities of the farmers in the six *barangays* were generally the same for clearing and in the preparation of permanent plots. The exception was in the observance by Subanun farmers of a ritual before making any clearing in the forest.

<u>Preparation of Plants</u>. Preparation of seedlings for wetland rice planting, particularly among Subanuns in the lowland *barangay* of Mamalad, involved three basic activities: seed drying, soaking, and seedbed preparation. Wetland rice farming follows two crop seasons, each of which starts during a rainy month (*tindupî*). Rice seedling preparation was therefore undertaken during these same months, mostly by men, although women were deemed capable of carrying on this task.

In the upland *barangay* of Small Potongan, the practice of *padugò* (literally, "bloodletting") was observed by many in the area for both upland and lowland rice, as well as for corn. Performed individually or collectively, with the *balyan* as ritualist, this is practiced to keep pests away from the crops. It involves mixing the blood of the chicken, or of any animal that constitutes part of the offering, with the seeds. In the lowland *barangay* of Peniel, *padugò* is done in preparation for planting upland rice.

Planting. As soon as burning of cut grasses is accomplished, planting of seeds follows.

In the upland *barangay* of Small Potongan and lowland *barangay* of Peniel, planting follows after corn seeds are coated with either kerosene or alkaline solution. The linear distance between two holes is approximately two feet, such that corn plants will not overlap with one another when they grow to their full height.

Corn production takes two cropping seasons every year among Subanun farmers in the upland *barangay* of Small Potongan and the lowland *barangays* of Peniel and Mamalad - *panuig* and *pangulilang*, or the first cropping season and second cropping season, respectively. Each of these cropping seasons covers a period of four months, with planting periods (*tingpugas*) in April for *panuig*, and in August for *pangulilang*.

Planting rice is of two types, one, upland rice and the other, wetland rice. For upland rice, farmers in Barangay Small Potongan planted it on the same plot for corn during the months of March and April. It was done by both men and women as partners, in which the former dig the holes using *bunglay* and *hasok*, while the latter put the seeds into the holes then, with their hands, cover them with soil. For wetland rice in Mamalad, planting was done by uprooting seedlings from seedbeds then transplanting into the rice paddies after the 18-day period for land preparation. There are two crop seasons for wetland rice - the first cropping season (*panuig*) in June and the second cropping season (*pangulilang*) in January.

Planting is another activity that requires the performance of rituals. One of these rituals was locally known in Barangay Lake Duminagat as *paggasa* or *paghalad*. This is done before planting *kamote* or *gabi*. Consistent with their belief in the power of the supernatural beings that inhabit the natural resources, the *paggasa* or *paghalad* is performed to invoke sprits (*mangamuyò sa espiritu*) to keep watch over the crops and ensure productive yield. For the spirits who were regarded as the guardians of pests, the invocation is for the former to dissuade said pests from entering the farmers' plots, or from going beyond the marked boundaries of the territorial domain of the spirits, and from destroying the farmers plants. This may be done at home at one-year intervals. No such ritual was observed in the upland *barangays* of Gandawan or Mansawan.

In the upland *barangay* of Small Potongan, several rituals related to planting were *liso batáng*, *patadlis*, and *padugò*. *Liso batáng*, was done when planting grains (upland rice or corn) in great quantities (two or more sacks, each weighing 50 kg). Such practice is, nowadays, irregularly performed. The ritual is intended to ask permission from the spirit-owners of the seeds, as well as to request blessing for the seeds. Performed upon the *balyan's* advise, depending on the previous crop's growth, it was also called *pahabog*, which literally means "to become tall" or "heightened". Usually officiated by a male ritualist at the farm site, it is participated in by male and female adults and children, as long as they belong to the farming households contributing to the sponsorship of the ritual.

Patadlis was the planting ritual presently observed and regularly done in the farm site with members of the households sponsoring the undertaking. *Padugò* in Small Potongan was observed for planting lowland rice in great quantities. This is performed near the river at the intake point of the locally constructed irrigation canal. The blood of a pig and several chickens is poured into the water at that point. In the case of the lowland *barangay* of Peniel, the Subanun farmers, in the past, observed the performance of *liso batáng*; nowadays, it is *padugò* that is performed when planting upland rice and corn. In Mamalad, planting rituals were absent.

Subanun informants continue to observe certain other practices that have been handed down from generation to generation in planting the traditional crops. Some of these were *palihí, sal-ang,* and *paanuton/pasagbutan.*

- *Palihí*

Among the traditional farming practices which farmers observe is *palihí* (insurance of success or safeguards against adversities) in its diverse forms, depending on the purpose. It involves the simulation of the desirable characteristics of, or related to, the object or material used in the practice, such as, the full moon, low tide, saliva, ash and egg shell, stones, mat, leaf of a *babazig*, and flowery or watery plants and planting in the morning.

- Mixed farming/relay farming, *sal-ang*, and *paanuton/pasagbutan*

The practice of mixed farming by Subanun farmers is widespread for traditional crops, whether these are grown for subsistence or for cash. Commonly practiced today in the several study sites was planting in a single plot, *kamote* with *gabi* and *kanaka* along the periphery. The compulsion to engage in mixed farming had become all the more gripping in the face of prohibitions by law against the establishment of new clearings in the forest. Over time, the fallow period had shortened; maximizing the use of their small-sized *angkon* (from less than 1 ha to 3 ha) is the most urgent reason of the Subanun farmers for the practice of mixed cropping to ensure food supply year-round.

It was observed that where the provision of subsistence crops is greatly threatened by the prohibitions of law against making new clearings in the forest, the practice of mixed cropping is widespread, like in the upland *barangays* of Lake Duminagat and Small Potongan and the lowland *barangay* of Peniel. It is interesting to note that mixed cropping, meanwhile, was apparently less compulsory in areas where cash crops can be grown profitably (as in the case of the upland *barangays* of Gandawan and Mansawan), or where wetland farming is possible not only for subsistence, but also for commerce (as in the case of the lowland *barangay* of Mamalad).

Sal-ang is the practice which involves growing crops alternately in the same plot over a period of, say, four years. In such farm, the farmers skip (*sal-ang*) a plot to leave it free of any plant, and let it lie fallow (*paanuton/pasagbutan*, literally means "letting the grass grow"), after having grown crops therein for a period of time. The usual period during which a plot is planted to a crop is four years.

Crop rotation among the Subanun had been based on perceived fertility of soil as indicated in the quality and volume of produce of the current crop. For example, in the case of some farmers in Gandawan, *kamote* is planted alternately with other crops in the plot which, after a time, yields only a poor quality or small volumes of *sibuyas*. It is believed that planting *kamote* improves soil health. Growing *kamote* on a wide area not only prevents runoff, but also the microorganisms that produced from its decomposed leaves could be a source of soil nutrients. Essentially, propagation using stem cuttings allows for leaf nodes to serve as soil cover that enhances ground cover. On the other hand, when soil is assessed as *tabunok* (fertile), corn is perceived as suitable. When crop rotation fails to yield good produce, i.e., when even *kamote* can no longer thrive well therein, it is time to let the plot lie fallow. *Sal-ang*, thus, is a technique (of land and crop rotation) that allows for the best use of soil in time and space.

Paanuton/Pasagbutan is a practice that involves leaving the plot or garden to lie fallow after a period of continuous use. The length of time during which land is continuously planted to crops differs per crop group, and depends on the known suitability for a chosen crop. Plots are left to lie fallow after a period of land use. The period of land use may be between one year to 15 years. For some plots, thus, *paanuton/pasagbutan* is done for a period of as short as one year; for others, after two to three years, and still others, a period of as long as 15 years.

The length of time that land is planted before *paanuton/pasagbutan* seemed to indicate here the extent of availability of areas to till other than land lying fallow. On that count, one may say that among the six research sites, it was in upland *barangay* of Mansawan where such land was least available, and it was in the lowland *barangay* of Peniel where areas for clearing and cultivation were most available. (Ironically, though, between the two, it was in the lowland *barangay* of Peniel where the practice of mixed cropping was more prevalent, owing to the need to maximize the use of the small-sized farms for subsistence.)

Research indicated that growing different groups of crops in a three-year cycle minimizes attacks by diseases and pests. Allowing two years to elapse before the crop is grown on the same soil again would render the pests hardly able to thrive or carry over. Also, this system would ensure a more effective utilization of remnants or residue from *kamote* in green manuring.

Crop Care and Maintenance. After planting the germinated seeds or tubers to their permanent plots, key informants reported some activities, such as *pagbisbis* (watering), *pagbunglay* (weeding), *pag-abuno* (use of fertilizers), *pagpugong/pagpatay sa dangan* (pest control/eradication), and observance of ritual were undertken to ensure growth and high crop yield. It appeared that *pagbunglay* and observance of ritual (*paggasa/paghalad*) are traditional maintenance activities.

- *Pagbunglay* (weeding)

Regular weeding of plants with the use of *guna* (trowel) is another necessary activity which men and women do to free plants of grasses that might compete for space and soil nutrients. For corn and upland rice, weeding is done once for the entire crop season. In this task, children may assist their parents when not in school.

- *Paggasa/Paghalad*

To control pests, some Subanun informants used organic and inorganic pesticides, or traps. Others resorted to offering (*paggasa/paghalad*). A ritual is traditionally performed in order to invoke the spirits (*mangamuyò sa espiritu*) to watch over the crops. The ritual of *paggasa* or *paghalad* is performed by some farmers, particularly in Barangay Lake Duminagat, in supplication to the spirits for several purposes, such as to dissuade the pests from going beyond the marked boundaries of the territorial domain of the spirits guarding these pests, from entering the farmers' plots, or from destroying the farmers' plants.

- Use of traps

Farmers use traditional traps to control animals that the residents consider as pests, like rats, monkeys, and wild boars. These traditional traps are made of local materials, e.g., *gahong*, *balatik, lit-ag,* and *suyak*.

Harvesting. Harvesting or gathering the produce constitutes both the last stage of one farming cycle and the base period of another farming cycle. Different crops require different periods, modes, and tools for harvesting. The time for harvesting root crops for the first time is not the same.

Harvesting is another occasion for farmers to express their gratitude to the spirits. Farmers have different names for this ritual (*pamuhat/pagdiwata*). Farmers from Barangay Lake Duminagat called it *panampit* (invitation) or *pahalipay* (token in appreciation or share of the bountiful harvest). In Gandawan, it was called *pasungkô*. No such ritual was performed in Barangay Mansawan. In Small Potongan, a harvesting ritual called *tilaw* was performed at the time of initial harvest, especially of rice, before all crops mature and compel complete harvesting. When all the mature rice crops are harvested, another ritual called *pasungkô* is performed. Years back, in Peniel, farmers used to perform *pasungkô* as an offering to the spirits after harvesting corn, consisting of small amounts of cooked chicken and milled corn; today, it is no longer practised. Nowadays, in Mamalad, there were a few who perform the *pasungkô* or *tilaw* after a bountiful harvest. In general, the ritual is officiated by a *balyan*.

After a certain number of croppings and harvests, a farm plot may be left to fallow (*paanuton*) for a period of 1-15 years, otherwise, this is cultivated again for another crop season, either for the same crop that was previously planted or for an alternate crop in order to restore the fertility of the soil. While the plot is laid to fallow (*paanuton/ palibunan/pasagbutan*), other clearings may be made, or old clearings that had lain fallow are re-cultivated. Where there are no other areas to cultivate, the farmer is compelled to continuously cultivate the same plot.

SUMMARY AND CONCLUSIONS

By account of the informants, the natural resources were still abundant. But the government ban on the establishment of new clearings in the forests had rendered the present farms overutilized. Their testimonies indicated that crop yield was influenced by soil quality, climatic conditions, presence or absence of pests, and observance of traditional beliefs. Their perceptions of soil quality and climatic conditions, biological factors, as well as their observance of traditional beliefs had determined the nature of various practices that they undertake in their survival strategies. In addition, the observance of rituals had been prodded by experiences of illness, deaths, accidents, minimal or no harvest, or other forms of misfortune when these rituals are not performed as prescribed. Thus, there was a continuing observance of traditional practices. Informants underscored the value attached to harmonizing with the spirits in their farming activities. The traditional practices, with a belief system underlying them, were a function of the need for survival (dependent on the crop yield), not only for themselves, but also for others. The efficacy of traditional practices rendered their acceptability widespread among the Subanun across the study sites. The actual experience of the people in the efficacy of traditional practices was a compelling factor for people to resort to them when no technique, singly, accounts for good or poor harvest.

Swidden cultivation had been viewed as a time-tested farming approach in less dense upland ecosystems in the

Table 1. Land use intensity and fallow period.

Barangay	Period of Cultivation (in no. of years)	Fallow Period (in no. of years)
Upland		
Lake Duminagat	3-5	5-6
Gandawan	3-5	5-6
Mansawan	10-15	5-6
Small Potongan	3-5	5-6
Lowland		
Peniel	2-3	5-6
Mamalad	3-5	5-6

Philippines, as long as the length of required fallow period is strictly observed (del Castillo *et al.* 1994), although some may consider it environmentally destructive (e.g., Finley as cited by Suminguit 1989).

Several practices in farming were conservational. Among these were:

1. Clearing by cutting vegetative cover, then, either composting plant cuttings or burning (*silab*), only if the fallow period were longer (Appendix B, Plate no. 1).

   Many experts consider it a sound agroeconomic system for a tropical area. This is particularly true for a less dense population in an agroecosystem where no other form of cultivation is feasible or cost-effective (Atal and Bennagen 1983 as cited by Suminguit 1989). Besides, the ashes that it creates and leaves on the soil may contain nutrients, particularly potassium and phosphorous, which could enrich the soil quality and, thus, serve as plant fertilizer.

2. Mixed cropping and intercropping. The technique of multiple cropping in the same area not only allows for maintaining the health of the soil but also provides an ecologically sound way of managing pests since it renders protection against plant pest attacks or disease epidemics (del Castillo *et al.* 1994) (Appendix B, Plate no. 2 and no. 3).

3. Terracing is a farming practice which Subanun farmers in certain research sites have utilized. It is common knowledge that this farming system has proven sustainable among the Ifugaos in the Cordillera for more than 2,000 years (del Castillo *et al.* 1994).

4. Planting *kamote* all year-round. The creeping vines of this plant could very well serve as safeguard against erosive runoff, not to mention that the microorganisms that are produced from its decomposed leaves are healthy sources of soil nutrients. Another advantage of *kamote* is the manner of propagation using stem cuttings, which allows for leaf nodes to serve as soil cover.

5. Use of indigenous materials for fertilizer. Enriching soil through composting rice stalks is popular among the Subanun farmers in Small Potongan and Mamalad, as well as the use of chicken dung among those in Peniel. In the other research sites, clearing either by burning or decomposing plant cuttings, enrich soil quality.

6. Pest management through indigenous methods and indigenous traps. In areas where game resources abound, birds and wild animals like boars and monkeys constitute among the enemies of farmers. A number may have resorted to destructive means, such as the use of homemade bullet-fired guns in the upland research sites in Don Victoriano and Small Potongan, as well as in lowland Peniel; certain less dangerous homemade traps or *lit-ag* made of indigenous materials such as *giman*, *kilat*, and *gahong* are still in use.

   In Small Potongan, one safe way to ensnare birds or drive them away and prevent them from foraging into rice fields is the *hugay* – a string to which tin cans are hung, suspended across the field. When abruptly yanked, the contraption drives away invading birds (e.g., *maya*).

7. *Paanuton/Pasagbutan* or fallowing. A time for natural restoration of vegetation and soil richness is the period during which an area is allowed to take some rest from a certain number of croppings for several years (left to lie fallow or *paanuton*), ranging from one to 15 years. This largely accounts for its sustainability. While the plot is lain to fallow, other clearings may be made, or old clearings that had lain fallow are re-cultivated. Where there are no other areas to cultivate, the farmer is compelled to continuously use the same plot.

8. *Sal-ang*. This involves skipping a plot in a mixed cropping farm, leaving it free of any plant to lie fallow (*paanuton/pasagbutan*), after having grown crops therein for a period of time or after having planted different crops in a cycle, that is, whether two-year, three-year, or other period lengths. Aside from conserving or restoring soil fertility and protecting soil from erosive runoff, it ensures food supply for the farming households. *Sal-ang* also involves growing crops alternately in the same plot over a period of time. Crop rotation among the Subanun is based on the perceived fertility of the soil as indicated by the quality and volume of produce of the current crop. When crop rotation fails to yield good produce, i.e., when even the durable *kamote* can no longer thrive well therein, it is time to let the plot lie fallow. *Sal-ang* is, in this sense, a technique of land and crop rotation that allows for the best use of soil in time and space.

   Growing different groups of crops in a three-year cycle minimizes attacks by diseases and pests. Allowing two years to elapse before the crop is grown on the same soil again disables pests from carrying over. Also, this system ensures a more effective utilization of remnants or residue from *kamote* in green manuring.

9. Observance of *kano-kano/pamuhat* (rituals). Rituals observed before planting (*pailis*), after planting (*liso batang/pahabog*), and harvesting (*pasungkò*), serve as safeguards against the unregulated cutting of trees or the cultivation of nonproductive, if not harmful, crops. The restraints that these rituals carry in the use of land and its resources (e.g., trees) can have direct or indirect long-term impact on biodiversity conservation. These rituals constitute dimensions of social life that act as effective regulatory mechanisms in resource use and management in that they safeguard against unhealthy, imprudent, and degrading practices.

10. Observance of *palihí*. What may be considered valuable for biodiversity conservation is the confidence generated by the faithful and convictive observance of the practices that guarantee healthy plant growth, that ascertain the productivity of crop yield in the future. It is this assurance derived from subscribing to a belief system that serves to reduce the compulsion for applying inputs, like inorganic fertilizers, which may eventually be harmful to the environment. It is in this light that the observance of *palihí* assumes significance for biodiversity management and conservation.

The Subanun regarded human beings as stewards of the vast resources in their surroundings. In the utilization of these resources, certain cultural prescriptions and proscriptions need to be considered. Culture, thus, exists to enable people to live in harmony with other human beings and the environment with which they share life.

The Subanun, in general, followed certain cultural practices, which, to them, were conservational in nature. For example, observance of rituals prior to clearing the land allows the Subanun to come into contact with the deities whom they believed were the ones in charge of the land. The ritual itself sets rules and guidelines for the Subanun on the location of areas where clearing may be done or where it is disallowed. In so doing, the ritual exercises a regulatory function.

There were several Subanun IKS elements that were conservational. The Subanun IKS, transforming through time, may synergize with modern technology-based approaches in various ways that, while assuming a pragmatism that is cognizant of the demands and pressures of the biophysical and socioeconomic environment, are also capable of conserving the natural resource base of the environment.

That the Subanun in the research sites had survived mainly through adaptive strategies (swidden farming, among others) is not enough testimony of the quality of life that they deserve. From the accounts of the key informants and the researchers' own observation of their living conditions, Subanun farmers and their families were generally deprived socioeconomically. The income that they derived from their vegetable gardens and other cash crops could not provide for all their basic needs. Thus, they were compelled to seek other sources of living in nearby communities through contract labor, among other things. In terms of community and farm facilities, these settlers were sadly neglected.

For one, accessibility was so difficult and risky since farm-to-market roads to the more interior and higher in elevation (e.g., Lake Duminagat and Small Potongan, even Peniel) were severely rough and hardly passable by ordinary four-wheeled motor vehicle. Water systems for their household and farms, likewise, need to be adequately developed. Certain research sites had not yet been energized, unlike in Small Potongan, Peniel, and Mamalad. Health service system had likewise remained a dream rather than a reality.

There was socioeconomic deprivation in the research sites, aggravated by environmental problems of forest denudation and poor soil, coupled with the restrictions which the government had imposed against expansion of land used in farming through new forest clearings; this, in return, led to overutilization of land and eventually, reduction in soil fertility. If these communities were to serve as effective social fence against undue intrusion into the Mt. Malindang National Park, according to the NIPAS Act, their capacity to meet increasing demand for survival (partly due to population growth and to environmental changes) must be strengthened. One approach toward this goal is to utilize a two-edged strategy, that is, improvement of the quality of life of the Subanun together with environmental protection and conservation. Such a direction of development entails optimization of the productive capacity of the land with due care for the ecological environment. It is in this light that the traditional survival strategies of the Subanun farmers must be enhanced by carefully integrating them with those introduced by various sources or the modern technology-based approaches of formal science that have proven their efficacy in simulating better-situated environments, such as those in the upland ecosystems in the Cordillera, in Mindoro, Palawan, Cebu, Bukidnon, Nueva Vizcaya, or Quezon Province.

Synergizing Subanun indigenous knowledge systems with modern technology approaches in development may increase the resultant levels of sustainability. Co-evolving with such adjustments in skills, the Subanun culture had undergone transformations, as evidenced in the syncretic nature of their knowledge, techniques, and practices just described. Such transformations are contexted in the particular circumstances - vicissitudes of the environment, social pressures, market-driven economy, and constraints imposed by law - impinging on their interactions with the biophysical environment, with various stakeholders, other ethnic groups, gender groups, organizations, or institutions.

A deep sense of environmental concern was articulated by some community-based and functional organizations in the research sites, as well as the desire for environmental renewal, restoration of cultural dynamism, and identification of Subanun indigenous knowledge systems which are vital in community development interventions. Also, pertinent community-based organizations had declared their intention to access BRP studies which bear upon their proposals for community-based development interventions, including programs for biodiversity conservation. Given such condition, it is with confidence that we say, all is not lost for the ecosystems inhabited by the Subanuns.

RECOMMENDATIONS

Discussions were held with community organizations and stakeholders to consider what actions to take in light of the above findings. The concerns focused on cultural revival, environmental renewal, advocacy for biodiversity conservation through the establishment of indigenous learning centers, capability building, organizational development and institutional strengthening, and livelihood. (Appendix C contains the details of the recommendations).

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APPENDIX A. Floral resources, their use or purpose per *barangay*.

Barangay or Study Sites	Use or Purpose					
	House Construction	Fuel	Herbal Medicine	Ornamental	Rituals	Livelihood
Lake Duminagat	*Bakhaw (Termstroemia megacarpa)* *Magatalok (Gardenia longiflora)* *Malabago (Pometia pinnata)* *Gulayan (Lithocarpus* sp.*)* *Bali batang (Commelina* sp.*)*	*Malabago (Pometia pinnata)* *Lagundi (Magnolia philippinensis)* *Magatalo (Mastixia premnoides* (Elm) Hallier f.*)* *Salindata (Acer laurinum)* *Tulan manok (Chionantiws* sp.*)*	*Kalingag (Cinnamomum mercadoi* Vidal*)* *Bayabas (Psidium guajava* L.*)* *Luy-a (Zingiber officinale* Roscoe*)* *Herba Buena (Mentha cordifolia* Opiz*)* *Tabako (Nicotiana tabacum* L.*)* White flower/*Bino-bino (Salomonia ciliata)* *Hagonoy (Chromolaena odorata)* *Palina (Canarium luzonicum)* *Guillon (Bischofia javanica)* *Elipante (Stachytarpheta jamaicensis)* *Balagon nga lupon* (?)		*Palina (Canarium luzonicum)* *Kamanyan (Canarium hirsutum* var. *hirsutum)* *Bunga (Areca catechu* L.*)*	

APPENDIX A. Continued...

Barangay or Study Sites	Use or Purpose					
	House Construction	Fuel	Herbal Medicine	Ornamental	Rituals	Livelihood
Gandawan	*Guillon* *(Bischofia javanica)* *Lipata* *(Dysoxylum* sp.) *Lagundi* *(Magnolia philippinensis)*	*Lipata* (?) *Lagundi* *(Magnolia philippinensis)*	*Guillon* *(Bischofia javanica)* *Mayana* *(Coleus blumei)* *Tuba-tuba* *(Jatropha curcas* L.) Cogon (*Imperata cylindrical* (L.) Beauv) White flower/*Bino-bino* *(Salomonia ciliata)* *Kaimito* *(Chrysophyllum cainito* L.) *Scuba miawis* *(Sida rhombifolia* L.) *Busikad* *(Cyperus brevifolius)* Cogon (*Imperata cylindrical* (L.) Beauv.) *Saging* *(Musa paradisiacal* L.) *Singgam-singgam* (?) *Kulabo* (?) *Gabon* *(Blumea* sp.) *Bayabas* *(Psidium guajava* L.) *Kasla* *(Jatropha curcas* L.) Abaca *(Musa textiles* Nec)		*Hagimit* *(Ficus minahassae)*	

APPENDIX A. Continued...

Barangay or Study Sites	Use or Purpose					
	House Construction	Fuel	Herbal Medicine	Ornamental	Rituals	Livelihood
Mansawan	*Nilo/Ngilo (Magnolia philippinensis)* *Bitaka* (?) *Bintuko (Euodia confusa)* *Gulayan (Lithocarpus* sp.*)* Almaciga *(Agathis philippinensis)* *Pulayo pula (Syzygium* sp.*)* *Iba-iba (Phyllantus* sp.*)*	*Nilo/Ngilo (Magnolia philippinensis)* Twigs of wild sunflower (?)	*Anonang* (no scientific name) *Buli (Corypha utan)* *Bayabas (Psidium guajava* L.*)* Avocado *(Persea americana)* *Kaimito (Chrysophyllum cainito* L.*)* *Mayana* red *(Coleus blumei)* White flower/*Bino-bino (Salomonia ciliata)* *Busikad (Cyperus brevifolius)* *Scuba miawis (Sida rhombifolia* L.*)* Cogon *(Imperata cylindrical* (L.) Beauv.*)* *Dol-dol (Bombax ceiba)* *Kukog banog (Elephantopus tomentosus* L.*)* *Hilbas (Artemisia vulgaris)* *Manzanilla (Chrysanthemum indicum* L.*)*	Orchids *(orchidaceae)* Red palm *(Pinanga insignis)*		

APPENDIX A. Continued...

Barangay or Study Sites	Use or Purpose					
	House Construction	**Fuel**	**Herbal Medicine**	**Ornamental**	**Rituals**	**Livelihood**
Small Potongan	*Tanguile* *Kalayaan* *Kulawis* *Tungating* Round timber Falcatta *Maria buhok*	Round timber	*Handilib-on* *Hagonoy* *Tanglad* *Lalano* *Labanog* *Bunal* Mahogany Kalingag	Pitcher plant *Manan-aw*	*Bunga* (*Areca catechu* L.) *Buyo*	Rattan
Peniel	*Tanguile* *Balayong* Narra *Durungay* *Anibong* Round timber *Kalayaan* *Tanguile* *Pulayo* *Tungating* *Gulayan* Pine tree Mahogany Falcatta	Round timber Coconut leaves	*Ikog sa iring* *Arabot* *Alibutra/albutra* *Pañawan* *Tres marias* *Tagima* *Balong* *Sibukaw* *Guilan*	Orchids (*Orchidaceae*) *Ikog sa iring* *Salapid*	*Kalingag* (*Cinnamomum mercadoi* Vidal) *Dingan* (*Agathis philippinensis*) *Buyo* *Bunga* (*Areca catechu* L.)	Rattan

APPENDIX A. Continued...

Barangay or Study Sites	Use or Purpose					
	House Construction	Fuel	Herbal Medicine	Ornamental	Rituals	Livelihood
Mamalad	*Tugas* Mahogany *Lawaan* *Kalubi* *Kawayan* *Bong-bong*	Round timber Coconut leaves	*Ikog sa iring* *Kaimito (Chrysophyllum cainito* L.) *Gamot sa lain-laing kahoy* *Bulak sa manan-aw* *Mayana (Coleus blumei)*	*Manan-aw* *Salapid*	*Bunga (Areca catechu* L.) *Buyo*	

APPENDIX B.

Plate No. 1

Burning cut grass on a farm located on the plain, Barangay Gandawan

Plate No. 2

A typical farm plot of mixed crops (*gabi* and *kamote*) Barangay Small Potongan

Plate no. 3

***Pasilong*, a farm technique which involves planting *kamote* under various crops, like corn Barangay Peniel**

APPENDIX C. Workshop recommendations.

In a series of consultations/workshops with the Banwa Langaran division of the community organization *Pie'k Salabukan Banwa Na'k Suban'n Sa'k Misamis Occidental*, identification was undertaken of the aspects of Subanun indigenous knowledge systems (IKS) that were vital in community-based strategic planning for development interventions. The consultations/workshops also aimed at raising awareness on the availability of new data derived from the researches conducted under the BRP, which bear upon the plans of the communities for biodiversity conservation and other development strategies. The said consultations/workshops resulted in several aspirations that constituted the main basis for the recommendations in the report of IKS study of the BRP Socioeconomic and Cultural Studies Master Project, namely:

1. Strengthen the Subanun culture through education programs on Subanun literacy, numeracy; also renewal of values, beliefs, practices, language, dances, songs.

2. Ensure the health of the Subanun through relevant health programs. These programs should be derived from existing data, as well as new data provided by the researches in the BRP.

3. Environmental renewal
   a. Enforcement of tribal laws/customs on environmental management.
   b. Sourcing of organic fertilizer and popularization of knowledge about composting and green manuring.
   c. Protection of remaining resources by strengthened local organizations, and placement of the traditional guards, *magalong*, as forest guard.
   d. Teaching the young about environmental renewal.
   e. Agroforestry, afforestation, reforestation, cover cropping, and contour strip cropping, reversion to the forest of extremely erosion-prone cultivated areas, hastening the fallow period, and developing other terrace fields.

4. Set up indigenous knowledge learning centers. Advocacy for biodiversity conservation could very well be promoted by this learning center, grounded on the IKS elements that are conservational.

5. Capability building. Skills enhancement of the community residents is important in identifying relevant means of
   a. caring for the freshwater bodies;
   b. local governance based on Subanun methods; and
   c. integrated pest management.

6. Strengthen relations of people's organizations with local government, nongovernment organizations, and with other stakeholders for
   a. advocacy of environmental renewal;
   b. recognition of the territorial boundaries of ancestral domain;
   c. planning of and management of the ADSPP (Ancestral Domain Sustainable Protection Plan), in accordance with the observance of the right to self-determination; and
   d. securing funds and other resources for the above recommendations.

7. Animal husbandry and other livelihood activities. Other means of livelihood must be engaged in to keep them from resorting to the use of inorganic inputs to farms or from undertaking indiscriminate activities (e.g. excessive logging) in order to cope with the increasing demands for survival.

8. Small Watershed Management Households. This is as an institutional approach to afforestation/reforestation program.

SEARCA is the first among "centers of excellence" established by SEAMEO, an inter-government body that promot ce, and culture within Southeast Asia. SEARCA's core programs are Graduate Scholarship, Short-term Training, Research and Development, and Knowledge Exchange in agriculture and rural development

The Biodiversity Research Programme (BRP) for Development in Mindanao is a collaborative research programme on biodiversity management and conservation jointly undertaken by Filipino and Dutch researchers in Mt. Malindang and its environs, Misamis Occidental, Philippines. It is committed to undertake and promote participatory and interdisciplinary research that will promote sustainable use of biological resources, and effective decision-making biodiversity conservation to improve livelihood and cultural opportunities.