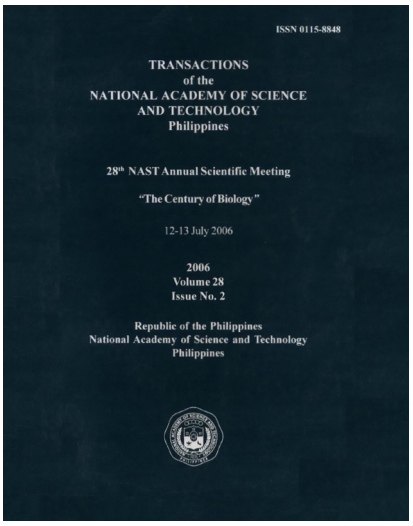
TRANSACTIONSNASTPHL
ISSN 0115-8848 (print)
ISSN 2815-2042 (online)
https://transactions.nast.ph
Vol. 28 Issue No. 2 (2006)
doi.org/10.57043/transnastphl.2006.4595

Transactions NAST PHL, is the official journal of the National Academy of Science and Technology Philippines. It has traditionally published papers presented during the Academy's Annual Scientific Meeting since 1979 to promote science-based policy discussions of and recommendations on timely and relevant national issues as part of its functions as a national science academy. Starting in 2021, this journal has been open to contributions from the global scientific community in all fields of science and technology.




# Bioresource Management and Our Common Future

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**Citation**
Rola AC et al. 2006. Bioresource management and our common future. Transactions NAST PHL 28(2): 227-254. doi.org/10.57043/transnastphl.2006.4595

*Trans. Natl. Acad. Sci. Tech. Philippines 28:227–254 (2006)*
*ISSN 0115-8848*

# BIORESOURCE MANAGEMENT AND OUR COMMON FUTURE[1]

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**Abstract**

Survival of societies largely depends on biological (bio) resources management, which is the responsible use of living resources — plants and animals, and the natural environment that support these, for both traditional and new applications. Bioresources are of two levels — ecosystems and species. Bioresources' utility also vary temporally and spatially. In the early times, when population growth was low and customary rules prevailed, bioresources were not under threat. Collective action evolved in the villages to safeguard the land, water and the biological resources for sustainable use. As countries developed, the state became the more powerful steward of all resources. While protected areas in forests and marine sanctuaries were set-up, the weak property rights, the lure of commercialism and the seeming lack of collective action to protect these resources have led to resource degradation in recent times.

It is hypothesized that governance through policies and institutions influence bioresources conditions. At the ecosystem level, the four cases of best practices cited in the paper showed that community participation, external support and local government leadership were factors for sustainable bioresource management. Species management practices have a dearth of documentation; and the paper poses some management strategies for this level. Among the recommendations is the critical role of science and technology in the development of bioresource management plans and in monitoring of desired outcomes.

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[1] This paper is a synthesis of the discussions during the Roundtable Discussion (RTD) sponsored by the National Academy of Science and Technology (NAST) Social Science Division, March 23, 2006, Philippine Social Science Council, Quezon City. Contributions from the participants of the RTD are gratefully acknowledged.

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**Keywords:** bioresource management, governance, policy instruments, institutions, genetic diversity

## Introduction

The theory that explains the causes of extinction of biological species is still evolving. As a species, the dinosaurs were seen to have inhabited the earth for the longest time, more than 175 million years. Then about 65 million years ago, they became extinct. Scientists have many theories, e.g., due to climate change, others thought that a huge meteorite hit the earth about 65 million years ago and this had caused forest fires. So much smoke and dust filled the air that sunlight could not reach the earth's surface (The Golden Book Encylopedia, 1988). But that was a "millions of years ago" story.

In the contemporary world, about 137 species of animals go extinct everyday, or about 50,000 species each year, a rate not seen since the age of the dinosaurs (Sevin, 2000). Observed causes of such high rate of extinction include habitat degradation and fragmentation, hunting, human and animal conflict, competition with domestic animals for food and water. *Homo sapiens*, to survive, became a cause of lower species extinction.

Current thinkers, however, remind us that societies survive or collapse depending upon how their inhabitants are able to manage the biological resources (or bioresources) —plants, animals and the natural environment that support these (Diamond, 2005). Bioresource management is at two levels: ecosystems and species. Ecosystems management focuses on habitats such as forest, coastal, marine, sloping lands, etc. Species management includes plant and animal species, such as rice and their wild relatives, tree species, animal species. There can also be management of microorganisms and genetic resources now used as inputs in biotechnology transformations.

In his book, Diamond (2005) identifies "failures of group decision-making on part of whole societies or other groups" as a major reason why societies collapsed. According to him, throughout recorded history, actions and inactions by self-absorbed kings, chiefs, and politicians have been the regular causes of societal collapses. As a result of lust for power, for instance, Ester Island chiefs and Maya kings acted so as to accelerate deforestation rather than prevent it.

There were four factors that contributed to this failure of group decision-making (Diamond, p.421). First, a group may fail to anticipate a problem before the problem actually arrives. But this is a constraint of illiterate societies with no writing skills and limited oral transmission. They did not anticipate the extinction problem because they had no prior experience of these problems and may not have thought about the possibilities.

Second, when the problem does arrive, the group may fail to perceive it. The most common situation under which societies may fail to perceive a problem is when it takes the form of a slow trend concealed by wide up-and-down fluctuations, such as global warming, in contemporary times. According to Diamond, politicians

call this "creeping normalcy", as it takes "a few decades of a long sequence of such slight year- to- year changes before people realize, with a jolt, that conditions used to be so much better several decades ago, and that what is accepted as normalcy has crept downwards." (p.425).

Third, after they perceive it, they may fail even to try to solve it. There are several reasons for these, which according to social scientists are driven by the theory of rational behaviour, arising from clashes of interests between people. Several of these concepts are well known in the economic and social science literature— "tragedy of the commons"[3], the prisoners' dilemma, and the "logic of collective action". This was the stage of what Diamond refers to as the ISEP— "it's someone else's problem".

Finally, the fourth explanation to the failure in decision making is that societies may try to solve it but may not succeed. The reasons given were quite obvious: the problem may be beyond their capacities to solve, a solution may exist but can be prohibitively expensive, or the efforts may be too little or too late.

On the flip side, Diamond also cites successful decision-making on the part of the whole that has brought about longer existence of other societies, and that included societies of the current times. He attributed the survival[4] to the attitudes of the leaders of these societies.

Contemporary literature has not really developed a theory that may have counter arguments to the point raised by Diamond (2005), but are mostly in support of this. These are studies about incentives of societies to manage their natural resources. The work of Rasmussen and Meinzen-Dick (1995) on roles of local organizations in natural resource management was supported by two major bodies of literature: empirical analysis of forestry, fisheries, grazing, and irrigation management and game theory literature. Resource management literature highlights the physical and technical characteristics of the resource, the characteristics of a group of users, and the attributes of institutional arrangements as key factors affecting the management capacity of organizations. Rasmussen and Meinzen-Dick (1995) further used the simplistic game theory to predict a tragedy of the commons for natural resources, although according to them, "more refined versions provide insights into the role of communication, group size, time horizons, trust, and social norms in supporting collective action"

This paper derives motivation from Diamond's theory. It is hypothesized that governance through policies and institutions influence bioresources conditions.

The paper is structured as follows: Part II discusses the evolution of bioresources management strategies in the country from the economic and political

[3] The current solution to the tragedy of the commons will be for communities to design, obey and enforce their own rules.

[4] Part of the reason why some societies succeed and other fail involves difference among environments rather than among societies. But while environmental conditions certainly make it more difficult to support human societies, in some environments than in others, that still leaves much scope for society to save or doom itself by its own actions (Diamond, p.438).

development. Part III describes the status of bioresources in the country, using a macro perspective. While the macro story appears discouraging, Part IV showcases four of the current best practices in ecosystem level bioresource management.

These evolving good practices on ecosystem management were influenced by participatory research studies and efforts of local development workers. The RTD centered on discussion about species level bioresource management and Part V tackles the challenges of designing bioresource management plan at the species level. The paper ends with a brief section (Part VI) on recommendation highlighting in particular, the role of science and technology in the development of bioresource management plans and monitoring of desired outcomes.

## Bioresource Management in the Philippines

### A. Bioresource management strategies in the early times

Historically, institutions influence resource use and management (Rola and Coxhead, 2005). Prior to colonization, tribes and communities managed their communal resources by customary law. Collective action evolved in the villages to share responsibilities to safeguard the land, water and the biological resources for sustainable use. As examples, forest and catchment areas were protected to minimize the processes of erosion and sedimentation, hence, protecting soil microorganisms; maintenance of embankments and water channels leading to paddy lands was a shared responsibility. Riparian zones were observed and safeguarded. Both local knowledge systems and community-based practices may have, in the past, ensured the sustainable harvesting and conservation of bioresources, which helped in the conservation of biological diversity over time. Long-rotation bush farming fallow systems were widely regarded as 'sustainable'.

Colonization created the elite and the masses' division in the Philippines, and the start of clashes of interests in resource use. Customary law cannot accommodate such conflicts. The state assumed the lead role in controlling resource use and access, and new resource management institutions were imposed from outside the community. But even as local offices of national resource management agencies may be established, these had no autonomy and little effective authority. Because state power was low at the frontier; the resource base becomes, in effect, open access. What followed was rapid deforestation, shortening of fallow periods and general degradation of soil and water resources (Rola and Coxhead, 2005).

In the recent times, there is growing community demand for environmental quality and resource conservation. This trend is complemented by a more general decentralization of power and authority. In the best situations, decentralization plus local demands for more environment-friendly development are to be complemented by national laws and policies. In the best outcomes, national agencies, local governments and community groups collaborate to design (and more importantly, to implement) resource management policies that are compatible with individual and community needs and aspirations.

## B. Contemporary Bioresource Management Strategies in the Philippines[5]

### Structure of Management

Current initiatives for bio resource management in the Philippines were a result of the global views about sustainable development. Sustainable development is meeting human needs of the current generation without endangering the ability of future generations to meet their needs (World Commission on Environment and Development, 1987). The Philippines' response[6] to the call for sustainable development was the creation of the Philippine Council for Sustainable Development (PCSD)[7]. The PCSD is mandated to oversee and monitor the implementation of the Philippine Agenda 21 (PA 21), the Philippines' blueprint for sustainable development, by providing the coordinating and monitoring mechanisms for its implementation. This arrangement was complicated by the fact that by law, the Department of Environment and Natural Resources remained the state's agency for overall management of the country's resources. It was facilitated when local governments began to have power over the resources within their jurisdiction. Several national departments manage resources; and this responsibility is also given to local level institutions.

### Governance of Resources

Governance of resources is characterized by a hierarchy of coverage of the institutions (national to local), multiplicity of state and non-state institutions, the different mandates or themes and the issues over its use (technical, social, economic, political) (Figure 1).

The Philippines' configuration of this governance space is in Figure 2.

The national government and its agencies totaling at least six, still have the power over most bioresources management decisions because of political clout and financial and technical capacities. The local governments are seen to be still weak in capacity and financial capability to manage resources; and devolution of this function has not been complete.

### Devolution of Resource Management Function

The *codal* provisions of the Local Government Code (LGC) strengthened the legal framework for attaining sustainability at the local level. With this power

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[5] The discussion in this section refers to current elements of ecosystems management only, although this is also very important as ecosystems are habitats of the various species of flora and fauna.

[6] As the government's commitment to the Agenda 21 agreed upon during the Earth Summit in Rio de Janeiro in 1992

[7] This is headed by the Director-General of the National Economic and Development Authority (NEDA) as Chairperson, the Secretary of the DENR as the Vice-Chairperson and with membership coming from both government and non-government organizations.

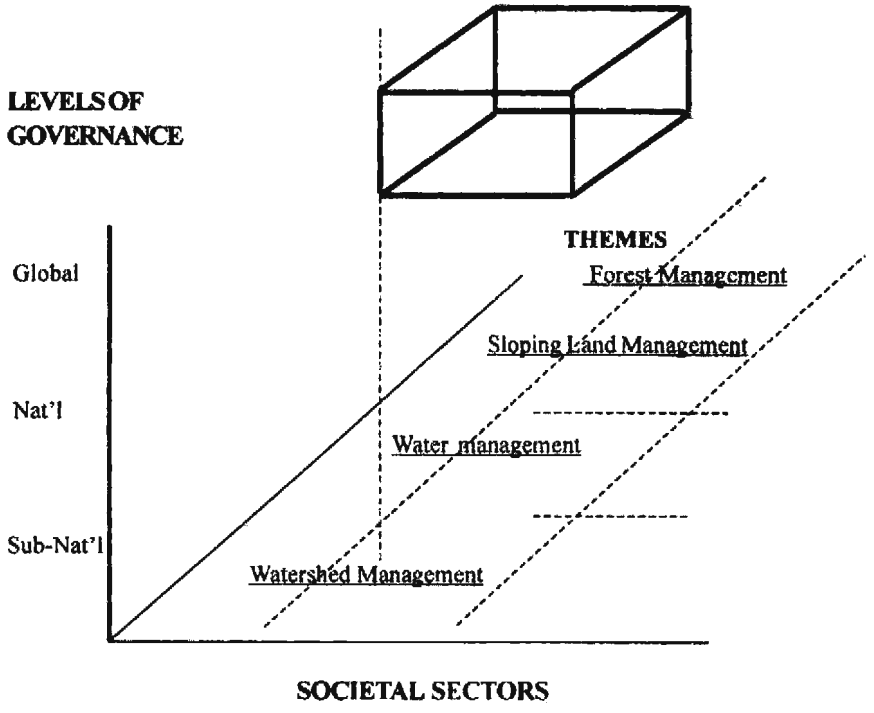


Figure 1. Three dimensions of resource governance (adapted from Malayang 2004).

shift, local governments must assume accountability and responsibility in achieving the sustainable development goals of the country. The local executives (mayors and governors) are given the mandate to "adopt measures to safeguard and conserve land, mineral, forest, marine and other resources of the municipality, city or province". The local legislative bodies are also mandated to protect the environment and impose appropriate sanctions/penalties for acts that endanger the environment. Even the village chiefs (*Barangay* captain) are given the responsibility to "enforce the laws related to population control and protection of the environment". The LGC also invoked the participation of the civil society, and the involvement of the private sector in providing opportunities for financing and developing local enterprises, and provides for the due recognition of ancestral domains and other customary rights in protected areas.

In general, the resource management planning process—from budgeting to implementation, monitoring, and evaluation including the preparation of annual investment plan, originates from the lowest level to the highest levels of governance up to the management plan of the National Economic and Development Authority (NEDA).

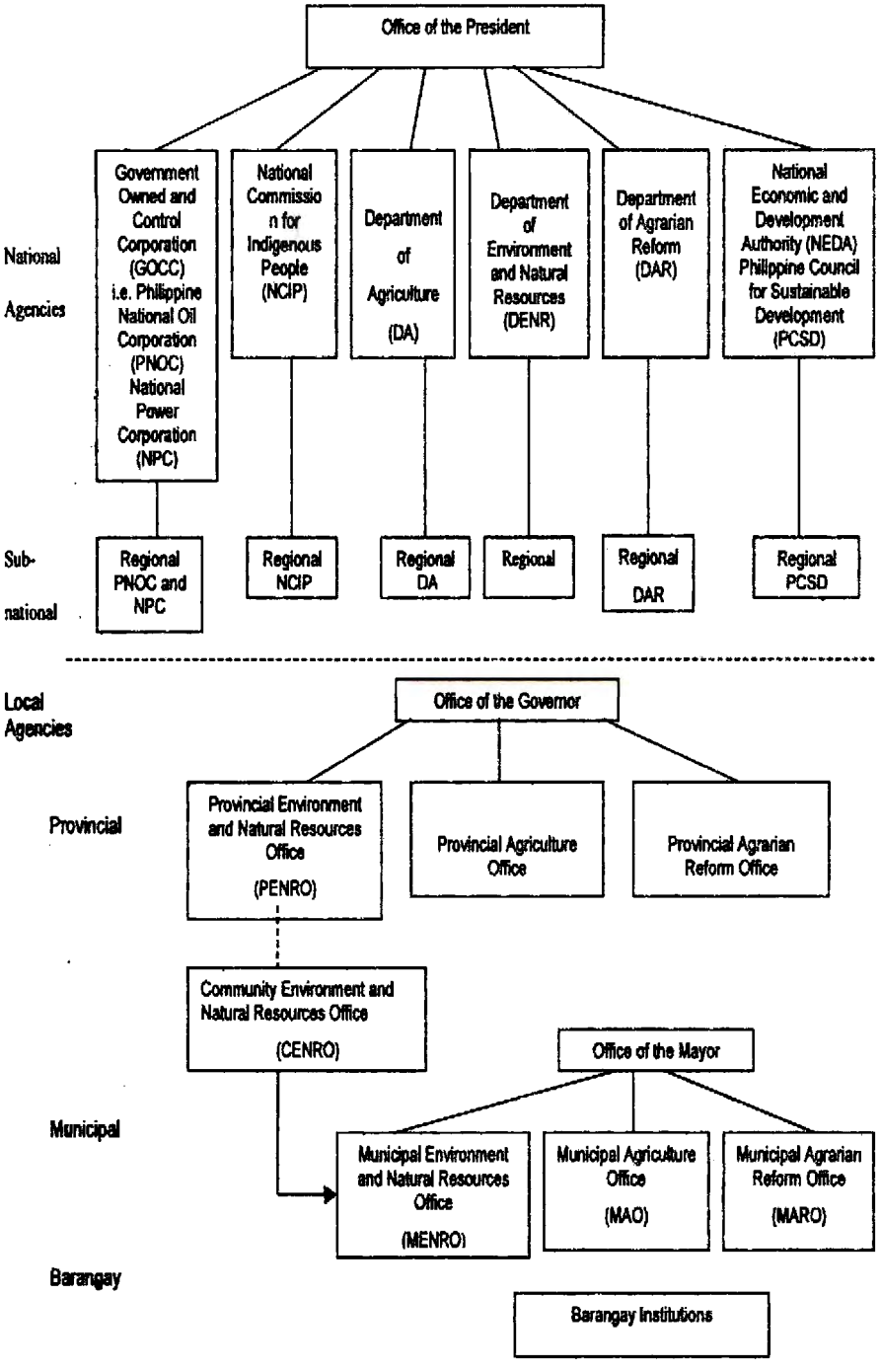


Figure 2. Resources governance in a decentralized system in the Philippines

**Policy Instruments**

The Philippines is one of the richest countries in terms of statutory instruments. There are policy instruments for forests, lands and water. There are laws such as the Clean Air Act, the Clear Water Act, the Waste Management and Disposal Law, and other environmental laws. Most of these are ecosystem level resource management instruments. The following discussion concerns three policy instruments that significantly influence bioresource habitats:

**1. National Integrated Protected Area System of 1992 (NIPAS)-Republic Act No.7586**

The NIPAS law recognizes the critical importance of protecting and maintaining the natural biological and physical diversity of the environment and declares it the policy of the state to secure for the Filipino people of present and future generations the "*perpetual existence of all native plants and animals through the establishments of a comprehensive system of integrated protected areas within the classification of national park and provided for in the Constitution*". It specifies areas with unique features for this purpose. It indeed sets the tone for bioresource management in the country. It also recognizes that administration of these protected areas is possible only through cooperation among national government, local government and concerned private organizations.

Protecting the country's natural parks (protected areas) was first recognized in 1932, when the US colonial government sponsored Republic Act 3915 establishing the Philippines' first national parks. The law declared all parks as game refuges and bird sanctuaries, created advisory committees that assisted forestry officials in managing each park and penalized illegal activities such as squatting and poaching.

Currently, for each protected area in the country, there is an assigned Protected Area Management Board (PAMB) that acts as the manager. This board is composed of members of different sectors and coordinated locally. The Chair of the Board is the regional director of the DENR. PAMB also has local government units, civil society, and indigenous communities since many of these protected areas are actually in places where there are indigenous communities. Funds for this management usually come from the national government. But resources are scarce, and most PAMBs may not really be operational at the moment. The PAMB also illustrates the fact that because environment is porous, it is not practical to assign environmental management functions to political administrative units.

**2. Indigenous People's Right Act (IPRA)-Republic Act 8371**

Hand in hand with the NIPAS law is the IPRA law which renders recognition and protection of the rights of indigenous cultural communities to their ancestral lands to ensure their economic, social and cultural well-being. The main instrument

provided is a certificate of ancestral domain title. Under this law, indigenous communities can get titles to ancestral domains that can sometimes cover thousands of hectares, and including so called ancestral waters. This law has created a lot of conflicts between the local state agents and the Indigenous People (IP) communities, especially in the access to community resources. This brings us back to clashes of interest because the group is not homogeneous, and consensus decisions on proper resource use cannot be reached.

For instance, the IPRA stipulates a "Free and Prior Informed Consent" (FPIC) by the IP communities before anybody can access or use resources in the IP areas. This can be a potential instrument for bioresource management, to wit, there should be prior consent of cultural communities to make sure that bioprospecting does not result to biopiracy, the most common sin of many multinationals prospecting in many places around the world. But we do not have a multitude of forest guards and the *bantay-dagat* knowledgeable in the very resources that make money outside of the country. Also, there is a possibility that the people who sign the FPIC can be bribed. And it is very risky socially if any official at the lowest level in charge of protecting the environment can be bribed.

### 3. Riparian Laws—The Public Land Act and the Forestry Code

The Public Land Act stipulates that applicants wishing to use the river banks would agree to maintain as permanent timberland a strip of forty meters wide starting from the bank on each side of any river or stream. This timberland is to be planted exclusively to trees of known economic value, and that the user shall not make any clearing thereon or utilize the same for ordinary farming purposes even after patent shall have been issued to him or a contract lease shall have been executed in his favor. The Forestry Code on the other hand, provides that 20-meter strips of land along the edge of the normal high waterline of rivers and streams with channels of at least five meters wide should be devoted for forest purposes; and strips of mangrove or swamplands at least twenty meters wide, along shorelines facing oceans, lakes, and other bodies of water and strips of land at least twenty meters facing lakes should also be maintained.

Non-implementation of the riparian laws could have caused the death of rivers in the country (Rola and Tabien, 2001). In current times, most of these areas, which are by law public lands, have private titles. Will local governance be able to rescind these titles and save the riparian areas, thereby minimizing river pollution from agriculture or household sources? Currently, there are programs to mitigate environmental risks jointly managed by some local governments and the community members having properties along the river banks. One of these is the establishment of village nurseries for bamboo that can be planted along the river banks (Rola et al, 2004a).

The lack of or non-implementation of bioresources management policy has brought about the increasing degradation of the country's bioresources as revealed by national level data, shown in the subsequent section.

## State of Bioresources in the Philippines

Increased demand for food, clothing and shelter due to rapid population growth are the primary drivers of resource use. Depletion and extinction occur because many resources are non-renewable. Therefore, population management (the demand side) is directly related to bioresource management (the supply side). Given the weaknesses of the institutions in the management of both sides of the equation, the future state of the country's bioresources could be in jeopardy. Recent global assessments concluded that extractive behaviour of the current generation is not sustainable (MA, 2005). The following is a discussion of the available evidences on the state of the Philippine bioresources such as forests, coastal and marine resources, and plant and animal life.

### Forests

The land area of the country is about 300,000 square kilometers, most of which was originally forested. In the past, it supplied indigenous Philippine people food, drinks, spices, medicine and lumber. The forests yielded commercial products as well, including the Manila hemp (abaca), used for making ropes, textiles and hats. Bamboo, cinnamon, cloves, and pepper plants, formed a valuable part of the early economy.

When the Spaniards came, there was 90% forest cover. Colonialists found the forests lush, which were eventually used as a vehicle to attain economic progress. Deforestation became rampant as forest products were the primary motor of development. Most of these logs and lumber fed into the ship building of the Spanish colonialists. When the Americans came in 1900, the forest cover was down to 70%. Six (6) million hectares were lost during 300 years of Spanish rule.

The Americans (1901–1944) continued the regalian doctrine introduced by the Spaniards, maintaining the state-controlled management of the forest resources. The Americans' demand for cheap timber was a motivation for formulating policies during its colonial period. As a result of forest destruction, open access to the deforested lands ensued. Absence of institutional arrangements, programs of settlement, and weak property rights accelerated the degradation of forest resources.

In 1944, during the Philippine independence from the Americans, another 6 million hectares were lost. There was a combined loss of 12 million hectares of forest cover during the Spanish and American periods. By 1990, about 40 years after American rule, 14.2 million hectares of forest cover were lost. More forest was lost under the Filipino rule than the combined colonial rule (Ong, 2006). The immediate reasons for the drastic reduction of the primary forest area are large-scale logging and conversion to agriculture, and are strongly associated with the rapid increase in human population, reaching about 70 million in 1997. Over 15 million upland people (Ong, 2006) today threaten the survival of the remaining forests, despite government effort at protection.

Preservation of the primary rain forest should be a high priority for the Filipino people to protect the remaining flora and fauna. The genes that these resources contain can be the source of technological breakthroughs for the future. The bad news is a large number of endemic species in the Philippine tropical rain forest and the forest itself are now threatened with complete destruction, making the country a "hot spot", that is, an area where there is a high probability of species extinctions (Bengwayan, 2002). Already some 52 native vertebrate species are in the critical or endangered categories, and a great many more are listed as threatened. Most endemic land vertebrates (including birds, small arboreal frogs, and many mammals) require primary-forest habitats and fail to survive in highly disturbed and secondary forests.

**Coastal and Marine Resources**

The islands are surrounded by coral reefs and have one of the richest collection of coral reefs in the world, with about 500 species found in the surrounding coral reefs. Fish of all kinds, shellfish and mollusks, are common and the Sulu pearls are world famous. But the situation in our country as far as our marine bioresources are concerned also looks rather grim. The coral reef ecosystem is a support ecosystem that produces a lot of bioresources in terms of fish, invertebrates, seaweeds and so on. But like any natural system, a coral reef ecosystem can only produce so much. If the pressure on the reefs is beyond the carrying capacity, then degradation occurs. But these ecosystems are resilient. If you release the pressure, then the resource is renewable although it takes a long time. A lot of pressure is now being placed on the marine bioresources because of population pressure. Analysis of marine hot spots in the world revealed that among the ten top marine biodiversity hot spots in the world, the Philippines ranked as number one.

**Plant and Animals**[8]

Both plant and animal species are abundant in the Philippines; the country ranks twenty-third in the world in terms of the numbers of plants to be found in the country; one-fourth of the 13,500 plant species are endemic to the country. Over one hundred and seventy thousand animal species can be found in the Philippines, ninety-eight of which are endemic. Rare species include the world's smallest monkey, the Philippine Tarsier, the white-winged flying fox, one of the world's rarest mammals, and the Philippine Eagle, the world's largest eagle. The islands have over one hundred ninety-six species of birds, including colorful parrots and many birds found nowhere else.

The number of plant and animal species in the Philippine rain forest is incompletely known. There are an estimated 13,500 plant species, of which about

[8] Source of data in this section is from Alcala (2002).

8,000 are flowering plants; about 3,200 are endemic. Plant genetic resources for instance, supply the raw materials that breeders and farmers need to attain food security. Once upon a time, corn wasn't corn and coffee wasn't coffee. Farmers created all our crops out of the wild plants. Many of these crops' wild relatives could be in existence, but could also be disappearing fast.

Philippine land vertebrate species number about a thousand: approximately 80 amphibians, some 240 reptiles, 556 birds (resident and migratory), and 174 mammals. It is the exceptionally high level of endemism that is now attracting international attention. Experts say that Philippine mammals have the highest percentage of species endemism in the world on a hectare-for-hectare basis, and this could be true for other groups as well. Seventy-five percent of the amphibians, 70 percent of reptiles, 44 percent of birds, and 64 percent of mammals are found nowhere else in the world. We have an estimate of 11,000 species of wildlife. Half of these are found only in the country, and about 16% are endangered or threatened.

In summary, in terms of bioresources status, the country is considered a hot spot. This is further revealed by the findings of the Yale's 2005 Environmental Sustainability Index, which ranked the country as 125$^{th}$ of 146 countries studied. It will be such an understatement to say that it is important to define strategies to identify, conserve, and sustainably and equitably use and manage bioresources both at the ecosystem and the species level.

## Initiatives for Bioresources Management at the Ecosystem Level: Four Cases in the Philippines

The following cases are examples of best practices for bioresource management at the ecosystem level. These initiatives have several common elements including the development of an ecosystem management plan, use of data in the planning process, involvement of external groups in the plan intervention, and collective action by the various stakeholders. The institutional arrangements of decentralized governance and more secured property rights were also found to affect the behavior of stakeholders in bioresource management.

We refer back to Diamond's theory that societies fail to do group decision-making because they were an illiterate society and that community members may not have anticipated the extinction problem. Contemporary issues point to more modern and science-based management approaches, through management plan development, but with mostly external (to the community) support. These "observers" could have some forecasts of future scenarios based on their own experiences, if no interventions were to take place in a particular community. The natural reaction by community members to collectively solve the problem once perceived is also noticeable in these examples. Among the four cases presented below, a couple reveals that environmental degradation is reversible with good bioresource management.

The first two cases are similar: they show that protected area management is important to further the goals of sustainability. The third example showcases

community empowerment in monitoring its own bioresource and how these efforts can be integrated in local water governance. The last case refers to the role that community-based technology adoption had in bringing back to life aquatic bioresources in the irrigated rice environment thus, improving the welfare especially of the poor rural folks. All of these cases revealed the importance of collective action and how they sway institutions to achieve more sustainable bioresource management at the ecosystem level. The relevance of the policy of decentralization in bioresource management also becomes apparent.

**1. Protected Area Management: The Mt. Kitanglad Range Natural Park[9]**

Mt. Kitanglad Range Natural Park (MKRNP) is the headwater source of several major river systems draining North and Central Mindanao, including the Cotabato province. Its creeks and rivers flow in a radial pattern and feed into three major rivers in Mindanao. One of these rivers, the Manupali River is an important water source that drains into the Pulangi River, a source of irrigation and electric hydropower in Bukidnon. In turn, the Pulangi River drains into the Illana Bay, a major waterway for the North and Central Mindanao. Therefore any destruction in the Mt. Kitanglad will affect to a great extent the downstream portion of the Northern and Central Mindanao.. The logging concessions grants that operated in the area in the 1970s through the 1990s resulting in significant deforestation had given impetus for a more proactive protection of the Park by the locals.

The Park, primarily located in the province of Bukidnon encompasses 40, 176 hectares. Seven municipalities and one city of the province share the boundaries at the summit. It is one of the country's priority protected area as provided for in the National Integrated Protected Areas System Law (NIPAS). In following the processes of the NIPAS law, Mt. Kitanglad was proclaimed as a protected area under the natural park category through Presidential Proclamation No. 896 dated October 24, 1996. Republic Act 8978 is its enabling law signed on November 9, 2000.

The Mt. Kitanglad Protected Area Management Board (PAMB) started operations as early as 1993[10], with the Protected Areas and Wildlife Bureau (PAWB) of the DENR spearheading the effort. The PAMB serves as the in-situ policy-making body of the park. It is composed of 59 members from government and non-government sectors, and from local communities. The Regional Executive Director of the DENR-Region 10 acts as the chair of the board, while the Provincial Planning and Development Coordinator of Bukidnon serves as an ex-officio member. Members of the board are the municipal mayors of the eight towns sharing the boundary, 28 barangay captains of the village centers of the buffer zone, 9 tribal leaders, 8 repre-

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[9] Source of data was from Rola et al (2004a).

[10] This could have been spurred by the fact that this site was chosen as one of the ten priority protected areas that would later on have external funds to start developing its management plan.

sentatives from the non-government organizations, three representatives from the media, 1 from the other government agencies and 1 from the people's organization. The office of the Protected Area Superintendent (PASu) became functional in 1994, this office is directly accountable to the PAMB. The Provincial DENR supervises the day-to-day activities but the ground management is by indigenous communities, the local governments, and representatives of the PAMB. Other institutions involved in the management are the special interest groups such as the tenured migrants, industry sector (such as commercial banana, poultry, and relay communication operators) as well as voluntary organizations such as the mountaineering societies, research and academic organizations.

International institutions are also involved in the conservation activities within the park. These external partners are generally not present in other protected areas of the country.

*The MKRNP management plan*

The Park's management plan completed in 2000 with help of partners from the science community and the NGOs field workers, is now operational. Among its management strategies are the following: (a) adoption and implementation of an effective park protection, zoning, and resource management program; (b) formulation of an integrated policy and livelihood support and assistance framework for the conservation, sustainable use and economic development of protected areas beneficiaries in partnership with the local communities; (c) ensuring biodiversity conservation awareness and information programs; and (d) institutionalization and strengthening of capacities for effective protected area management and supervision. A major part of the management is to ensure that water quality and quantity are maintained in the whole watershed, i.e. both upstream and downstream use.

*Implementing the Plan*

To make the plan workable for local officials especially those located in the buffer zone, several seminars and training workshops were held to orient and familiarize them with the implementation procedures. At the buffer zone, 370 Kitanglad Guard Volunteers (KGV) administratively under the DENR, guard the forest and watch out for forest fires. These members of the local indigenous communities or the IPs promote biodiversity conservation in the protected area and do patrol activities within the park. They report illegal activities to the DENR and PASu aside from posing as escorts to DENR personnel during visits and are responsible in hauling apprehended logs within the park. They are annually deputized by the DENR to do community-based park protection.

Because the MKRNP was enacted through a national law and PAMB has a legal personality, enforcement and subsequent prosecution of violators of the park ordinances is possible. To illustrate, 79 cases had been filed against forest violators around the park. As a result, the encroachment into the protected areas

by those seeking for agricultural and other economic opportunities had been minimized during the past decade (1994–2004).

*Financing the Plan*

Financial support for the development of the management plan to protect the MKRNP has had humble beginnings. In 1993, municipal mayors had to fund meetings from their own pockets. Having been chosen to be one of the country's 10 sites covered under the Conservation of Priority Protected Areas Project[11] (CPPAP), it was able to have funding for seven years starting in 1994.

During the life of CPPAP, funds amounting to P6.9 million were provided to the indigenous peoples for non-destructive livelihood activities (NDLA), mostly in terms of agro-forestry related projects; and PhP12 million for production related livelihood activities [12]. With the termination of the CPPAP in June 2002, the LGUs and their barangay counterparts took over funding the management of the plan. Other entities such as the DENR and the NGOs, the local indigenous and migrant communities who are directly dependent on the park continue to maintain their stake. In the later years, the local governments have also increased their funding for watershed management activities to as much as P2.6 million for Calendar Year 2002. In March 2004, PAMB, by organizing a water policy forum, solicited funds from the private companies who are resource users of the watershed services, especially water. One source of revenue of the Park comes from user fee charges for the environmental services that it offers.

Financing the plan was facilitated by several factors:

1. engagement of local communities in the activities and hence, some savings in the protection and guarding of the park;
2. local governments committed funds as a result of mutual trust among the membership of the management body, the PAMB; and
3. the trust and confidence given by the private sector to the PAMB in the management of the protected area.

The management process institutionalizes the sustainable management regime as exercised by the empowered communities (of both the IPs and the tenured migrants). These empowered communities enjoy a firm tenure over the resources, are actively involved in biodiversity conservation and protection activities, and supported by the local government, the private sector, and other community members who have internalized conservation values and the respect for cultural integrity.

One lesson learned in this exercise is that the protected area management can be implemented successfully by changing the locus of decision-making from national to local agencies (Sumbalan, 2001). Decentralizing management does not merely mean devolving responsibilities previously concentrated with the national bureaucracy but also means accompanying devolution with decision-making authority to various stakeholders. The experience in Mt. Kitanglad demonstrated

that sensitivity and recognition of cultural and local knowledge, as well as, flexibility to negotiate with various stakeholders sustained MKRNP protection and development activities. Decentralization provided a venue for the participants such as the non-government organizations, local communities, indigenous peoples, and other related projects to come together for a common purpose, which is survival.

## 2. Protected Area Management: The Tubbataha Reef National Marine Park[13]

The Tubbataha Reef National Marine Park covers some 33,200 hectares and lies in the middle of the Sulu Sea, above 150 kilometers away from Puerto Princesa, the capital city of Palawan. The reef structure consists of both fringing and atoll reefs and harbors a diversity of marine life equal to or greater than any other such area in the world. In 1983, 46 coral genera, 300 coral species and at least 40 families and 379 species of fish were recorded. In 2000, 448 species from 57 families of fish were recorded.

In the late 1980s, the conditions of the once pristine reefs of Tubbataha deteriorated due to the destructive fishing methods used by fishermen. These destructive fishing methods were carried out not only by local fishermen but also by migrant fishermen from South and Central Philippines and from Taiwan and China. Though these fishing activities were limited due to monsoon winds, the cover of living coral on the outer reef flats were surveyed to have decreased by 24% within 5 years. The introduction of seaweed farming in 1989 also threatened the reef but fortunately this was stopped in 1991.

The management issues in Tubbataha National Marine Park have evolved substantially since 1989 when reefs were at their lowest point and illegal fishing was rampant. In 1999, Tubbataha was managed and protected and the management plan is now being implemented.

Just like the Mt. Kitanglad, Tubbataha Reef management activity started with its declaration as a natural park through a Presidential Proclamation in 1988. The first draft of the management plan based on limited information was done in 1989. It was only in 1992 that a research expedition collected baseline data on the coral reefs and from there, the Park management plan was re-drafted, though illegal activities still increased. In 1994, the Park was elevated to the World Heritage status, a UNESCO program. In 1996, the Coastal Resource Management Plan (CRMP) refined the management plan in collaboration with external donors and local agencies. The PAMB was formed in 1998; a year later, a Global Environment Facility (GEF) 5-year funding for park management based on the revised plan was approved.

Monitoring of the reef became a joint venture of various organizations, including local people. The fish abundance survey reflected the relative success of the new management since the abundance of fish per unit area was 26% higher on average than in 1996. While illegal activities such as use of explosives in

[13] Source of data was from White and Ovenden (no date).

fishing was contained, the current threat is the ability or inability of the Park managers to maintain constant surveillance in Tubbataha to deter the threat of illegal entry of fishermen from the Philippines and other Asian countries. The Park Navy personnel can take active role in park management.

Whereas MKRNP was managed predominantly by the locals, the management model for the Tubbataha seems to be the predominance of external institutions in its protection and care. With its status as a UNESCO World Heritage Site, Tubbataha has acquired more sustained funding both from national and international sectors possibly because of its environmental services not only to the Philippines but also worldwide.

### 3. Community-based Water Monitoring in the Uplands[14]

Collective action by community members has made possible the monitoring of water quality in an environment of rapid agricultural growth and urbanization, and the perceived consequence— increased water degradation due to soil erosion and bacterial (*Escherichia coli*) contamination.

The Water Watch Group (*Tigbantay Wahig* in the Binukid dialect) started as a volunteer group in early 1990s to support the community based water quality monitoring project under the SANREM-CRSP SEA[15] that was being implemented in Lantapan, Bukidnon. The objectives of the project were to facilitate the development of water quality and watershed assessments by local communities, and provide physicochemical data that would be used to improve water quality and policy (Deutsch et al, 2001; Rola et al, 2004b). Local citizens, including the native tribe (*Talaandig*) members and migrant farmers volunteered to receive training in water quality monitoring and principles of watershed management.

In 1995, the core group of water monitors proceeded to form a people's organization (The *Tigbantay Wahig*, Inc.) and incorporated themselves as an officially recognized non government organization. The monitoring results of the *Tigbantay Wahig* were disseminated to community members, educators and local policy makers, resulting in more serious actions by the local government for the need to develop a municipal watershed management plan and its implementation strategies. The mandate of this group is ideal in the monitoring and evaluation scheme of the municipal level plan, as long as they can be recognized as such in the formal governance structure.

The group was able to generate support from the local government to continue with their water quality monitoring work making them formal partners in

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[14] Source of data was from Rola et al (2004b).

[15] SANREM CRSP brings together researchers from universities and specialist institutes in the Philippines, the U.S., and other countries as well as the International Agricultural Research Centers (IARCs) to work with farmers and other natural resource managers, communities, civil society institutions, and government agencies at local and national levels in the search for the means by which upland communities will be enabled to make better natural resource management decisions. The project funded primarily by the US Agency for International Development was implemented in Bukidnon from 1994 to 2004. Field activities of the third phase (2006-2010) are on going.

the management of natural resources at the municipal level. This move is also in consonance with the local government code provisions to involve communities in the management of resources. But in this case, civil society groups partnering with local governments could have been facilitated by their good mutual relations. This is of course true if the society is culturally and ethnically homogenous. Lantapan is populated by two groups: native Talaandigs and migrants mostly of Cebuano origin.

## 4. Community-based pest management and the irrigated rice environment [16]

To minimize the social costs to farmers' health and environment of too much pesticide use in rice, the technology called integrated pest management (IPM) was developed and launched in Asia in the 1980s. IPM is defined by the UN Food and Agriculture Organization (UNFAO) Panel of Experts as "a pest management system, that in the context of the associated environmental and population dynamics of the pest species, utilizes all suitable techniques and methods in as a compatible manner as possible and maintain the pest population at levels below the economic injury". IPM uses various techniques such as cultural control, plant resistance, biological and chemical control methods for the management of weeds, insects, rodents, and diseases. It uses pesticide as the last resort in preventing crop losses. Adoption of IPM in the 1980s was not very quick. In the 1990s, IPM extension was transformed: (a) from an individual to a community concern; (b) from an insect pest control to an ecology wide concern, (c) from a linear top down approach to a participatory method of technology delivery, and (d) from a traditional lecture teaching method to experiential learning (Palis, 2002). This was done through the season long farmer field school (FFS).

FFS is a non-formal education approach to IPM extension. It is referred to as "school without walls", where farmers learn together by undergoing an intensive training on IPM over the entire life cycle of the crop. Farmers meet 14–16 weeks, consisting of weekly meetings that last half a day and facilitated by the village agricultural technician. It also has an agro-ecosystem perspective where it builds on biological control as its ecological foundation and it anchored on four principles:

1. grow a healthy crop through the use of resistant varieties, better seed selection processes, and efficient nutrient, water and weed management;
2. conserve natural enemies-beneficial predators and parasites;
3. observe the field weekly to determine management actions necessary to produce a profitable crop; and
4. farmers become IPM experts and trainers.

Farmers who attended the FFS were found to improve their scientific knowledge of the rice ecosystem (Rola et al, 2002).

The study conducted by Palis (2002) in the village of Matingkis, Munoz, Nueva Ecija in both the wet and dry seasons of 1992–95 and 1999 aimed to

[16] Source of case study data was from Palis (2002).

determine the adoption and spread of IPM through the FFS, and assess the impact of IPM on farmer's livelihood and on the development of the community as a whole. The study's results showed that there was a dramatic decline in the proportion of the FFS farmers who were applying insecticides before and during the FFS and the seasons thereafter. Since then, the proportion of insecticide users had dropped considerably. Similarly, the proportion of non-FFS insecticide users dropped from more than 95% for both seasons in 1992 to 35% in the 1995 dry season and 29% in the 1995 wet season. It remained at 30% in both seasons of 1999.

Environmental impacts included the reappearance and perceived abundance of natural paddy foods such as fish of different varieties, native frogs, native snails, and others. Farmers claimed that the government's Masagana 99 program in the 1970s, which brought about intensive use of pesticides, had destroyed the aquatic life in the rice paddy ecosystem. Fishes, even in small streams, died. Fish such as the native *hito*, *dalag*, and *silap*, native shells, and shrimps disappeared shortly after the intensive use of pesticides in the 70s until the early 1990s, before IPM was practiced. Farmers in the study mentioned that they did not eat previously few available foods like tilapia because of the belief that toxic elements from the pesticides may have accumulated in the fish. Dead fish floating in the irrigation canals was an ordinary sight.

Lately, farmers had generally observed increase in the paddy food since the introduction of IPM in the village. Some of the paddy foods that disappeared during the 1970s and the 80s like native snails, small crabs called talangka, and some native species such as *sulib, silap, ayungi, gurami* and *biya* are now reappearing in increasing volumes especially the wet season. Most of these foods, found in the irrigation canals and paddy fields, augment the village food supply and anyone can gather them freely. IPM when adopted by all community members has generated benefits for everyone. Without the farmers' collective action to minimize pesticide use in rice, the resurgence of native food species in the paddy fields may not have occurred.

The cases above demonstrated that it is possible to manage ecosystem level bioresources with local participation, with external support, and with local government leadership. The common thread is that the stakeholders agreed that the resource was an important one for the survival of communities and therefore collective action was not difficult to attain.

### Challenges of Bioresource Management at the Species Level[17]

So far, the subject of bioresource management has focused on ecosystems management, mainly due to the available documentation of the cases. As a country, there is a need to look into the species level management needs, where we consider bioresources as inputs to production of goods and services for the satisfaction of human wants and needs. But bioresources (i.e. biological specimens such as plants, animals, microorganisms, etc) are global public goods whose benefits are

[17] With contributions from Macaranas (2006).

indivisively spread among the entire community. Because of this "publicness", markets fail in their allocation and governments have the natural role to provide for these goods.

**Policy on Bioresources Management at the Species Level**

In an earlier section, data showed that the Philippines is in danger of losing its bioresources diversity, and this loss is shared by the whole world, because of the large number of endemic species in the country. Initiatives for institutional and legislative framework for bioresource management at the specie level have been very limited, if not nil.

The Philippines needs a more aggressive bioresource management policy. As a nation, we are party to international laws and treaties on bioresources conservation and other related issues, but we do not have our own local initiatives.

For instance, the International Treaty on Plant Genetic Resources for Food and Agriculture is a legally-binding Treaty covering all plant genetic resources relevant for food and agriculture. The Treaty is vital in ensuring the continued availability of the plant genetic resources that countries will need to feed their people. Its objectives are the conservation and sustainable use of plant genetic resources for food and agriculture and the fair and equitable sharing of benefits derived from their use, in harmony with the Convention on Biological Diversity, for sustainable agriculture and food security. Through the Treaty, countries agree to establish an efficient, effective and transparent Multilateral System to facilitate access to plant genetic resources for food and agriculture.

Another important international agreement is the trade related aspects of intellectual properties (TRIPS) agreement which was piggybacked with the World Trade Organization Agreement. This means that countries signatory to WTO like the Philippines are now beholden to accept the trade related aspect of Intellectual Property Rights (IPR). TRIPS noted that national governments have the sovereign right over the biological resources. But increasingly, the implementing rules and regulations that defined these rights are in question by many countries.

To address these concerns, the Philippines issued an Executive Order 247[18] which states that it is the policy of the state to regulate prospecting of biological and genetic resources so that these resources are protected and conserved. Moreover, it requires the consent of indigenous cultural communities, thus, prospecting will be allowed within ancestral lands and domains of indigenous cultural communities only with prior informed consent of those affected communities.

**Development of a Bioresources Management Plan**

The following are the suggested steps in developing management plan for bioresources at the species level:

[18] But implementation of these international laws at the local level has been constrained mainly by lack of capacities and resources.

1. Define inputs to the plan

The three inputs needed for this plan are the data bases of the inventory of the bioresources in the country, the database of the skills that are needed in this exercise and the traditional knowledge that connects bioresources to their origins and use.

The more important information for management is the existing inventory rather than the losses because this is where action can be initiated. The absolute figure for bioresource inventory is not known. To start with, activities should involve preparation of an inventory of flora and fauna wealth and their genetic makeup. It will be useless to plan if we do not know the stock, i.e. the number if species we have, and where they are located.

Moreover, we need a database of a worldwide network of Filipino scientists who can help in this inventory work. There were programs to entice scientists to work in the Philippines, but these were not sustained. The contribution of many of these scientists deployed overseas have vastly improved the state of the art of knowledge in many disciplines.

Likewise, the knowledge connected to the bioresources is continuously uncovered or developed by various scientists and are transformed into goods and services through indigenous or imported technologies by business, yet it seems that the Philippines is unable to manage this knowledge base for its own development. It is equally important to document the traditional knowledge that accompany community-based bioresource use and management. Aside from data for planning, there are needs for maps of rural areas.

2. Design strategies for bioresource management

Bioresources management system should be concerned with the vision/ mission of what it is we wish to be known for in that area and how we intend to go about achieving that (Macaranas 2006). The Philippines has signed many multilateral environmental agreements and conventions that have shaped responses to the issues of bioresources management at the global and national levels. As discussed previously, we are also known for legislating national laws and developing excellent plans to implement the commitments, crafting programs where civil society plays the central roles, and devising some management processes that are recognized as best practices though not properly scaled up or implemented on a wider scale, to make any dent on the severe environmental problems facing the country.

(a) Participatory Models: Role of institutions and innovative partnerships

Communities have the starring role in the managing bioresources. They can partner with the LGU in this activity. The private sector can also

practice their corporate social responsibility by soliciting partnerships with the local communities. But despite some cases of best practices shown by the case studies, there is still fundamentally a lack of collaboration at the local level. This can be caused by lack of trust among the stakeholders.

On the other hand, some of the community-based practices in bioresource management have gone beyond the scope of what is statutory, as provided under the Local Government Code (LGC). For example, innovations like the *bantay dagat or bantay gubat* programs are not in the LGC. But they are actually being done. The cases above show that this cooperation is possible but with the right mix of elements. Therefore there is a need to understand the incentives for communities to behave so that they become stewards and managers of their bioresources. Maybe a study of the system of governance of the IPs can explain some of these differences in behavior.

(b) Financing the Plan: Investment needs and fund generation strategies

The big question is, "How do we generate the kind of resources to manage our depleted bioresources, conserve them, perhaps rehabilitate and grow the base from which our economic growth may come from?"

A couple of ideas come to light. One is to be familiar with how we can use intellectual property rights of the bioresources, and thus, generate some benefits from its future commercial use. For instance, the ayahuasca plant used as medicine by the Amazon indigenous people, and anti-diabetic herbal concoction used for centuries in India, have been patented in the US, depriving the countries from which they originated the right to use them or an equitable share of royalties. There are similar cases for the Neem tree, the Basmati rice, and the Andean root crop maca (Macaranas 2006). Thus, a major policy issue in resource management is, "how do we really share in the benefits of our own resources, and thus fund their management"?

Second, is the traditional strategy, i.e. to tap the various stakeholders inside and outside of the country. Among these are the public sector, the private sector, the external donors, and the other communities of stakeholders. The public sector can allocate a percentage of our GDP for bioresource management. Trust funds are needed for many of these protected areas.

On the private sector side, it is very clear, that in terms of investments in conservation and in science and technology areas in general, our corporations have a very poor record. There are only very few corporations that make it to the list of those who have some ecological consciousness. These corporations are convinced that we not only share a common future with them but their destiny is in the public's hands.

External donors have been actively supporting us in bioresource management. From 1978 to 2003 or a total of 25 years, available record of inflow of funds for environment was 1.2 billion dollars. External donor can be tapped because the country holds species that are globally useful (as in Tubbataha Reef Marine Natural Park). One way to entice the rich donors or philanthropists will be to name new found organisms after these donors. In other countries, bids to name newly found organisms are offered to interested wealthy persons who can provide the needed financial resources to manage the newly discovered species. Filipinos working abroad, roughly 10% of our population can also be sponsors of bioresources inventory, and conservation programs.

(c) Global trade and bioresources management
Macaranas (2006) summarizes the issues as follows:

> "TRIPS agreement is the major policy area that bears watching since global markets for bioresources will grow increasingly and it is not clear how poor countries may share equitably as their own resources are accessed by both domestic and outside businesses, and traditional knowledge holders may not be properly recognized. These are issues at the heart of its implementation. Rural livelihoods, biotechnology for new products and IPRs eventually converge from these issues."

Furthermore, Macaranas (2006) reminds us that the main concern that must be raised in bioresource management is whether the Philippines has enough skilled human and financial resources to properly implement for its own benefits the WTO and the TRIPS, among other international agreements.

3. Outputs and Outcomes of Bioresources Management Strategies

There is also a need for a scheme of monitoring and evaluation of the plan implementation; i.e. an evidence that there are improvements in the sustainability of bioresources, by establishing indicators. The indicators will assess the benefits and costs of bioresources exploitation, development and utilization. Multidisciplinary research by biologists, governance and management experts, and social scientists will be needed in the monitoring of impacts.

**Some Complementary Measures for Bioresource Management**

Bioresources management needs macro level policies, other sectoral initiatives and changes in society's attitudes and mindsets in resource use and

conservation. The following ideas from the RTD participants are complementary measures for local level bioresource management.

1. Structural changes

   If the economy shifts to more industry or service oriented jobs, then perhaps there will be less damage to our natural ecosystem. Growth of industry and service sectors can relieve pressure in the use of natural resources. To do this, human capacities for industrial or service type jobs will be needed.

2. Use of market instruments

   Markets influence consumption behaviour of people. Prices reflect scarcity. At the species level, bioresources are public and, hence, non-market goods. Therefore, valuation especially of genetic resources will have to be done.

   At the ecosystem level, a strategy is the conservation, protection and restorative (CPR) economics. Massive natural reforestation to restore the required 50% forest cover of the country's land mass and converting it into a business establishment; and a national network of marine sanctuaries to restore marine life will showcase the wealth of the country and will be attractive for ecotourism. Other CPR- like activities include cleaning of rivers, restoring aquatic organisms, establishing urban vegetable farms and herbal gardens. This can be done with private sector participation.

3. Population management

The following is an illustration of the practical impact of population numbers alone on bioresources as discussed by Ong (2006).

> If we use 1.2 billion as a number of people in China, with a one-child policy, then there are 400 million households in China. If one household will consume one chicken a night, that means 400 million chickens. So the first question is how big is the cage for 400 million chickens? The estimate is ten times the campus of Diliman, just to house the 400 million chickens for one night's consumption. And how much feed do you need for the chickens? So farms will have to produce for chickens, not just humans. And how big a farm do you need to produce feeds? How much waste will be produced? And how much feathers will be produced, in case you develop a pillow industry? And remember this is only for one night' consumption; imagine how much China would need in one year.
>
> —Ong (2006)

This point shows that population management is just as important as bioresources management. Population programs have to be seen as complementary measures. Many believe that a vigorous population management effort is essential for the sustainable development of the country.

4. Changing MAPs and bridging GAPs

As discussed by Ong (2006):

> MAP refers to mind set, attitude and practices. GAP is Goal, aspiration, promise. No single individual or organization can be successful in the campaign to save the Philippines from being a biodiversity hotspot. To change mindsets, for instance, one can shift to CPR. Our attitude towards consumer products and our practices will have to change. There is also a need to set goals that will serve as the target, something to aspire, a promise. Changing maps and bridging gaps could be the key to ensure our common future and survive as a people.

This needs group think, social structures and collective action. This means anticipating and working for the common good.

## Conclusions and Recommendations

Based on the empirical evidence at the ecosystem level, institutions such as the PAMB and policies such as decentralized governance could potentially have an important impact on bioresource management. While the ecosystems serve as habitats of species, what is perceived to be urgently needed are measures to assure that species are themselves managed properly, in as much as loss of species qualify the country as "hot spots" in terms of internationally crafted biodiversity indicators. Participants to the roundtable discussion had several innovative ideas to make this happen as summarized in the previous section.

From the discussions, recommendations can be drawn as follows:

1. Institutionalize bioresource management planning.
   The major recommendation from the discussions was to make bioresources management an integral part of the development plans. This planning exercise starts at the lowest level of governance.

2. Capacity building will be needed.
   The science community can build capacities at various levels, such as creating database for inventories of species, introducing participatory approaches and defining good governance indicators. Fund management skills by local officials are also to be developed.

3. Science-based bioresource management planning is ideal.
   It was revealed that science contributed to the protected area management planning by supplying the necessary data to the decision makers. In ideal

situations, scientists shall continue to work with the other sectors including government especially in developing monitoring and evaluation techniques to monitor outcomes and evaluate the performance of these management strategies.

4. Multidisciplinary teamwork is imperative.
Bioresource indicators are biological variables; management and governance concerns are social sciences, therefore, a multidisciplinary team is needed to work with the implementers of the management plan. Researchers and development workers can also help in evolving community-based institutions that would be relevant for bioresource management.

5. Develop a policy on benefit sharing.
The question of benefit sharing in the commercial use of bioresources should be studied rigorously, to have potential sources of funds for management.

6. There is a need to study the indigenous peoples' governance and management practices, considered as having sustainable outcomes.
Most of the studies in the past focused on resource management practices, including anthropologic and cultural norms of IPs. Studies can also include their governance sanctions, norms, and incentives.

7. Identify ways to integrate information and communication technology in bioresource governance.
Maps will be needed, so use of GIS can be handy. Mapping will not only be an exercise of identifying and locating the species, but also of knowing its value or use.

8. More efforts on theory development to support empirical work on bioresource management will be needed.
Theoretical underpinnings of meso-level analysis of factors that condition governments, the private sector, local organizations and other stakeholders to work together to support a more sustainable, equitable and efficient bioresources management decisions need more study. Understanding these factors may create a more significant dent to achieve sustainable development.

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