STATUS OF MANGROVE RESEARCH AND MANAGEMENT IN THE PHILIPPINES: CHALLENGES AND OPPORTUNITIES

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1. Introduction

The documented history of research and other studies on mangroves in the Philippines date back to the 17th century (1600–1699). This was mentioned in a book entitled, "*Libro de medicinas de esta tierra y declaraciones de las virtudes de los árboles y plantas están en estas Filipinas*" ("Book of medicines of this land and declarations of the virtues of trees and plants of the Philippine Islands"; De Mercado 1665–1698 cited by Zamora 1983). Historical research has enhanced the understanding of past human influences on mangroves and has provided insights that can improve current conservation and management efforts. This study presents one of the most comprehensive studies on mangroves in the Philippines. Historical changes in the country's mangroves and their use were examined in 875 published accounts for 1698–2014, a period of 316 years.

2. Sectoral, Regional and Topical Contributions to the Mangrove Literature

Six categories of institutions or sectors have been identified as contributors: academic and research institutions, peoples' organizations (PO), government (GOP), nongovernmental organizations (NGO), foreign international agencies (IA) and Others (Fortes & Salmo, in press). Understandably, academic and research institutions contributed 47% to the body of literature. It is followed, in the order of decreasing contribution, by Government (23%), Others (17%), NGOs (11%), and IAs (2%). The category "Others" are those individuals or groups without identified affiliations (**Fig. 25**).

In relation to the regions of the country, the following regions stand out (in the order of decreasing contribution; Fortes & Salmo, in press): Region VII (Central Visayas), Region IVA (CALABARZON), Region VI (Western Visayas), Region IVB (MIMAROPA), and Region V (Bicol) (**Fig. 26**, complemented by **Fig. 27**). The contributions of the other regions varied with the National Capital Region (NCR), Region IX (Western Mindanao), Region XII (Central Mindanao) and the Autonomous Region of Muslim Mindanao (ARMM), which have the lowest contributions. Knowledge contributions from Regions I (Ilocos), II (Cagayan Valley), III (Central Luzon), VII (Eastern Visayas), X (Northern Mindanao), and XI (Southern Mindanao) were variously intermediate. CAR (Cordillera Administrative Region) is landlocked and has no mangroves.

Interestingly, the greater bulk of what we know about our mangroves is directly tied up with the history of the degree of their use and availability, access to higher educational institutions, and presence or absence of mangroves. This is shown by the relative preponderance of publications in Central and Western Visayas, CALABARZON, MIMAROPA, and the Bicol Region. It should be noted that some of the earlier studies on mangroves were undertaken in the NCR. But probably because of urban development pressure, mangroves had to give way and were almost completely destroyed. Hence, our knowledge about them remains only in cursory and esoteric reports on fishpond development and in environmental impact assessments attendant to industrial and commercial constructions (Fortes & Salmo, in press).

In this paper, mangrove studies in the Philippines are initially categorized under seven topics: Taxonomy, Physiology, Economic Uses, Biogeography, Ecology, Biodiversity and Conservation and Management (Fortes & Salmo, in press). **Fig. 27** shows the distribution of literature on mangroves in the Philippines among the seven major research topics and at decadal periods from 1698–2014. The effort started with focus on the utilization of the resource and the more basic natural sciences that date back to the late 1600s. This was pursued until the mid-1900s. After this period, a significant increase in the effort was seen, especially in mangrove uses, taxonomy and conservation. This trend was consistent with the rising need of that time to respond specifically to the economic and environmental problems and imperatives. The 1970s was the "decade of awakening" on mangroves and fishponds. From 1977–1979, the then National Mangrove Committee of the DENR, formulated a national mangrove research and management program and implemented high intensity of mangrove studies, symposia and conferences.

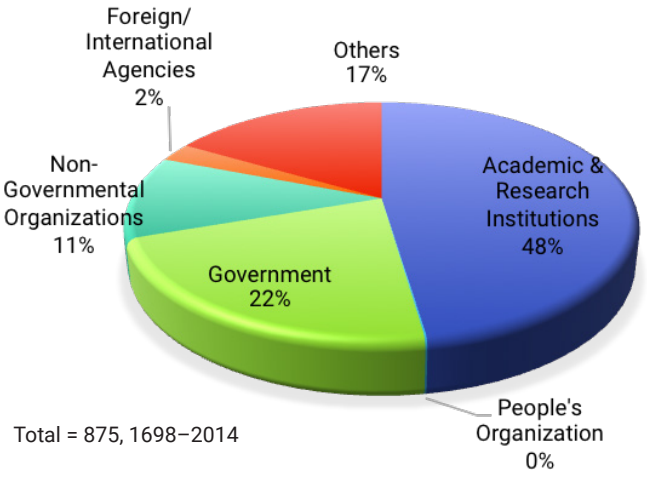


Figure 25. Contributions by institutions or sectors to the literature on mangroves in the Philippines (Fortes & Salmo, in press).

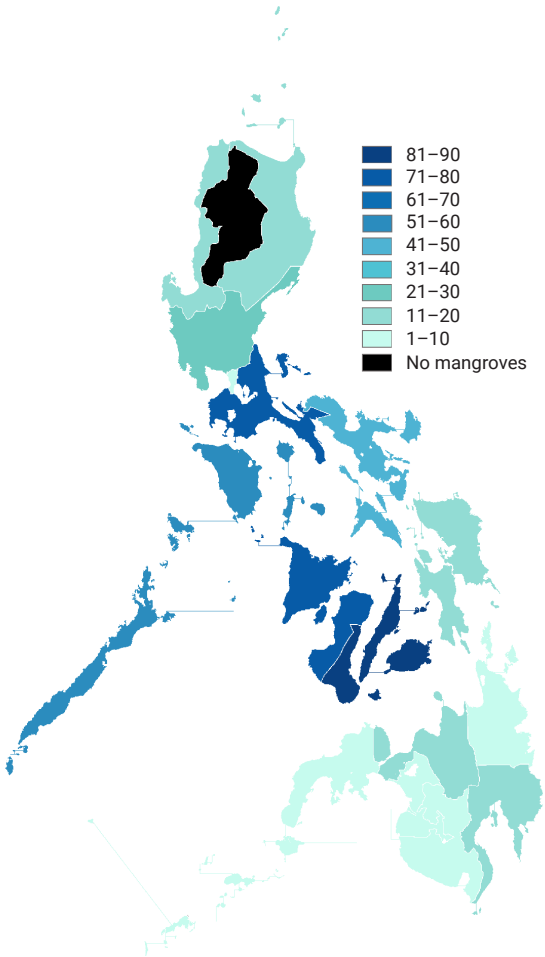


Figure 26. Regional distribution of literature on Philippine mangroves.

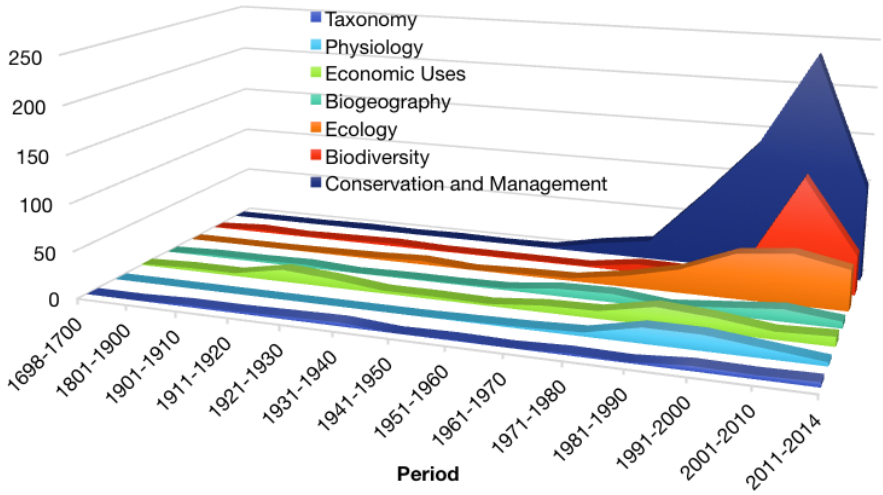


Figure 27. Distribution of literature on mangroves in the Philippines among the seven major research topics and at decadal periods from 1698–2014 (Fortes & Salmo, in press).

From the 1980s up to the present, studies under the seven topics continued with much greater vigor. Hence, in terms of research topics where the 875 literature materials are distributed, **Fig. 27** shows a clear bias towards the topics Conservation and Management, and Biodiversity and Ecology. These topics are fueled by directly aligned emphasis required by the funding institutions, e.g. the Fisheries Sector Program of the Department of Agriculture (FSP, 1992–1993), Coastal Environment Program of the Department of Environment and Natural Resources (CEP, 1993), the National Mangrove Inventory undertaken by the National Mangrove Committee of the then National Resources Management Center (NRMC, 1990s), and Coastal Resources Management Project (CRMP, 1996).

3. Mangrove Literature in the Philippines: Grey vs. Peer-reviewed

Among the 875 published works written during the period 1698–2014, 85% belong to the grey literature, while only 15% are internationally peer-reviewed (**Fig. 28**; Fortes & Salmo, in press). Three important implications of this finding include: (1) there has been huge investment on mangrove studies, which are largely unsystematic, "reactive," and mainly descriptive, not synthetic; (2) mangrove research in the Philippines, having non-robust empirical basis, has largely been marginalized to literature with outcomes having little reliability and predictive value; and (3) with reference to the preponderance of published works dealing with conservation and management (see **Fig. 28**), it is alarming to consider that mangrove conservation and management in the country, despite huge financial investments, lacks scientific inputs.

It should be emphasized, however, that in this paper, both ISI-indexed and grey literature are given equal importance, since it is our intent to mainly point out the history of research on mangroves. More importantly, in conservation and management, we give greater concern to the needs of varied users of the ecosystem's goods and services, plus policy decision makers who have less opportunity to access ISI literature, much less understand and use them directly to address their needs. Hence, the impact factor of an academic journal based solely on the number of citations, when used as a proxy for its relative importance, does not apply here. Interestingly, for a fisher, a boatman or a common local government official, a visually appealing and easily understandable and obtainable poster or a brochure is more useful than a rarely accessible and incomprehensible ISI-indexed article. It is desirable, though, that the latter published materials should result from high quality peer-reviewed journals.

4. Challenges and Opportunities for Mangrove Research and Management

It is clear that the early years of mangrove research in the Philippines is characterized by a high degree of impetus for fundamental research, which is influenced by the bright research atmosphere in the region. This impetus, however, soon waned in favor of direct utilization and protection of the resource infrequently backed only by 'research' with low degree of reliability and predictability (hence, sustainability). The imperatives of the times, however, has changed, characterized by rapidly dwindling coastal resources, largely influenced by equally increasing destruction of the habitats imposed by both natural calamities and human-controlled activities. The time is now calling for a renewed emphasis on research that directly and effectively addresses the need to support conservation and management of the resource. This effort should be focused on sustaining its ecosystem services through developing the resilience of coastal communities in the face of environmental uncertainties. This is

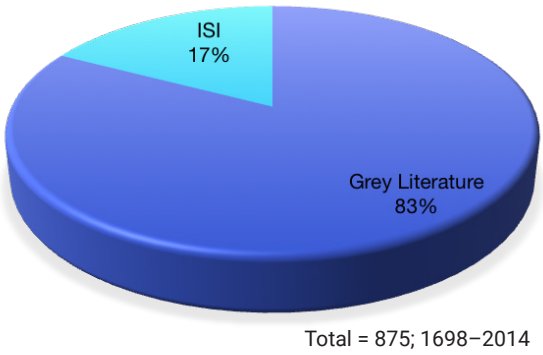


Figure 28. Number of ISI-indexed and grey literature in mangrove studies in the Philippines (1698–2014; Fortes & Salmo, in press).

the greatest challenge posed to mangrove managers. However, it could also be a big opportunity for them to improve and enhance existing practices and outlook on the resource. Some of the aspects of this challenge are discussed below.

5. Mangroves, Climate Change, and Natural Disasters

Although empirical data are still wanting in the Philippines, climate change is affecting mangroves principally through increasing temperature, which will tend to shift the vegetation to higher latitudes. On the other hand, it may cause potential problems through changes in rainfall pattern, increased frequency of storms, altered CO_2 levels, and possibly the impact of ultraviolet radiation. The changes in rainfall pattern now appear to alter flowering in some species in the southern Philippines, while the most obvious impact is the increased intensity of storms, which, in mangrove areas, have uprooted young and newly reforested areas (Fortes & Salmo, in press). If storms or their effects intensify over the next century, mangrove community structure and dynamics would inevitably be altered, bringing about a change in the timing and degree they make available their services to coastal communities.

Accelerated sea level rise (ASLR) is one of the most certain outcomes of global warming. With a coastline of 36,289 km, the Philippines take a serious view of the potential effects and possible responses to ASLR. The physical effects of sea level rise include inundation (submergence) of low-lying wetland and dry land areas, erosion, saltwater intrusion, increased risk of flooding, and storm damage. In turn, these physical changes may cause substantial socio-economic losses of coastal structures, both natural and man-made, and dislocation of the population and change of livelihood. The same physical changes may bring about certain ecological consequences such as redistribution of wetlands, destruction of coral reefs, reduction in biological diversity and loss of wildlife, and changes in the biophysical properties of the coastal zones. To avoid these unwanted changes, it may be necessary to

invoke a range of possible responses such as construction of seawalls and dikes, upgrading of coastal infrastructure in consideration of high water levels, relocation of coastal populations, mangrove regeneration, or other options. The threat of sea level rise (and associated changes in sediment dynamics and salinity) will inundate low-lying mangroves and erode their substratum. If sea level rise accelerates, some additional sites would also begin to slowly deteriorate and submerge. In some areas, the sinking or subsidence of the mangrove system, coupled with human development, is the major cause of wetland loss (Fortes & Salmo, in press).

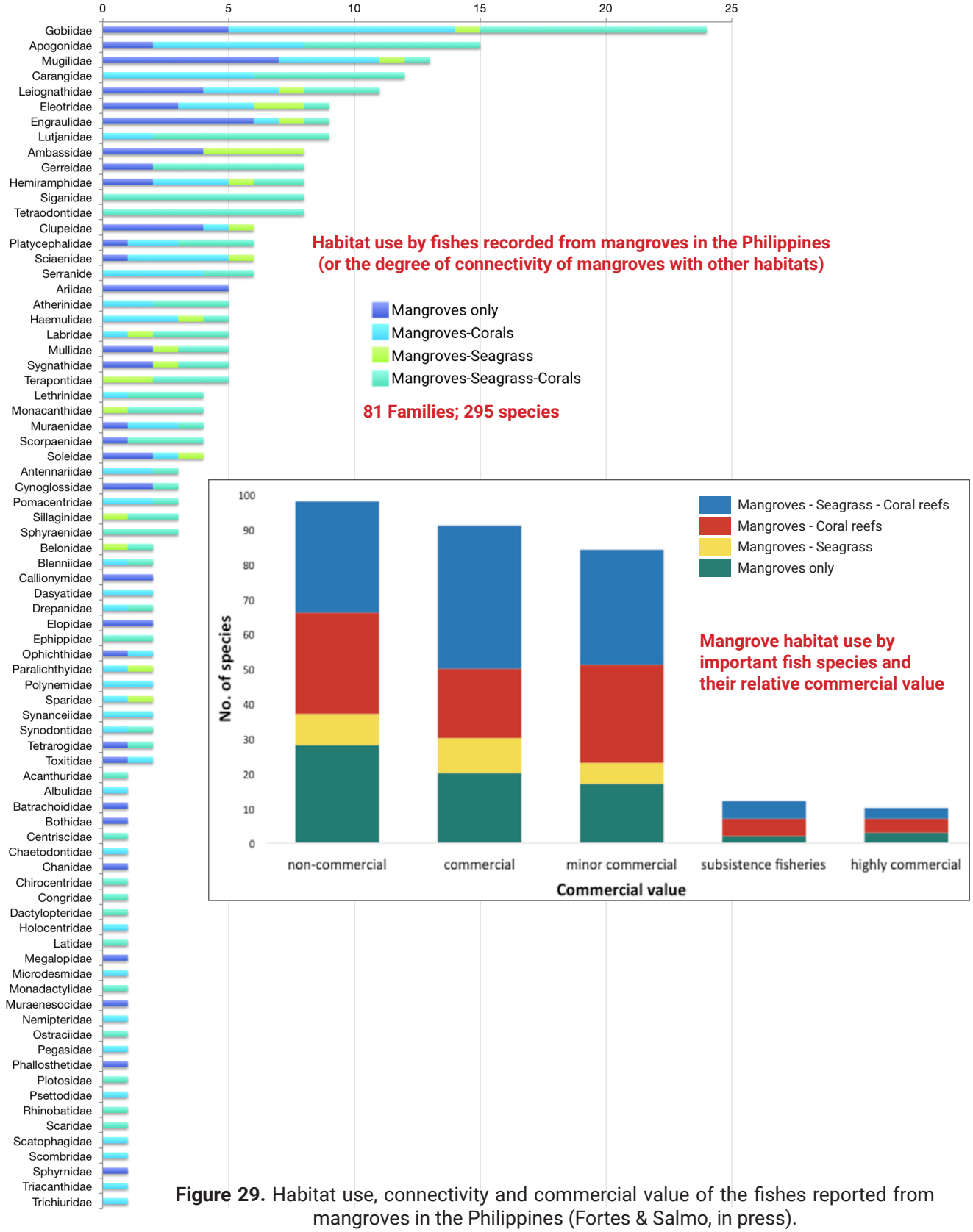


Figure 29. Habitat use, connectivity and commercial value of the fishes reported from mangroves in the Philippines (Fortes & Salmo, in press).

6. Habitat Use, Connectivity and Commercial Value

In the Philippines, a total of 295 fish species belonging to 78 families was found in mangroves, of which 139 can also be found in seagrasses, and 200 also in coral reefs (**Fig. 29**; Fortes & Salmo, in press). **Fig. 29** implies that habitat use by fishes from mangroves may reflect the degree of the connectivity among the habitats. The three most dominant families in terms of number of species listed were Gobiidae (gobies, 24), Apogonidae (cardinalfishes, 15), Mugilidae (mullets, 13 species), Carangidae (jacks and pompanos, 12 species); and Leiognathidae (ponyfishes, 11 species). Majority are carnivores that mainly feed on benthic invertebrates and small fishes. The community overlaps suggest that: (1) mangroves provide additional structural and functional services to those found in adjacent seagrass beds and coral reefs; and (2) these habitats are interconnected through fish migration.

These ecosystem services are not only important in maintaining the population structure of fish and other marine organisms, but also in supporting the livelihood of fishers that depend on fishery resources. Out of the recorded species of mangrove-associated fish, 197 have commercial importance (i.e. highly commercial, commercial, minor commercial, subsistence fisheries). This denotes that the mangrove ecosystem supports 27% of commercial fish species in the Philippines (FishBase 2014) and highlights the contribution of these habitats to food security. This also calls for further protection of this habitat in light of its rapid degradation. More information on the ecosystem services of mangroves are given below.

7. Mangrove Ecosystem Services and Human Well-being

People are aware of the fast depletion of mangroves. They are also aware of the importance of proper supervision of mangrove planting activities. People are currently recognizing that the ecosystem services of mangroves are tied closely with their well-being (**Fig. 30**). **Table 18** gives the status of our knowledge on the integrity of the mangrove ecosystem, and the services it provides, especially to coastal communities (Fortes & Salmo, in press).

8. Systems Analysis of Mangroves

With all the data and information now available, and being generated by numerous sectors and individuals on Philippine mangroves, the time is ripe to seriously adopt a systematic approach to the conservation and management of the natural resource. This way, the interactive nature and interdependence of external and internal factors in the ecosystem will be emphasized and be the focus of continuous studies and research. The outcome could be used to evaluate the ecological and market elements that affect the integrity of the system, and profitability of business initiatives emanating from it. In simpler terms, the approach could help in understanding how components of the ecosystem, living and nonliving (e.g. air, water, movement, plants, and animals), influence one another within one complete unified whole; or in understanding the larger system that makes their lives "healthy" or "unhealthy", or for them to survive or perish. **Fig. 31** (Fortes 2010, modified from MEA 2005) is an example of how the mangroves in the Philippines are looked at using the system analysis approach.

9. Mangroves as a Blue Carbon Ecosystem

The global community established the International Blue Carbon Initiative, a transdisciplinary, global program focused on mitigating climate change through the conservation and restoration of coastal and marine ecosystems. It coordinates the International Group of Experts on Blue Carbon (IGEBC), which has formulated an action agenda to "identify effective, efficient and politically acceptable approaches to reduce the atmospheric concentration of CO_2." Together with the International Blue Carbon Policy Working Group, it provides guidance for needed research, project implementation and policy priorities.

The IGEBC has identified mangroves as a 'blue carbon' ecosystem, together with seagrasses and wetlands. Recent reports produced by the United Nations Environment Programme and International Union for Conservation of Nature (e.g. 'Blue Carbon' and 'The Management of Natural Coastal Carbon Sinks,') found that, when healthy, mangrove forests, saltwater marshlands and seagrass meadows are extremely effective (up to 100 times faster and more permanently than terrestrial forests) at storing atmospheric carbon, thereby mitigating climate change. Hence, by conserving these "blue carbon ecosystems," carbon offsets could be far more cost effective than current approaches focused on trees. Preventing mangrove forest removal gives opportunity for countries to benefit from carbon payments for the preservation of threatened carbon stocks (Barbier et al., 2008). Furthermore, there would be substantial add-on benefits to biodiversity, fisheries, tourism and coastal protection–providing a strong argument for their protection and restoration. On the other hand, Lovelock et al. (2011) provides the first global impacts of carbon emissions that result from coastal ecosystem conversion, in addition to its economic implications. They estimate that 0.15-1.02 Pg (billion tons) of carbon dioxide are being released annually, resulting in economic damages of USD 6–42 billion annually. Indeed, "blue carbon provides a new opportunity for motivating and supporting coastal ecosystems conservation globally, hence, for sustaining the multiple benefits these ecosystems provide."

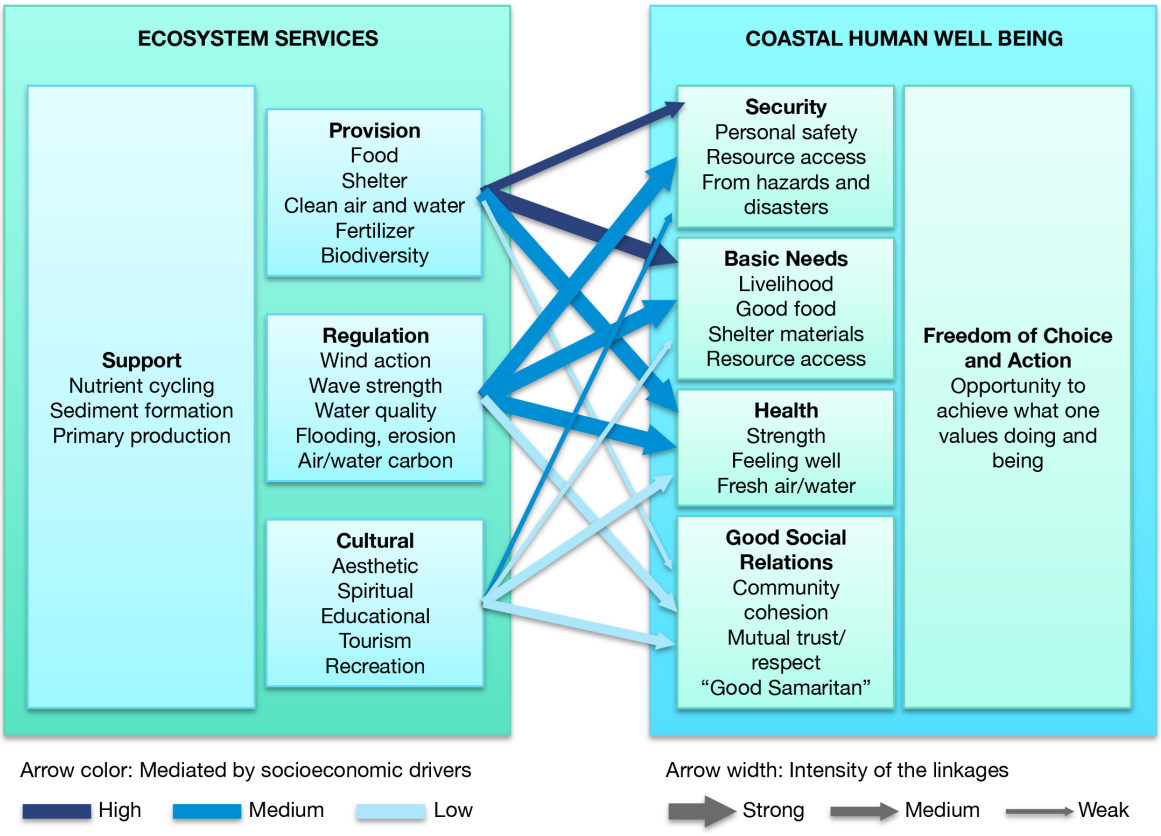
10. Problem in the Decision-Making Process in Community-Based Resource Management

There is a basic defect in natural resources management (including mangrove management) in the Philippines. This defect lies in incomplete or no serious objective-oriented interaction among the players. The major players are Policy (which has the authority and the power to make

Table 18. State of knowledge on mangrove integrity and its goods and services.

Rating	Components	State and Conditions ('traffic lights' and arrows)
	Water quality	Declining water quality due to fragmentation of habitats, pollution, soil erosion; studies recently initiated
	Trends in invasive alien species (IAS)	Largely unknown
	Traditional knowledge and practices	Needs more emphasis and urgent studies
	Goods and services and their economic valuation	Common goods, services largely known, but as largely not valuated
	Conservation and management policies	Many, still increasing, but enforcement remains problem for both

Color of traffic lights indicate the level of urgency: red, very urgent; yellow, moderately urgent; green, less urgent; length of arrows indicate the state of our knowledge on the topic: shortest, not yet known; longest, sufficient.



Fortes 2010 (Modified from MEA 2005)

Figure 30. Matrix of the ecosystem services of mangroves in the Philippines linked with aspects of human well-being (Fortes 2010, modified from MEA 2005).

decisions), the academic institutions or science (which has the knowledge or know-how), and the community (which has the real need to address the issues since they affect their lives and property). Oftentimes, funding agencies (which have the money) and NGOs (non-governmental organizations), which are strong in advocacy, also play a major part. In reality, however, the nature of the interaction among these players can be shown in **Fig. 32**. From the weak and inadequate interactions among the players, there is a need to convert these into the desired actions which are more regular and effective. **Fig. 32** shows that ideally, well-informed decisions should be fully disclosed to the communities.

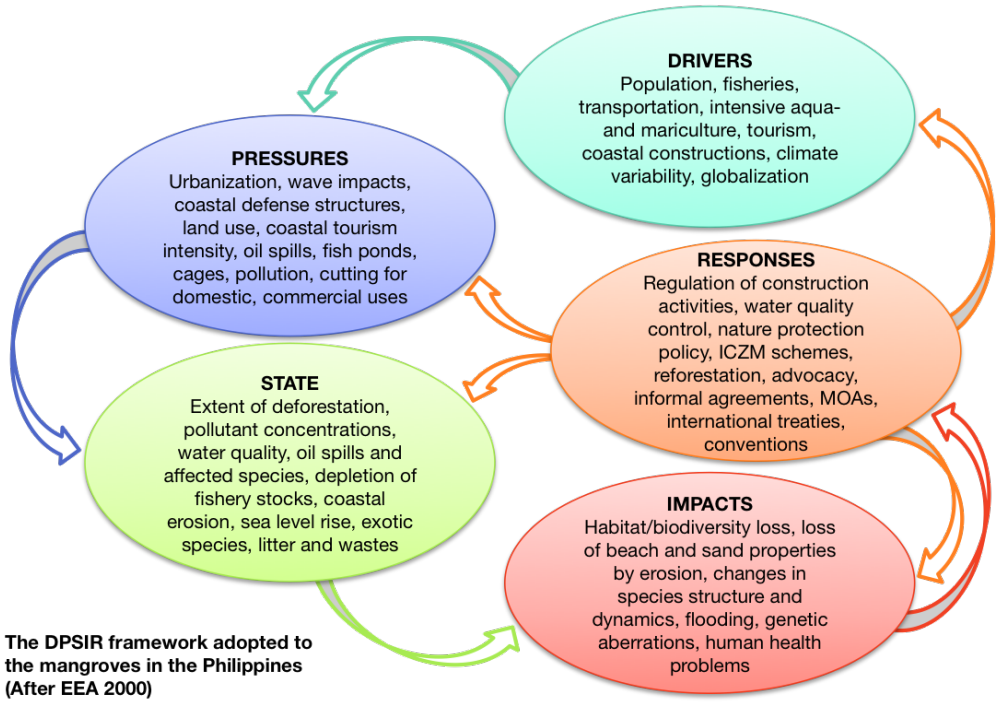


Figure 31. An example of how the mangroves in the Philippines are looked at using the system analysis approach (Fortes & Salmo, in press).

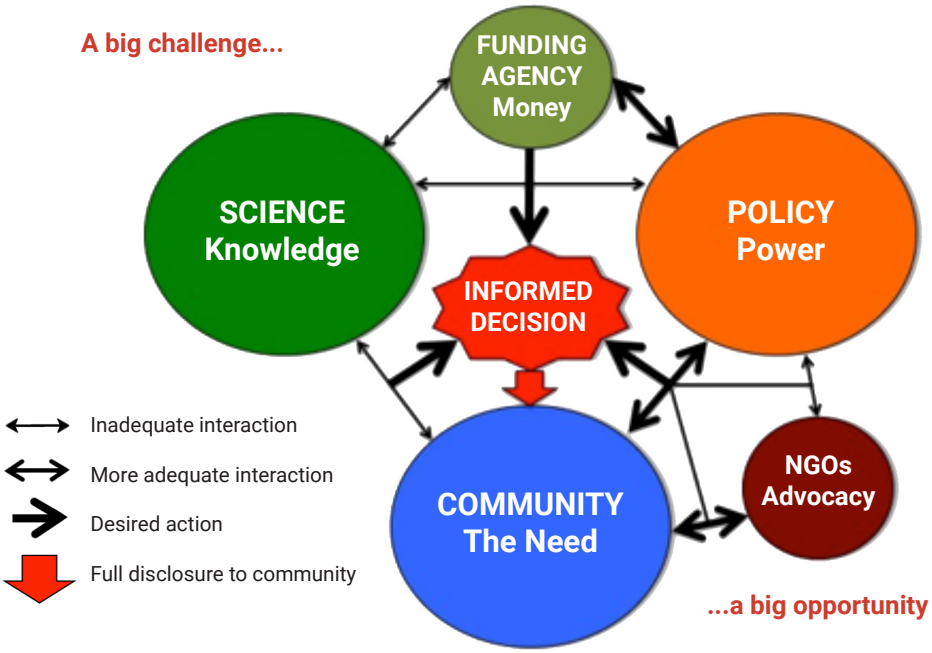


Figure 32. Interactions among the players in the decision-making process in natural resources management in the Philippines.

Table 19. Summary of the status and trends in research and management of mangroves in the Philippines (Fortes & Salmo, in press).

Rating	Components	State and Conditions ('traffic lights' and arrows)
	General knowledge on ecosystem	Good, but needs more focused studies
	Scientific knowledge on ecosystem	Fair, very slowly improving
	Conservation/ management knowledge on ecosystem	Good, but needs to be more science-based
	Total areal extent	Remains unknown, decreasing, but studies increasing in the last 5 years (remote sensing)
	Abundance and distribution of species	Fairly known (plants), both declining trend in species and fragmentation of habitats
	Status of threatened species	Needs more studies
	Genetic diversity of species	Virtually unkown, < 20 works exist in the region, studies proceeding slowly
	Species diversity of ecosystem	Fairly known for flora and fish, less so for other fauna
	Ecosystem diversity	Steady increase in studies
	Coverage of protected areas	Improving with notable increases and expansion; need to improve and document effectiveness

Color of traffic lights indicate the level of urgency: red, very urgent; yellow, moderately urgent; green, less urgent; length of arrows indicate the state of our knowledge on the topic: shortest, not yet known; longest, sufficient.

11. Conclusion

In a nutshell, the status and trends in research and management of mangroves in the Philippines are given in **Table 19** (Fortes & Salmo, in press). Slowly, a new trend is emerging wherein basic foundational research is gaining ground, with the realization that conservation and management cannot be successful and effective without the necessary scientific base. Our main collective challenge, is how to bring together the two worlds of science and policy, emphasizing the role of facilitating, synthesizing, translating and communicating science to inform, e.g. mangrove conservation action.

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Workshop output

Table 20. Output for Workshop 1: Core problems and their corresponding causes and effects

		CORE PROBLEMS		
	Core Problem 1: Mismanagement	**Core Problem 2: Siltation and sedimentation**	**Core Problem 3: Mangrove Areas not legally delineated**	**Core Problem 4: Weak coordination**
CAUSES	Socio-economic	Management plan Root causes: 1. No community strategy plan 2. Weak IEC 3. Weak M&E	Poor planning	Too much budget
	Knowledge	Agriculture Root causes: 1. Waste 2. Low IEC	Key players cannot be identified	Weak harmonization of programs between NGAs and LGUs
	Institutional Weakness	Economic Development Root causes: 1. High population 2. Reclamation 3. Relocation (housing)	Identification of who has the legal mandate to protect or rehabilitate	
EFFECTS	- Land use conversion - Employment/income reduction - User conflict - Attitude towards mangrove resources - CC Impact - Loss in supply of marine products - Exposure to natural hazards - Aesthetic/loss of value - Beach erosion - Biodiversity loss - Siltation	- Low ecosystem services - Low survival rate (suffocation) - Pollution - Oceanography sub-effects: 1. Effect on circulation of water 2. Bathymetry	- Waste of budget, time, resources - Duplication of activities - Poor planning - Poor partnership	- Sense of ownership - Waste of money, effort and time - Duplication - Poor partnership and governance

Two workshops were carried out during the two-day State of the Mangrove Summit for Southern Luzon. The workshops aimed to achieve the summit objective of coming up with a plan of action to enhance mangrove management.

The first workshop focused on issue identification and analysis using a problem tree. The main objective was to synthesize and analyze the issues surrounding the mangrove management of Southern Luzon. The participants were divided into three groups. Group 1 included the provinces of Mindoro Oriental and Palawan, representatives from the Institute of Social Order, Conservation International-Philippines, and graduate students from the Ateneo de Manila University. Group 2 consisted of representatives from Cavite, Batangas, Forest Management Bureau (FMB), and graduate students from the Ateneo de Manila University. Lastly, Group 3 was made up of representatives from Marinduque, Romblon, and the University of the Philippines–Marine Science Institute (UP-MSI). Three guide questions were posted to assist the participants. The guide questions are as follows:

1. As mangrove managers, what are the three most pressing problems in the management of mangroves?
2. What are the root causes and effects related to these pressing problems?
3. How are these problems, causes and effects interrelated or interlinked? Please show these through a problem tree.

	Core Problem 5: Poor implementation of mangrove management programs	Core Problem 6: Declining Mangrove Forest Cover	Core Problem 7: Lack of baseline data on mangrove cover
	Lack of community participation	Mangrove Cutting Root cause: Weak enforcement of environmental laws	Poor inter-agency coordination
	Lack of technical personnel Root causes: 1. Poor eco management zoning 2. Lack of science-based approaches in planning and implementation	Fishpond conversion Root cause: Weak enforcement of environmental laws	Institutional crisis
		Charcoal making Root cause: Weak enforcement of environmental laws	Weak dissemination on the use of standard tool on monitoring and reporting
		Land conversion into settlements Root cause: Weak enforcement of environmental laws	Low priority in establishing a mangrove data management
	- Lack of sense of ownership - Sustainability of projects - Low compliance to policy	- Low source of fingerlings - low income of fisherfolks and low fish catch - Siltation of other ecosystems (corals, seagrass beds) - High vulnerability to hazards (e.g. coastal erosion, sea level rise, storm surge) - Poor water quality	- Double reporting - Continuity of program - Inaccurate/ skewed data - Duplication of efforts and initiatives (manpower, resources) - Confusion among stakeholders

Table 20 provides a summary of the problem tree. Seven core problems were identified by the participants, namely: (1) mismanagement; (2) siltation and sedimentation; (3) mangrove areas not legally delineated; (4) weak institutional coordination; (5) poor implementation of mangrove management programs; (6) declining mangrove forest cover; and (7) lack of baseline data on mangrove forest cover. Various causes were identified for these core problems, which ranges from lack of knowledge on mangrove management to poor policy implementation due to weak institutions. The identified effects likewise varied from socio-economic consequences on those directly relying on mangrove resources to low survival of mangroves and consequently, low ecosystem services derived from this resource.

Workshop 2, on the other hand, focused on suggesting solutions for the identified problems from Workshop 1. The participants were grouped into their provinces and were requested to create a project plan. To come up with a plan, the participants started by choosing two core problems identified from Workshop 1, looking at its respective root causes and creating solutions that could address these root causes. These solutions served as the basis for the project plans, which were further detailed by enumerating the needed personnel, materials/ equipment, funding sources and the corresponding timeline for accomplishing it.

Table 21 shows the suggested solutions for the identified problems and its corresponding root causes. Some of the solutions include employing appropriate management interventions; enhancing scientific research to aid mangrove management; harmonizing efforts, policies, programs, and activities related to mangrove management; and community empowerment and awareness.

Table 21. Output for Workshop 2: Project Plan

Problem	Root Cause	Solution
Mismanagement	Institutional weakness	Harmonize programs, projects, activities: - Create multi-sectoral technical working group - Involvement in policy-making - Define roles and functions of each agency involved to avoid overlapping of functions
	Knowledge	Provision of adequate proper education, IEC trainings, capacity building to communities and stakeholders: - Adaption of research output - Provide technical assistance to coastal communities and other stakeholders
Siltation and sedimentation	Economic/Coastal Development	- Science-based data - Mangrove management plan - Policy for the allowed, restricted and prohibited use
	Lack of Management Plan	Development of mangrove management plan or inclusion to ICM plan of the LGU including its business plan
Weak coordination between NGA and LGU	Weak harmonization of programs between NGAs and LGUs	Integration of local and national projects
	Too much funding due to many different sources	Propose an inter-agency/multi-sectoral organization to do proper planning and proper allocation of funds
Poor implementation of mangrove management programs	Lack of community participation	Increase community awareness through IEC
	Poor eco-management zoning	Conduct scientific studies to support zoning
Declining mangrove forest cover	Weak enforcement of environmental laws	Community empowerment/ creation of community based monitoring system
Lack of baseline data	Inter-agency coordination	Harmonization of all mangrove initiatives including gathering and collection of data
	Low priority in establishing mangrove database management	Centralized data banking