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Pilot Ecosystem Account for Southern Palawan

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WAVES – Global Partnership for Wealth Accounting and the Valuation of Ecosystem Services

Wealth Accounting and the Valuation of Ecosystem Services (WAVES) is a global partnership led by the World Bank that aims to promote sustainable development by mainstreaming natural capital in development planning and national economic accounting systems, based on the System of Environmental-Economic Accounting (SEEA). The WAVES global partnership (www.wavespartnership.org) brings together a broad coalition of governments, UN agencies, non-government organizations and academics for this purpose. WAVES core implementing countries include developing countries—Botswana, Colombia, Costa Rica, Guatemala, Indonesia, Madagascar, the Philippines and Rwanda—all working to establish natural capital accounts. WAVES also partners with UN agencies—UNEP, UNDP, and the UN Statistical Commission—that are helping to implement natural capital accounting. WAVES is funded by a multi-donor trust fund and is overseen by a steering committee. WAVES donors include Denmark, the European Commission, France, Germany, Japan, The Netherlands, Norway, Switzerland, and the United Kingdom.

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The ecosystem accounts were developed by the members of the SP TWG under DENR, namely: Alejandrino Sibucao, Jr., Leyminda Marañon, Larlyn Faith Aggabao, and Eugene Soyosa of the Forest Management Bureau (Carbon and Land Accounts); Raul Mangabo and Rosario Mamuric of the National Mapping and Resource Information Authority (NAMRIA) (Land Accounts); Myline Aparente of the Ecosystems Research and Development Bureau, and May Lacao of PCSD (Ecosystem Service Supply and Use Account and Ecosystem Asset Account for Crop Production); John Francisco Pontillas (PCSD) (Coastal Ecosystem Condition Account and Fishery Production Account); Silvino Alcantara, Jr. (Phil WAVES Project Coordination Unit, FASPS-DENR), and Wilson Pambid (PCSD) (Ecosystem Service Account: Erosion Control and Water Regulation by Forests).

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Note on the Report

This final report presents the collective findings of the Technical Working Group for Southern Palawan ecosystem accounting, a pilot undertaking conducted between January 1, 2014 and December 10, 2015 in the island province.

The Southern Palawan ecosystem account explores potential pathways to developing specific accounts based on a comprehensive framework called the System of Environmental-Economic Accounting-Experimental Ecosystem Accounting (SEEA-EEA), which shows the interactions between the economy and ecosystems, consistent with the System of National Accounts.

Although experimental in nature, the account is replicable across time and geographical scales (e.g., national). It is also useful in policy making.

Through this groundbreaking endeavor, substantial capacity has been built locally to produce ecosystem accounts and update them on a regular basis, thus helping ensure effective policy making and sustainable management of natural resources.

EXECUTIVE SUMMARY

Resource-rich Palawan in southwest Philippines is reeling under increasing conversion of forest lands to plantation and household-level agriculture, intensive mineral extraction, illegal logging, and other pressures on its ecosystems despite boasting large protected areas and a significant share of the country's remaining forests.

Driving these and other economic activities in the island province are competing demands on the province's natural resources while various ecosystem management options bring a number of trade-offs between environmental sustainability and economic progress. Land conversion, for instance, is taking place on a large scale, especially on the province's southern side, as land is cleared for new uses despite the attendant adverse impacts on biodiversity, forest ecosystem services, and water supply.

Between 2003 and 2010, closed forest cover in Southern Palawan alone declined from 130,000 hectares (ha) to 30,000 ha. Ecosystem degradation is clearly on the rise in the province, and even more so in its southern region, home to more than 450 species of terrestrial vertebrates found across the island province.

The Philippines is taking steps to address these and other trends in land use change affecting ecosystem integrity and the supply of ecosystem services in Palawan and elsewhere in the country. A vital step in this direction is the national government's revitalized efforts to mainstream natural capital accounting (NCA), an evidence-based tool that takes stock of the state of one's natural resources, into policy making.

An integral part of NCA is ecosystem accounting, which links natural capital analysis with economic data, thereby clarifying the contributions of the ecosystem to economic activities. Ecosystem accounts are useful for monitoring trends in natural capital forecasting and building scenarios for planning, developing and analyzing management and policy options, and enforcing resource management policies.

Today, the Philippines is one of the core implementing countries of a World Bank-led global partnership called Wealth Accounting and the Valuation of Ecosystem Services (WAVES). This initiative aims to promote sustainable development by mainstreaming natural capital in development planning and national economic accounting systems.

As part of the WAVES project, Southern Palawan was selected as one of two pilot test sites in the Philippines to develop ecosystem accounts (the other being Laguna de Bay in the southern Luzon province of Laguna). This technical report explores the specific challenges confronting natural resource management in Southern Palawan and presents the key findings of the ecosystem account, which were developed at different scales (depending on data availability), including the Pulot watershed and the municipalty of Sofroñio Española. It was developed over a period of almost two years (January 2014 to December 2015). The ecosystem account comprises the following:

- **Land account**, focusing on land cover, land use, and changes in land cover
- **Carbon account**, covering carbon stored and sequestered in the forests of the pilot site
- **Ecosystem condition account**, including terrestrial and coastal condition indicators
- **Ecosystem services supply account**, revolving around the flow of these services, specifically water regulation, crop production, and fisheries
- **Ecosystem asset account**, focusing on crop production

Key Findings

The Southern Palawan Pilot Ecosystem Account follows an adopted standardized system called the System of Environmental Economic Accounting – Experimental Ecosystem Accounting (SEEA-EEA) framework, which ensures comparability, both nationally and internationally, and consistency with regularly produced economic statistics. Therefore, ecosystem accounts can be used to monitor trends in natural capital as well as the enforcement of resource management policies.

Major loss of forest cover and rapid expansion of plantation crops were mainland cover trends

Rapid deforestation took place between 2003 and 2010, with closed forest cover declining from around 130,000 ha to 28,000 ha during the period. Pending confirmation of recent satellite imagery interpretations, this pattern seemed to have reversed in the period 2010-2014, when closed forest expanded from 28,000 ha to 33,000 ha — a development largely attributed to the enforcement of the National Log Ban and the establishment of an Anti-Illegal Logging Task Force in 2011.

A comparison of land cover classes shows a marked increase in perennial crops from 46,130 ha in 2003 to 115,845 ha in 2014. Data from the Philippine Statistics Authority shows that the expansions consisted mainly of oil palm and coconut plantations since 2007. Extensive coconut plantations may have been a result of fiscal incentives provided by the Philippine Coconut Authority at the time.

The carbon stock dropped significantly as a result of deforestation in Southern Palawan

The carbon stock in Southern Palawan's forests stood at 16 million tons of carbon (C) in 2003, dropping to 9.2 million tons C in 2010, and slightly recovering to 9.4 million tons C in 2014.

Deforestation during the period 2003-2010 had major impacts on the carbon stock in the region's forests. The modest recovery of closed forests between 2010 and 2014 only led to a slight increase in carbon stock, which was not sufficient to offset the earlier decline. Overall, the decrease in carbon stock could also be attributed to the wide-range conversion of closed forest to other types of land cover.

Coastal ecosystems such as corals and mangroves are suffering from rapid degradation

The overall volume of mangroves in the municipality of Sofronio Española dropped considerably from 337,053 m^3 in 2001 to 189,652 m^3 in 2010, representing a decline of over 43.73% in just nine years. A number of factors may have contributed to this disturbing pattern, including land conversion to fishponds, and localized cutting and clearing.

Coral reefs in the study area were equally under high pressure as a result of overfishing, destructive fishing, and pollution. Coral condition declined in the past 10 years with 12 out of 15 sites registering a reduction in live coral cover. Moreover, live coral cover rapidly declined in all sites, and there were no survey sites remaining under very good and excellent coral cover condition in 2010.

Other coastal accounts were certainly no bright spots either as the condition account also recorded a decline in seagrass density and percentage cover in half of the sites, while species composition was largely unchanged. Seagrasses are more resilient than coral reefs to pressures from sedimentation and runoff, but they are affected by changes in water clarity, which in turn affects photosynthesis.

Ecosystem services are key contributors to crop production, water regulation, and fisheries

Crop production

The most significant crops planted in the Pulot watershed in 2014 were coconut (1,455 ha), oil palm (1,012 ha), and rice (570 ha). This makes the watershed different from the rest of Palawan, as a large area of land is used for oil palm due to the vicinity of a nearby oil palm mill. Moreover, between 2010 and 2014, irrigated paddy fields decreased while rainfed sites increased significantly, indicating that irrigation water supply could not meet the demands of paddy production.

In addition, yields were much lower in the Pulot watershed than elsewhere in the Philippines. For example, the average yield of coconut plantations at 1.28 tons per hectare was very low compared to the reported national average yield of 4.6 tons per hectare. This low average yield may have been the result of underestimating coconut production, damage from pests and diseases, or poor management of the plantations. Moreover, the resource rent of oil palm production was negative due to a very low yield. Many plantations had either zero or low production due to insufficient water supply to enable oil palm fruit production. This was related to rainfall being too low for oil palm in certain times of the year and the sensitivity of oil palm to dry periods.

Water regulation

The Pulot watershed is suffering from water scarcity, particularly for irrigation that has been increasing over time. Part of the Pulot irrigation scheme is not used for cropping because of insufficient water to irrigate the full area; an area that almost doubled from 50 hectares in 2000-2005 to 96 hectares in 2006-2010. This was driven both by sediment being trapped by the dam, which reduced the facility's storage volume; and changes in stream flow related to deforestation upstream.

The hydrological modelling conducted for the ecosystem account shows that cutting down forest trees further reduces water supply to the irrigation scheme. Without forest cover, rainwater is very rapidly drained from the watershed. Moreover, forests act as buffer by storing and gradually releasing water throughout the year. The accounts show that if the forests upstream of the irrigation scheme were lost, paddy production in the irrigation scheme would drop by around 20%.

Fishery production

The 28,813 ha of municipal waters of Sofronio Española is a rich fishing ground. Calculations based on a survey for the Phil WAVES project showed that total catch by all fishermen amounts to 1,665,853 kg/year. The gross sales value of this catch is 41,144,818 pesos (US$883,884)/year (42 pesos/kg * 1,665,853 kg/year).

Preliminary estimate of the value of fishery production ecosystem service generated by the coastal marine ecosystems in Sofronio Española, measured in terms of resource rent, is calculated at 42 pesos (US$0.90)/kg or a total of 70 million pesos (US$1.5 million)/year (42 pesos/kg * 1,665,853 kg/year) for the municipality.

In summary

Understanding these and other ecosystem conditions in Southern Palawan highlights the extreme importance of mainstreaming the ecosystem accounting framework into decision making. The ecosystem accounts can serve as a benchmark to identify key policy needs and impacts as well as areas where specific policy interventions should be carried out as a matter of priority. They can also be used to monitor changes in the ecosystem. An important dimension of the value of these accounts lies in showing trends in ecosystem condition, asset, and service flows over time, requiring regular updating of the accounts.

Given the capacities built and the lessons learned in the process of developing these accounts for Southern Palawan, the cost of updating them in the future should be much lower compared to establishing them. Potentially, given the rate of ecosystem changes in Palawan, updates should take place at least once every two or three years. This should mark an important step forward as the Philippines pursues natural capital accounting in earnest.

Summary of Account Indicators for Policy Makers

	2001	2003	2010	2011	2013	2014
Land account (Southern Palawan)						
Annual cropland (1000 ha)		52	48			50
Plantations (1000 ha)		46	114			116
Closed forest cover (1000 ha)		130	28			33
Open forest and grasslands (1000 ha)		305	334			323
Mangrove forest (1000 ha)		16	17			17
Carbon account (Southern Palawan)						
Carbon storage (million ton C)		16	9.2			9.4
Carbon sequestration (million ton CO_2/year)		2	2			2
Carbon account (Pulot watershed)						
Carbon storage (1000 ton C)		208	139			142
Carbon sequestration (1000 ton CO_2 /year)		38	38			39
Ecosystem condition account (Pulot watershed and adjacent coastal zone)						
Pollution loading: annual average nickel concentration in 9 sample points (mg/l) /[1]					0.2	0.2
Pollution loading: annual average copper concentration in 9 sample points (mg/l) /[1]					0.03	0.02
Pollution loading: annual average suspended sediments in 9 sample points (mg/l) /[1]					16	10
Coral reef condition: average coral reef condition (% live coral cover in 26 sample points)	50%			35%		
Seagrass condition (% cover in sample sites)	37%			11%		
Mangrove condition (volume of trees, in 100 m^3)	206			69		
Ecosystem Service Supply and Use Account (Pulot watershed)						
Paddy production (ton rice/year)			3,620			3,848
Corn production (ton corn/year)			77			183
Coconut production (ton copra/year)			1,724			1,907
Oil palm fruit production (ton fresh fruit/year)			8711			9,783
Water regulation by forests (water available for irrigation during paddy growing seasons) (1000 m3 water/year)						71
Ecosystem Service Supply and Use Account (Sofronio Española)						
Fish production (ton/year)						1,665
Fish production, resource rent generated (million pesos/year)						70
Ecosystem Asset Account (Pulot watershed) – Net Present Value at 10% discount rate						
Cropland (million pesos)						
Irrigated paddy fields			251			332
Coconut plantations			119			184

/[1] The data above shows the trend in water quality for the selected years. (No data was available for specific accounts for certain years.) By means of comparison, the concentrations can be benchmarked against national or international standards. A study by the Organization for Economic Co-operation and Development proposes the maximum allowable concentrations for heavy metals in surface water (without being used as drinking water) in order to protect fish life and ecosystems (http://www.oecd.org/env/outreach/38205662.pdf). These are as follows: dissolved copper 0.02 mg/l; dissolved nickel 0.02mg/l. For nickel, these concentrations have been exceeded in the study area. The European Union Freshwater Fish Directive [78/659/EEC] specifies that in order to protect fish life, total suspended solids should be below 25 mg/l in the EU. However, protection of coral reefs is likely to require lower sediment concentrations than those required for protection of inland waters in the EU.

[1] Requires validation, based on Pulot municipal water scheme only

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Acronyms

BFAR	Bureau of Fisheries and Aquatic Resources	**NAMRIA**	National Mapping and Resource Information Authority
BOD	Biochemical Oxygen Demand	**NEDA**	National Economic and Development Authority
BSWM	Bureau of Soils and Water Management	**NHRC**	National Hydrology Research Center
CRC	Cooperative Research Centre	**NSO**	National Statistics Office
DAR	Department of Agriculture	**PCSD**	Palawan Council for Sustainable Development
DBM	Department of Budget and Management	**Phil WAVES**	Philippines WAVES
DENR	Department of Environment and Natural Resources	**PSA**	Philippine Statistics Authority
DOF	Department of Finance	**RUSLE**	Revised Universal Soil Loss Equation
EARU	Ecosystem Accounting Reporting Unit	**SedNet**	Sediment River Network Model
EU	Ecosystem Unit	**SEEA**	System of Environmental-Economic Accounting
ENRAP	Environment and Natural Resources Accounting	**SRTM DEM**	Shuttle Radar Topography Mission - Digital Elevation Model
ESA	European Space Agency	**TWG**	Technical Working Group
FASPS	Foreign-Assisted and Special Projects Service	**WAVES**	Wealth Accounting and Valuation of Ecosystem Services
FFB	Fresh Fruit Bunch (of oil palm)	**WLM**	Waste Load Mode
MMPL	Mt. Mantalingahan Protected Landscape		

1| Introduction

Background

The resource-rich island province of Palawan in southwest Philippines is reeling under increasing conversion of forest lands to plantations, shifting cultivation, intensive mineral extraction, illegal logging, and other pressures on its ecosystems despite boasting large protected areas and a significant share of the country's remaining forests.

Driving these and other economic activities are competing demands on the province's natural resources while various ecosystem management options bring a number of trade-offs between environmental sustainability and economic progress. Land conversion, for instance, is taking place on a large scale, especially on the province's southern side.

Between 2003 and 2010, closed forest cover in Southern Palawan alone, which holds vast potential for ecotourism and agriculture, declined from 130,000 ha to 30,000 ha. Ecosystem degradation is clearly on the rise in the province, and even more so in its southern region, home to about 41% of the more than 1,100 species terrestrial vertebrates found across the island province.

The Philippine government is cognizant of this dire situation and has begun to take steps toward ensuring that natural capital is systematically integrated into both macroeconomic indicators and natural resource management in the country. An essential part of this undertaking is the selection of Southern Palawan (alongside Laguna de Bay) as one of two pilot test sites for an international undertaking that seeks to implement and institutionalize natural capital accounting.

This global partnership, of which the Philippines was selected as one of the core implementing countries, is the World Bank-led Wealth Accounting and Valuation of Ecosystem Services (WAVES), which aims to promote sustainable development by mainstreaming natural capital in development planning and national economic accounting systems. The National Economic and Development Authority serves as the national coordinating agency for the project, with support from the Philippines WAVES Steering Committee.[2]

The rollout of WAVES in the Philippines builds on the country's efforts in natural capital accounting in the 1990s and early 2000s, which led to the formation of considerable capacity and technical skills that still exist today.

At present the Philippines WAVES project covers water, mineral, mangroves, land, and ecosystem accounts. The first four will be implemented at the national scale, and the ecosystem accounts at the scale of a test site. The choice of Southern Palawan and Laguna de Bay Basin as pilot test sites for ecosystem accounting in the Philippines highlights the significant challenges policy makers face in natural resource management in these areas.

Addressing these challenges requires a evidence-based approach based on detailed information on changes in natural resources and natural capital.

As issues of natural ecosystem management affecting the two test sites are also widespread in other parts of the Philippines, the lessons learned from the pilot accounts are expected to help establish ecosystem accounts elsewhere in the country. By applying the resulting methodologies and framework in other parts of the country, ecosystem accounting can inform development planning and policy analysis in support of the goals of sustainable use of natural resources, economic growth, and poverty alleviation.

[2] The members of the national Philippines WAVES Steering Committee are the Department of Budget and Management (vice chair), Department of Finance, Philippine Statistics Authority, Department of Environment and Natural Resources, Climate Change Commission, Department of Agriculture, Office of the Presidential Adviser on Environmental Protection/Laguna Lake Development Authority, and Union of Local Authorities of the Philippines.

Methodology used

One of the objectives of WAVES is to pilot and test different methodologies for compiling ecosystem accounts based on a framework called the System of Environmental-Economic Accounting (SEEA)-Experimental Ecosystem Accounting (EEA).

The SEEA contains internationally agreed standards (including concepts, definitions, and accounting rules and tables) for producing globally comparable data on the environment and its linkage with the economy. The EEA, on the other hand, is one of three subsystems that provides further details on specific topics relating to ecosystems and seeks to build bridges between the accounting community and the community of experts in select subject areas, including ecosystems.

WAVES aims to test how the SEEA-EEA framework can provide science-based evidence and information to help assess the economic, environmental, and social trade-offs between different natural resource use options and their implications for sustainable development.

Using the SEEA framework offers several advantages. It facilitates linking an analysis of natural capital with economic data, thereby clarifying the contribution of ecosystems to economic activities in physical and monetary terms.

The use of the framework, if regularly undertaken, also helps to enable monitoring of trends in natural capital, and ensures efficiency of resource management policies in contrast to other types of assessment that are typically one-off studies.

Regular production of the ecosystem accounts contributes to capacity building and greater cost efficiency. As an adopted and standardized system, the SEEA accounting approach ensures data comparability both nationally and internationally and promotes recurring production of consistent data, thus enabling monitoring and comparison over time.

There are a number of methodologies and approaches to assessing projects and policies, including Cost-Benefit Analysis (CBA), Strategic Environmental Assessment, and Environmental Impact Assessment, among others. Some of these measure strictly environmental issues, while others such as the CBA include an economic component and valuation of environmental factors.

There is a difference between these environmental-economic methods and analyses using the accounting framework. National capital accounts are designed to be readily used together with national accounts data. Valuation methods are based on exchange values and reflect the contribution of ecosystems to economic production and consumption, not to welfare. In this regard, ecosystem accounting aims to produce datasets on a regular basis in order to show trends in ecosystems and their uses.

Still a developing field, ecosystem accounting is distinct from the physical environmental accounts included in the SEEA-Central Framework, an internationally adopted statistical standard. In some cases, it calls for quite advanced modelling exercises and is often undertaken at a sub-national level.

As methodologies and access to data are rapidly developing, applying this system at a regional or national scale becomes increasingly viable. The accounts presented in this report illustrate this development.

Institutional setting

In the past there were efforts to value ecosystem services for the benefit of society and market-based economies in the Philippines. To explore the possibility of modifying the conventional economic accounts and take into consideration environmental and natural resource degradation in the country, the Philippine government conducted projects related to resource accounting such as the Philippine Environmental and Natural Resources Accounting Project (ENRAP) in the 1990s.

This was a major initiative to improve the ability of the conventional national economic accounting system to reflect the dynamics between the market economy and the natural environment. The experiences under ENRAP are relevant to the present ecosystem accounting study.

The development of the accounts for Southern Palawan was a multi-agency task involving key agencies and organizations at the national and local government levels. It was coordinated by the Philippines WAVES Steering Committee, which was chaired by the National Economic and Development Authority.

The national Technical Working Group (TWG) for Southern Palawan is chaired by the director of the Foreign-Assisted and Special Projects Service (FASPS). The director of the Planning and Policy Service (PPS) of the Department of Environment and Natural Resources (DENR) serves as vice-chair. The local TWG is chaired by the Provincial Environment and Natural Resources, DENR and the vice-chair, director of the PCSD responsible for the implementation on the development of the ecosystem accounts.

TWG membership includes various offices and bureaus under the DENR, namely, the Biodiversity Management Bureau, Forest Management Bureau, Land Management Bureau, Environmental Management Bureau, Mines and GeoSciences Bureau, Ecosystem Research and Development Bureau, Planning and Policy Service, Knowledge Information System Service, DENR Region IV-B Field Office, the Philippines WAVES Coordinating Unit under FASPS, the National Mapping and Resource Information Authority (NAMRIA), and representatives from non-government organizations, and academic institutions in Palawan.

Aside from Palawan-based organizations, NAMRIA also played a major role in the development of the account. The national mapping agency developed the land account and provided inputs to the development of the other accounts. It also supported the development of the coastal zone condition account.

The World Bank through the WAVES Partnership Program provided technical assistance and capacity building in ecosystem accounting while national government agencies and government-owned and controlled corporations extended support for data acquisition.

The Philippine Statistics Authority (PSA) supported the development of the ecosystem account by assisting with data collection strategies, including survey design, quality assurance, and the valuation carried out in this pilot ecosystem account.

Finally, additional support was extended by the European Space Agency (ESA) through the GECOMON project. Through this project, additional remote sensing analysis was conducted by GeoVille and Argans, two companies specializing in this field. In Palawan, GeoVille conducted several analyses, including of land cover change, forest cover and bathymetry (or the measurement of depth of water in oceans, seas, or lakes), and coastal conditions. The results of the NAMRIA and the ESA support are presented in this report.

2| Methodology

SEEA-Experimental Ecosystem Accounting Framework

The System of Environmental-Economic Accounts (SEEA) - Experimental Ecosystem Accounting (UN et al., 2014) — subsequently called 'ecosystem accounting' in this report — involves the measurement of 1) the extent and condition of ecosystems; 2) the ecosystem's capacity to generate ecosystem services as a function of its extent and condition; 3) flows of ecosystem services; and 4) the linkages between ecosystems and economic activity (UN et al., 2014a, Edens and Hein, 2013; World Bank, 2009).

Under the SEEA approach, ecosystem services and ecosystem assets can also be valued in monetary terms following the valuation principles of the System of National Accounts (SNA) (UN et al., 2009).

Fundamental to ecosystem accounting is the spatial approach, as well as the distinction between flows of ecosystem services and stocks of ecosystem assets, which is in line with the SEEA framework and the SNA. In ecosystem accounting, ecosystem condition, capacity and services flows are analyzed using maps and tables (UN et al., 2014a) as part of a spatially explicit approach.

Such an approach allows integration of scarce data on multiple ecosystem services at aggregation levels (e.g., province or the country) relevant to accounting. The spatial approach also supports additional applications, such as land use planning. For instance, ecosystem accounts can indicate which parts of the landscape should be better protected to sustain the supply of regulating services such as water regulation, which are critical to the provision of other ecosystem services like crop production.

Information on ecosystem condition, capacity, and ecosystem service flow is measured according to small spatial areas known as basic spatial units (BSUs), and may be aggregated according to ecosystem types or administrative units (UN et al., 2014a). BSUs are assumed to be homogenous for purposes of the account, and may be measured using a grid (raster format) or specific, individually defined shapes (shape format). They typically measure from 100 to 10,000 square meters depending on the country, data availability, and the spatial variability of the ecosystems involved.

The ecosystem accounting approach differs from the complementary SEEA – Central Framework (SEEA-CF). The former aims to analyze ecosystem assets and ecosystem services in a manner that conforms to national accounts.

The SEEA-CF has a different and complementary focus, which includes, but is not limited to, emissions to the environment, expenditure for environmental protection, as well as accounting for water, carbon, minerals, land, and timber. It is not spatially explicit, because it does not use maps to the same degree as the SEEA-EEA approach. Moreover, the linkages between ecosystem condition and ecosystem services are not specified. Hence, the ecosystem accounting provides a more comprehensive way of looking at ecosystem services.

Note that some benefits related to ecosystem services are also included in the national accounts, such as tourism, timber production, and crop production. However, the ecosystem account specifically aims to show the contribution of the ecosystem to achieving such benefits, as illustrated, for instance, by ecotourism.

Accounts included in the pilot

The ecosystem accounts covered by the Southern Palawan Ecosystem Account are presented in Table 2.1.[3]

Out of the full suite of ecosystem accounts[4], the most policy-relevant ones for Southern Palawan were selected, namely: land account, carbon account, ecosystem condition account, ecosystem services supply account, and ecosystem asset account.

A biodiversity account would have been highly relevant but has not been included for lack of data. Still, it may be added in a later phase if biodiversity data for Mt. Mantalingahan Protected Landscape in Southern Palawan become available.

Together, the ecosystem accounts provide a comprehensive and consistent picture of ecosystems, the services they provide, how these services are utilized in society, and the capacity of the ecosystems to sustain services supply in the future.

Units and spatial scope

Ideally, each account included in the SEEA-EEA framework should be developed for the same area. However, in the case of Southern Palawan, the availability of data (and policy information needs) varied considerably across the different themes captured in the accounts.

Thus the accounts in this pilot phase were created at different scales. For instance, the land and carbon accounts were developed for the whole of Southern Palawan. But a separate carbon account was developed for Pulot watershed (see Figure 2.1), located in the municipality of Sofronio Española in Southern Palawan, to facilitate a comparison of different natural resource management interests in this area. The ecosystem services account, which involved the development of a hydrological model, was likewise developed for the watershed. The condition account was developed for Sofronio Española.

In the future, accounts need to be developed at a more aggregated scale, and obtaining full geographical overlap between the accounts should be a priority.

The ecosystem accounts distinguish between the following units. The area for which the account is developed is called 'geographical aggregation' (UN et al., 2015). The Ecosystem Unit (EU) acts as the basic unit of measurement for ecosystem accounts. EUs are commonly related to specific land cover and land use types, such as mangrove forests or irrigated paddy fields. The BSU is the spatial unit of measurement and may correspond to a grid in a raster GIS or an individual spatial unit in a vector-based GIS. These terms are used throughout this report.

3 Note that mineral accounts are part of the SEEA Central Framework but not of the Ecosystem Accounts

4 The specific terminology that applies to the full suite of ecosystem accounts is currently being defined as part of a United Nations Statistics Division-coordinated project aimed at producing, among others, Technical Recommendations for Ecosystem Accounting. The guidelines were released in December 2015.

Table 2.1. The Southern Palawan Ecosystem Accounts

Account	Explanation	Application in Southern Palawan
Ecosystem Condition	Measures the physical condition of ecosystems (and trends in condition)	A condition account is created for the coastal ecosystems of one municipality, i.e., Sofronio Española.
Ecosystem Services Supply	Measures flows of ecosystem services, per ecosystem unit	Ecosystem services supply accounts are created for oil palm plantations, paddy fields, coconut plantations, and fisheries and the water regulation service of upland forests.
Ecosystem Asset	Measures the ability of ecosystems to generate ecosystem services under current ecosystem conditions and uses in monetary terms, as expressed in the Net Present Value of the expected flow of ecosystem services	An ecosystem Asset account has been prepared for crop production (rice, coconut).
Land	Contains information on land cover, land use, and land titles	A land cover account was prepared for Southern Palawan for 2003, 2010, and 2014.
Carbon	Contains information on carbon sequestration, carbon stocks, and changes in stocks	A carbon account was prepared for Southern Palawan (and for the Pulot watershed) for 2003, 2010, and 2014.

Valuation

An area that still requires further testing is how to conduct valuation for ecosystem accounting (UN et al., 2015). One of the challenges in this regard is identifying the appropriate discount rate to use.

In the case of the Southern Palawan ecosystem accounts, a pragmatic choice had to be made based on ongoing discussions and scientific developments. Further consideration of the discount rates to use is required when the accounts are scaled up.

In the valuation of carbon sequestration, which takes into account the damage costs avoided over a long period of time, 3% and 5% social discount rates have been used. For the provisioning services, in line with the recommendations and standard practices of NEDA, a 15% private discount rate has been used to analyze the asset agricultural land for paddy, corn, coconut, and oil palm fruit production.

Calculations using 10% and 12% discount rates have also been made for comparison. A 20-year discounting period has been used in all accounts. Where use of the ecosystem is not sustainable, the flow of ecosystem services over time needs to be adjusted. But the discounting period can be maintained at 20 years. However, in the course of this pilot, it was not possible to test the sustainability of the use of croplands. (There were no indications of soil degradation based on interviews with farmers, whose main concern was water.) Hence, in the analysis of the asset, a constant flow of ecosystem services is assumed.

It must be noted that the approach to discounting in the context of ecosystem accounting has not yet been specified in detail. The choice of the discount rate and the use of different discount rates for private and public goods require further discussion.

Case study area description

Palawan is the largest island province in the Philippines. It covers a total land area of 14,650 square kilometers (km^2). In 2010, the total population of the province was 771,667, around half of whom resides in Southern Palawan (PSA, 2014).

Palawan's economy is mainly supported by agriculture, followed by mining, logging, fishing, natural gas exploration, and tourism. The three major agricultural products of the province are rice (with 205,000 metric ton production in 2010), corn (9,000 MT), and coconut (240,000 MT). Palawan's mineral resources include nickel, copper, manganese, and chromite. It is also one of the richest fishing grounds in the Philippines, supplying 45% of Manila's fish consumption.

Meanwhile, its natural gas reserves amount to approximately 30,000 trillion cubic feet, which makes Palawan the main hydrocarbon-producing province in the country (Arellano, 2003). Local tourism generated 18 billion pesos (US$386.68 million[5]) in gross revenue in 2013, from a total of 883,000 tourist arrivals (Palawan Tourism Council, 2015). Local and foreign tourists, ranging from backpackers to high-spending visitors, are attracted to beaches, diving opportunities, and the impressive landscape of the island.

Unlike the northern part of Palawan, which has a strong focus on tourism, Southern Palawan gives greater priority to agricultural expansion and mining. The latter, however, is beset by competing demands on resources.

The three large protected areas on the southern side of Palawan island are threatened by unabated wildlife poaching, particularly bird hunting, as well as conversion of forest lands, mining claims, destruction of watershed areas, and illegal gathering of forest products.

Southern Palawan has four mining companies currently operating in the area, generating concerns about the environmental impacts of their operations. Such concerns revolve around both on-site (e.g., ground clearing) and off-site impacts (e.g., effluents, spillovers from reservoirs, run-off from mine deposits). How such impacts vary across the different types of mine remains unclear.

The variety of ecosystem services supplied and the need to address competing resource use claims make Southern Palawan an excellent case study area for testing the ecosystem accounting approach.

Based on the above, Southern Palawan was chosen as one of the priority sites for testing ecosystem accounting. The Southern Palawan ecosystem account was tested at different scales: 1) Southern Palawan region; 2) Pulot watershed; and 3) the coastal zone of Sofronio Española municipality

Initially, three different watersheds were selected to test ecosystem accounting at the scale of the watershed. But based on available data, only Pulot watershed, the largest watershed among the three, was chosen as a study site to pilot the developed ecosystem accounting method.

The watershed has experienced rapid land use change, specifically in the form of plantation expansion. It is also the most accessible in terms of distance and infrastructure. While the watershed is not necessarily representative of what has happened in Palawan in terms of land use change, its current state exemplifies the development agenda for the whole province, which involves a strong promotion of plantation agriculture.

For the land and carbon accounts, the ecosystem account focused on the entire

[5] At P46.55:$1. Based on the Bangko Sentral ng Pilipinas Reference Exchange Rate Bulletin as of September 1, 2016.

Southern Palawan. Marine data was available at the municipal level, making it possible to develop a marine condition account for the town of Sofronio Española.

The choice of varying scales for the different accounts was based on data availability and the capacity of and resources available to the TWG. For some services, in particular carbon, and for land use change, it was deemed better to analyze a larger scale to facilitate providing advice to policy makers.

For the services that require intensive data collection including crop production and hydrological services, the TWG decided to focus only on one watershed. In this regard, the coastal zone bordering the watershed was selected. Based on available datasets on coastal ecosystem condition, the coastal condition account was extended to include the rest of Sofronio Española. The implications of testing the approach at different scales are discussed in Chapter 7.

Pulot watershed is adjacent to the mountain ranges of the Mt. Mantalingahan Protected Landscape (see Figure 2.1). It covers 18,192 ha, of which 34% (totalling 6,158 ha) lies within the natural reserve. Almost 50% of the watershed area has slopes ranging from flat to moderate. The highest ground surface elevation at the site is at the extreme western tip of the Tapisan Creek, where the ground elevation is approximately 1,100 meters above sea level (masl). The lowest ground elevation is approximately 20 masl along the shores of Pulot (USAID, 2012). (Figure 2.1 presents a map of Pulot watershed.)

While the watershed is located in Sofronio Española, it also encompasses two other municipalities, Brooke's Point and Quezon. Nine barangays[6] make up the watershed, namely, Pulot Interior, Pulot Shore, Pulot Center, Punang, Labog, and Iraray in Sofronio Española; Calasaguen in Brooke's Point; and Sowangan and Quinlogan in Quezon.

Of the total watershed area, 12,950 ha or 71% lies within Sofronio Española. This municipality has a low population density, with an average of 11 people per km^2, and a total population of 29,997 as of May 1, 2010 (Philippine Statistics Authority - National Statistical Board, 2010).

Selection of services and indicators

The case study area consists of uplands, lowlands, and a coastal plain. For each zone, a number of key ecosystem condition indicators and services were selected. The selection was undertaken based on the policy relevance of the individual ecosystem services and data availability.

Given the experimental character of ecosystem accounting, focus was made on the services for which data were already available, thus excluding new services that required additional data.

Policy relevance was evaluated based on the policy issues discussed earlier. For the lowlands, the most economically important crops, in particular oil palm, corn, rice, and coconut, were chosen as the focus of this pilot undertaking.

Oil palm plantation expansion has also been one of the main drivers of land use change in Pulot watershed. Both physical and monetary indicators were selected since the TWG wanted to test as well the monetary valuation aspect of experimental ecosystem accounting. Logging of timber was not included in the account for lack of data on illegal logging. Logging is banned in Palawan.

The ecosystem condition indicators were determined based on three criteria: 1) the relevance of the individual criteria on policy making; 2) linkage between the indicators and policy-relevant ecosystem services; and 3) data availability.

In line with the upcoming Ecosystem Accounting Technical Guidance, three types of ecosystem condition indicators are identified.

[6] A barangay is the smallest administrative division in the Philippines and is the Filipino term for a village, district, or ward.

Geomorphological indicators

These indicators provide basic geological, soil, and geomorphological information on the earth surface. Such information is needed to model ecosystem processes and ecosystem services in the account. Factors such as soil type and slope length do not change from one year to the next and are part of the background information set relating to the accounts.

Environmental state indicators

These provide information on the overall state of the environment in which the ecosystem is functioning. Such information, which is often policy-relevant, is needed to analyze regulating services. The indicators, such as air pollution loads or erosion risk, change from year to year.

'Proper' ecosystem condition indicators

These reflect the state of the ecosystem. Regulating services are often a function of both the environmental state and ecosystem conditions. For example, flood risk as a function of annual rainfall and wind patterns, and the presence of ecosystems that mitigate flood risks (such as mangroves) jointly determine the regulating service 'flood control'.

"The variety of ecosystem services supplied and the need to address competing resource use claims make Southern Palawan an excellent case study area for testing the ecosystem accounting approach."

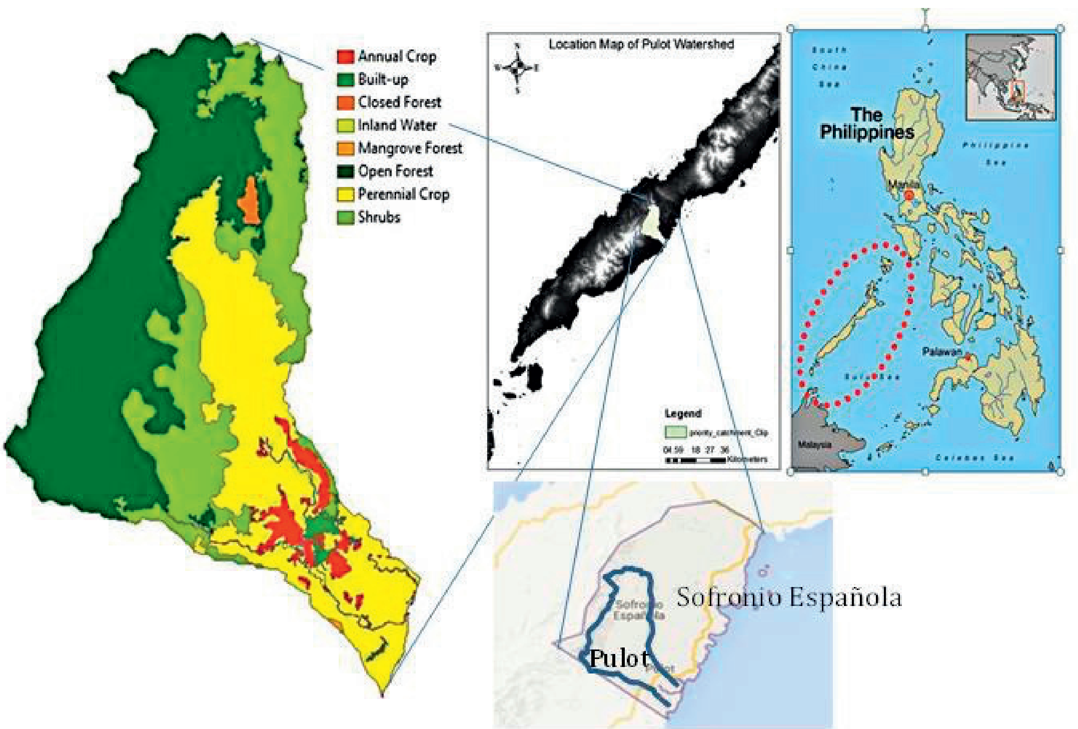

Figure 2.1. Location and land cover map of Pulot watershed

3| Land Account

Introduction

Land cover is the observed physical cover of the earth's surface, as defined by the Food and Agriculture Organization (FAO) of the United Nations.

NAMRIA, as the Philippine government's central mapping agency, is mandated to update the country's land cover data, as provided for in the DENR Administrative Order No. 31 (dated January 29, 1988)[7]. Two other legal bases for the agency's conduct of land cover mapping are Presidential Decree No. 705 (Revised Forestry Code of the Philippines) and the DENR Memorandum Circular No. 005, series of 2005 (dated May 26, 2005), adopting the definition of FAO concerning forest cover/land.

By developing a land account for Palawan, NAMRIA aims to produce more detailed and updated information on land cover extracted from the latest remote sensing data. It also seeks to generate countrywide land cover statistics for resource managers and development planners, among others. GIS and satellite remote sensing applications play an important role in generating information about land cover and land cover change.

Land cover information is derived from remotely sensed images using either visual or computer processing techniques, many of which require a substantial amount of reliable referenced data in assessing classification results. For Palawan, NAMRIA mapped land cover in 2003, 2010, and 2014, and created land cover change matrices for these years, as presented in Annex 2. Annex 3 lists land cover data by ECAN (Environmentally Critical Areas Network) land zoning plan.

"Oil palm plantation expansion has also been one of the main drivers of land use change in the Pulot watershed (in Southern Palawan)."

Methodology

The land account covers the entire South Palawan. It was classified based on NAMRIA's national land cover classification system, which in turn is aligned with the FAO Land Cover Classification System. To analyze land cover, NAMRIA used a SPOT image for 2003, Advanced Very Near Infra Red (AVNIR) Panchromatic Remote Sensing for Stereo Mapping (PRISM) and Satellite Pour l'Observation de la Terre (SPOT 5) images for 2010, and Landsat 8 for 2014. Ground truthing, or the act of finding out what is on the ground that is associated with a remotely sensed image, was done for both the 2010 and 2014 data. A validation of results shows an accuracy of over 80% for both the 2010 and 2014 classifications, which is in line with good practices in remote sensing interpretation.

For 2003, no ground truthing was done and the accuracy of the data is not known. The land cover classification involves three main steps: 1) pre-processing and interpretation; 2) field validation; and 3) post-processing, as explained in Figure 3.1.

[7]NAMRIA, pursuant to Executive Order No. 192 (dated June 29,1987), undertakes land classification, land cover mapping, aerial photography, remote sensing, management of resource information, and research and development.

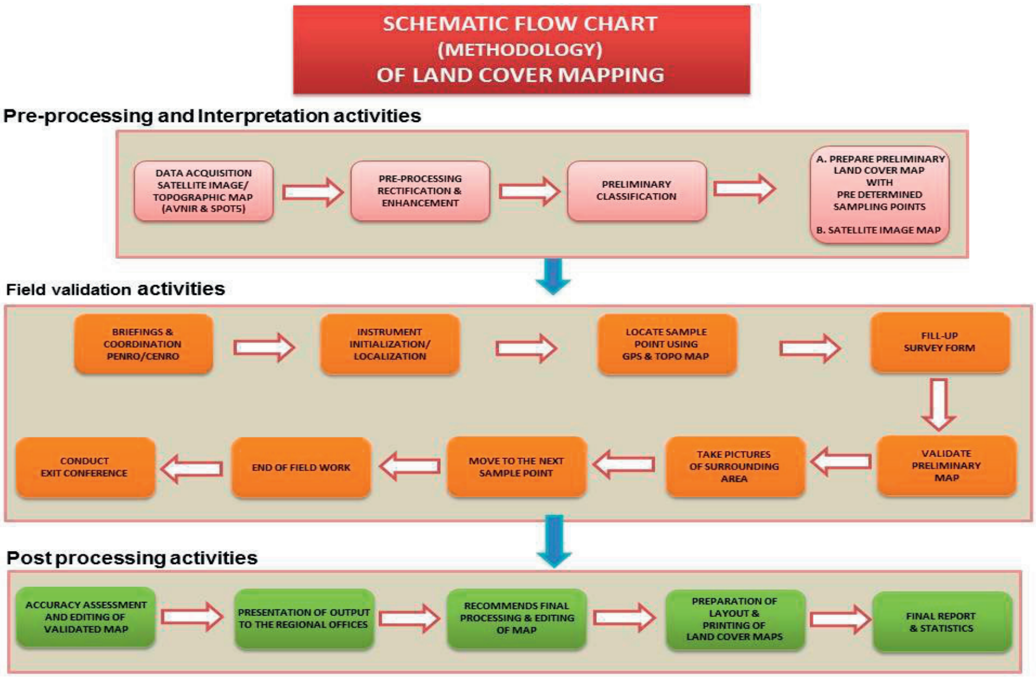

Figure 3.1. Land cover mapping methodology

Results

Land cover maps

Figures 3.2, 3.3, and 3.4 present Southern Palawan's land cover in 2003, 2010, and 2014, respectively. Note that there may have been a different attribution of some land cover classes in 2003 compared to 2010 and 2014, as discussed later. Table 3.1 presents the land cover change from 2010 to 2014.

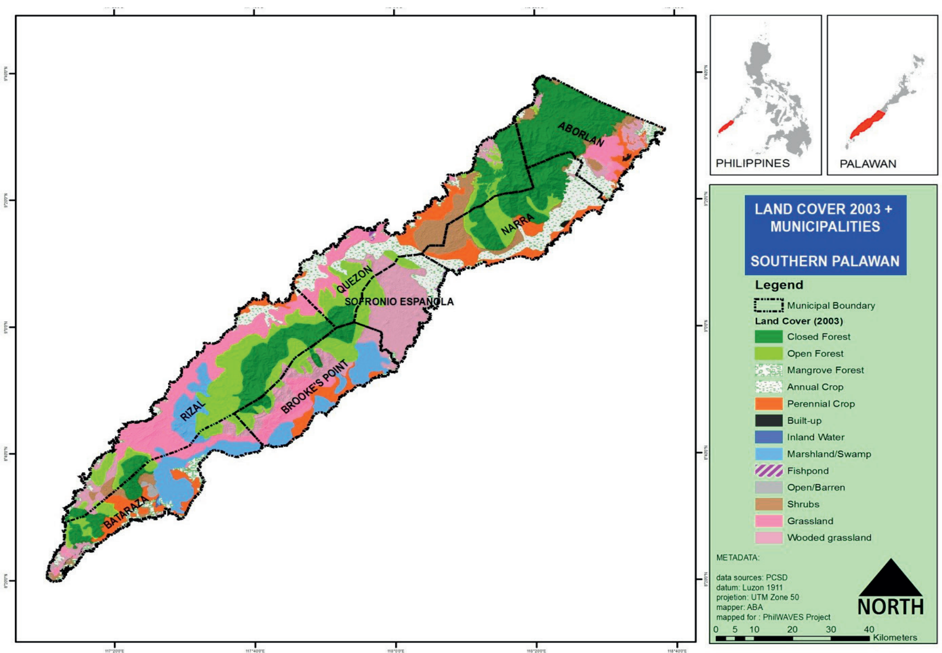

Figure 3.2. Land cover 2003 (NAMRIA)

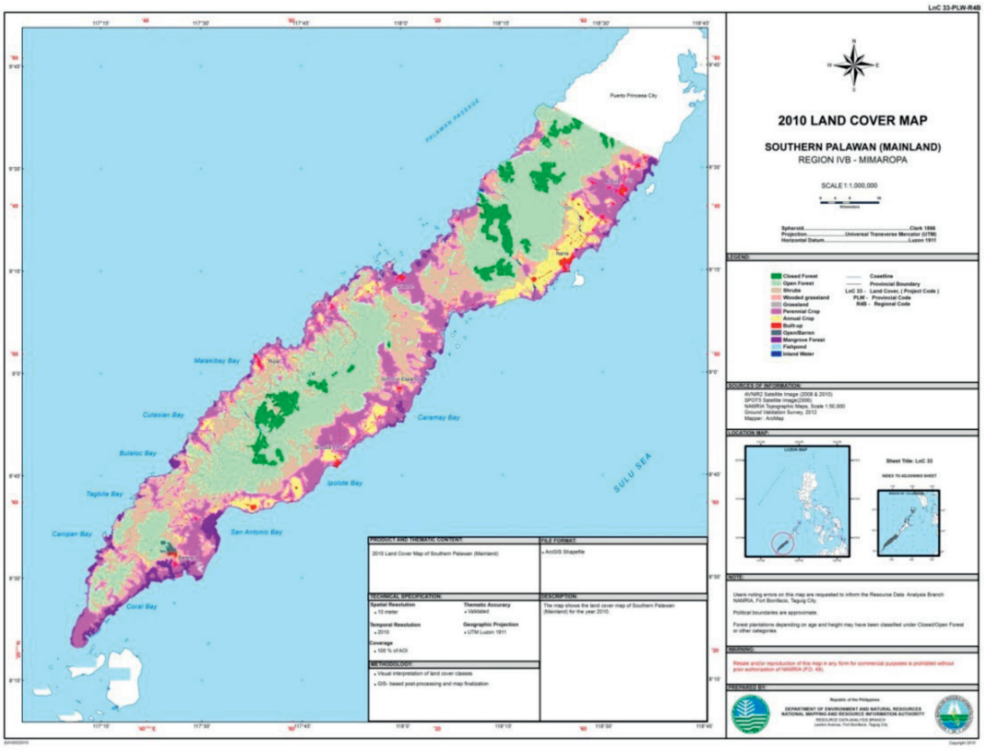

Figure 3.3. Land cover 2010 (NAMRIA)

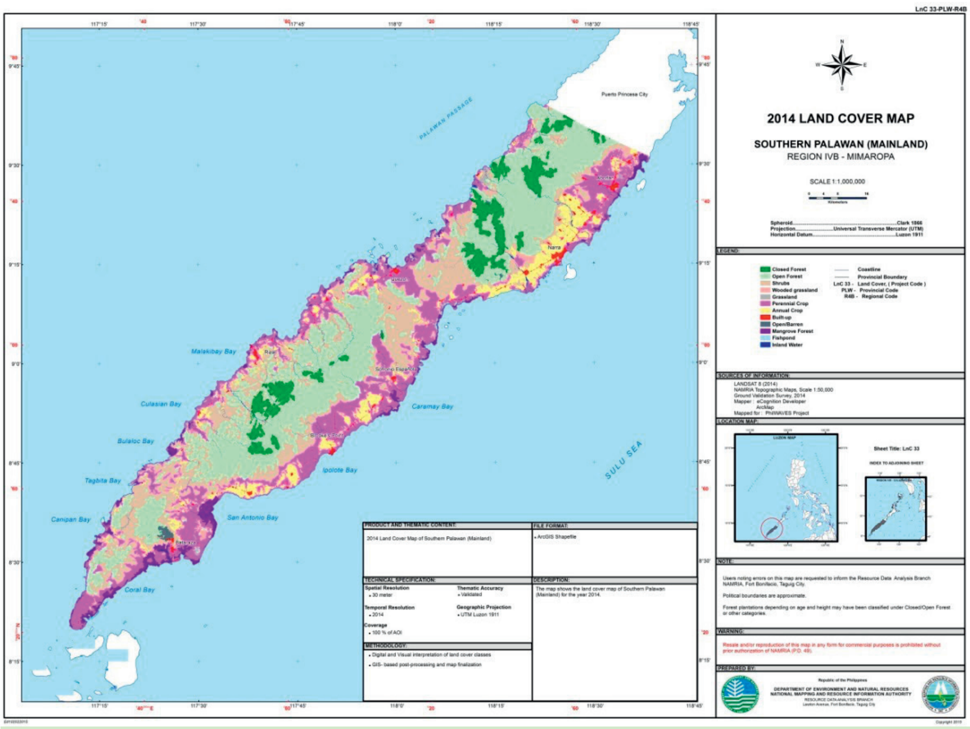

Figure 3.4. Land cover 2014 (NAMRIA)

Land cover change

Table 3.1 presents the results for Southern Palawan, where the attribution between classes changed between 2003 and 2010. This emergent issue is specifically related to the classes "open forest", "wooded grassland", "grasslands", "shrubs", and "marshland". These classes are generally hard to distinguish from each other in remote sensing analysis. NAMRIA indicated that the 2003 classification may not have been as accurate as the succeeding ones due to the lack of ground-truth data.

It is therefore likely that there have been different interpretations of these land cover classes. For example, a specific ecosystem type may have been labeled as an "open forest" in 2003 but was probably called "wooded grassland" in 2010. Hence, the distinction between the abovementioned classes is not entirely accurate. As such the four classes have been grouped tougher in one class.

In Table 3.1, these classifications are merged and indicate degradation of previously forested land, with or without some forest cover remaining. In this way, land cover change in the period 2003-2014 can be clarified.

A comparison of land cover classes shows a marked increase in perennial crops — specifically coconut and oil palm. Data from the PSA show that coconut was planted extensively in the period 2007-2010, possibly as a consequence of fiscal incentives provided by the Philippine Coconut Authority. These incentives included a fixed payment per seedling planted and per seedling raised to a certain height. In addition, after 2007, there has been a rapid increase in oil palm plantations. Both crops are further examined under the Ecosystem Services Account.

Closed forest cover decreased significantly in the period 2003-2010, but somewhat recovered between 2010 and 2014, with an increase of about 5,000 ha. This figure still represents a substantial loss given the decline in closed forest cover in 2003.

The recent increase may be an offshoot of the DENR's enforcement of Executive Order 23, which was issued by former President Benigno Aquino III in 2011, declaring a moratorium on harvesting and cutting of timber in the natural and residual forests across the country and creating illegal logging task forces. Such moratorium aims to protect the country's remaining forests and to ensure their provision of ecosystem services in the future.

The open/barren land cover class shows significant changes in a short period of time. However, it comprises only a small class in absolute terms and is sensitive to the timing of the remote sensing images. For instance, annual crop land may be classified as open/barren if the image is taken just before planting.

Similarly, the inland water category appears to vary considerably. But this may be attributed to the use of remote sensing images when paddy fields are under water. In this case, some of the paddy fields may register as open water as against a period when they are dry.

The inland water category shows large variations throughout this period. These may be due to the specific interpretation of the remote sensing images. Between 2010 and 2014 such images used for classification might have been taken when the paddy fields were under water, resulting in their classification as open water rather than cropland. The amount of land classified as open land/barren may include land that has been cleared for oil palm plantations or for shifting cultivation.

Annex 2 shows land cover change across classes from 2003 to 2010. However, given the inaccuracy of the classification, as explained above, such information should be interpreted with caution.

"The land cover points to the major deforestation that took place in the period 2003-2010 (in Southern Palawan)..."

Table 3.1. Land Cover Change in Southern Palawan

Land Cover	Land cover 2003 (hectares)	Land cover 2010 (hectares)	Land cover 2014 (hectares)
Built-up	709	6,966	7,425
Annual Crop	52,869	47,950	50,340
Perennial Crop	46,130	113,735	115,845
Closed Forest	130,121	28,025	33,206
Open Forest, (wooded) Grasslands, Shrubs	305,086	334,713	322,817
Open/Barren	1,383	961	1761
Mangrove Forest	16,297	17,020	17,054
Fishpond	720	1,440	407
Inland Water	193	2,696	3,653
Grand Total	**553,508**	**553,508**	**553,508**

Conclusion

A major challenge confronted the development of the land account for Southern Palawan for the years 2003, 2010, and 2014. The 2003 map was less accurate than the more recent ones (2010 and 2014), which means that changes in open forest cover and wooded grasslands cover could not be compared over time.

This highlights the importance of using consistent remote sensing and land cover classification systems through time to improve the accuracy of land cover accounts and the conclusions that could be drawn from them.

The land cover points to the major deforestation that took place in the period 2003-2010, when the closed forest cover decreased from around 130,000 ha to approximately 28,000 ha. This pattern appeared to have halted in the period 2010-2014, when land cover expanded from 28,000 ha to 33,000 ha. But this development cannot be considered statistically significant in view of the 80% accuracy of the remote sensing classification used for this pilot undertaking in Southern Palawan. The account also shows large growth in plantation crops, particularly coconut and oil palm.

Using land cover maps and by showing the changes tracked over time in land cover, the land account yields detailed insights into those changes, as well as information on the location of areas with the most rapid land cover change.

As the land account builds on the mapping expertise of NAMRIA, the application and expansion of the said account to other areas should be straightforward and low-cost since existing remote sensing interpretation technologies can be used.

Highlights of Land Account

- The land account measures how land cover has changed for the whole of Southern Palawan for the period of 2003, 2010, and 2014. Three broad trends can be observed in the data.
- First, the land account shows that major deforestation took place in Southern Palawan from 2003-2010 with closed forest cover dropping from 130,000 ha to 28,000 ha.
- Second, deforestation was stopped and even reversed between 2010 and 2014, as closed forest cover increased from 28,000 ha to 33,000 ha during the period. This coincided with the signing of the National Log Ban and the establishment of an Anti-Illegal Logging Task Force in 2011.
- Third, the account shows a marked increase in perennial crops from 46,130 ha in 2003 to 115,845 ha in 2014. Supplementary data from the Philippine Statistics Authority shows that the largest expansions occurred in oil palm and coconut plantations beginning in 2007; the latter possibly driven by fiscal incentives provided by the Philippine Coconut Authority at the time.

4| Carbon Account

Scope

Carbon has been included as a significant account in ecosystem accounting. The physical and monetary accounts of carbon provide insights into the contribution of the carbon sequestration service to the green economy of the Philippines. They also play an important role in advancing the implementation of a mechanism called Reducing Emissions from Deforestation and Forest Degradation Plus (REDD+) in Palawan's forests.

Carbon sequestration is the capture of carbon from the atmosphere by vegetation, in particular by different types of forests. REDD+ is a global effort to create a financial value for the carbon stored in forests, and offers incentives for developing countries to reduce emissions from forested lands and invest in low-carbon paths to sustainable development (www.un-redd.org, 2015).

In line with the SEEA framework (UN et al., 2014), carbon sequestration is considered an ecosystem service. In this regard, carbon stock serves as an ecosystem condition indicator. (Depending on policy preferences, both carbon stock or changes in carbon stock can be used as an indicator.)

In principle, carbon sequestration can be included in both carbon account and ecosystem services supply and use account. Since these two accounts are not being lumped together, presenting similar information across these accounts is acceptable. (This is in fact a regular occurrence in the System of National Accounts, i.e., one series in two accounts.)

In the pilot ecosystem account, carbon sequestration is included only in the carbon account. This shows that carbon sequestration and carbon stocks are equally important to inform decision making. Thus, in the case of Southern Palawan, they are presented side by side.

The carbon account for Southern Palawan was developed by the Forest Management Bureau of the DENR as a template for further carbon analyses within the agency. In the future, the ecosystem services supply and use account may be expanded to include carbon sequestration.

Unlike other ecosystem services, carbon sequestration is analyzed not only at the scale of Pulot watershed but also across Southern Palawan. The watershed was deemed too small by the TWG to provide policy-relevant information on carbon.

To date, the carbon account has covered only carbon stored and sequestered in the forests. The category "open forest" includes the following land cover categories: open forest, wooded grasslands, and shrublands (but not barren land). As explained in the section on Land Account, these classes cannot be readily distinguished in the available remote sensing data. They have therefore been grouped into one category (see the previous chapter). It is assumed that the data on carbon stocks and sequestration are representative of this broader class. But such data should be verified once the accounts are scaled up.

While other ecosystems also provide carbon capture and storage, they lack data. Forests will be increasingly important in terms of carbon storage and sequestration. Given the growing interest in REDD+, it is also policy-relevant to focus on forests as an ecosystem capturing and storing carbon.

The net carbon uptake or emission is dependent on two main biophysical processes. One concerns changes in forest/woody carbon stocks owing to the net annual biomass growth of existing forest and non-forest stands, and possible biomass regrowth in abandoned lands. The other revolves around land use, forest conversion, and timber logging practices, which can lead to carbon releases through biomass burning, decay, and soil carbon release.

Note that carbon storage and carbon sequestration in plantations are not captured. However, the inclusion of these important ecosystem services will be feasible in the next set of accounts, based on information on coconut and oil palm plantations and rates of carbon storage and capture in these ecosystem units.

Carbon accounting shows increases and decreases in carbon stocks as a function of growth or depletion of forest resources, among other factors. Using carbon database, together with other relevant data, the government can update the National Communications (NC) and improve its compliance with the Measurement, Reporting and Verification (MRV) requirements under the REDD+. States parties to the United Nations Framework Convention on Climate Change are required to submit national reports, including NCs, on their actions to mitigate climate change.

Hence, accounting for and valuing carbon sequestration in Southern Palawan can support land use planning and policy formulation including government spending to preserve forest resources. The Forest Management Bureau as a member of the Phil WAVES Southern Palawan TWG has prepared the carbon account for the years 2003, 2010, and 2014. The objective of the account are as follows:

- To provide carbon stock, carbon sequestration, and carbon values of forests in Southern Palawan corresponding to the years 2003, 2010, and 2014
- To offer insights or analysis based on the resulting accounts
- To link the accounts with policy issues or concerns affecting the forestry sector; and (d) provide recommendations in light of the findings

Çarbon sequestration is expressed in terms of CO_2 (carbon dioxide), which represents the element absorbed by vegetation from the atmosphere and the chemical element that contributes to climate change. Once absorbed by vegetation, carbon is stored in plants in the form of a series of organic molecules (but not as CO_2). Hence, carbon storage is commonly expressed in terms of tons of carbon (C) while carbon sequestration is usually expressed in terms of tons of CO_2.

The conversion factor to get tC from tCO_2 is:

$$1tC = 3.67tCO_2.$$

Methodology

Carbon storage

The carbon account specifies, in terms of tons of carbon, the opening carbon stock, carbon removals, carbon emission, net carbon emission, and closing carbon stock. Carbon stocks are calculated for the years 2003, 2010, and 2014.

Biomass and carbon accounting data are derived from the established volume account of timber. They are divided into five parameters: stem biomass, above ground biomass (AGB) – using biomass expansion factor (BEF), below-ground biomass (BGB), tree biomass, and tree carbon content. The assessment methodology is as follows:

1. Computation of Tree biomass

Tree biomass includes aboveground biomass and belowground biomass, expressed in tons of dry matter per hectare (ton dm/ha).

First, to compute the AGB, the stem biomass is multiplied by the BEF. The stem biomass is derived by multiplying the stem volume (in m^3) by the basic wood density. The BEF reflects the biomass ratio between stems on the one hand, and branches and leaves on the other. The BEF is commonly used in converting standing volumes of timber into total carbon stocks, for the purpose of national inventories of greenhouse gas emissions and sequestration.

BEF constants differ between ecosystems.[8]

Tree Biomass = AGB + BGB

[Stem Biomass = stem volume x wood density]

[AGB (in ton dm/ha) = Stem Biomass x BEF]

[BGB (in ton dm/ha) = AGB (tdm/ha) x (Root-to-shoot ratio)]

Second, the BGB, which is related to aboveground biomass based on the root-to-shoot ratio, is computed. It can be derived by multiplying the computed AGB by the root-to-shoot ratio. The root-to-shoot ratio, like the BEF, is also a variable used to quantify carbon stock. It is often considered as constant or species/area-specific values.

2. Computation of Tree Carbon Content

Tree Carbon Content = Tree Biomass x Carbon Fraction

Given the tree biomass, the tree carbon content can now be derived by multiplying the estimated tree biomass with the carbon fraction constant of 0.47 ton of carbon per ton of dry matter.

3. Computation of Carbon Dioxide Content

CO_2 Content = Tree Carbon Content x 3.67

Finally, the CO_2 equivalent is estimated by multiplying the tree carbon content by a factor of 3.67, which converts the mass of carbon to the mass of carbon dioxide. The conversion factor of 3.67 is computed by dividing the molecular weight of CO_2 (44) by the molecular weight of carbon (12).

The assumptions for the carbon stock calculations are specified in Tables 4.1 and 4.2.

Table 4.1. Factor Assumptions for the Carbon Account[9]

Factor Assumption:	
Average Wood Density	0.57 ton/m^3
Average Wood Density of Mangrove Timber Species	0.8 ton/m^3
Root-to-Shoot Ratio	
Closed Forest	0.33
Open Forest	0.32
Other Wooded Land	0.40
Mangrove	0.49
Carbon Fraction	0.45

[8] Data and assumptions are derived from the manual Tracking Greenhouse Gases: A Guide for Country Inventories (Villarin, J.T. et al., 1999) and the IPCC Good Practice Guidelines for National Greenhouse Gas Inventories (2006).
[9] From the FMB Forest Resources Assessment 2003; the ongoing DENR GHG Inventory Study for the AFOLU (Agriculture, Forestry and Other Land Use) sector. Factor assumptions for mangroves were taken from the Ecosystems Research and Development Bureau, 2012 and Carbon Storage of Selected Mangrove Forests in the Philippines study.

Carbon sequestration

This study analyses the carbon sequestration service of the forest (i.e., closed forest, open forest, and mangrove forest) in Southern Palawan and Pulot watershed. Mean carbon sequestration rate in tons of CO_2 per hectare per year of each forest type was derived using the following parameters:

Open forests have higher annual carbon sequestration because the mean annual increment of wood in these sites is generally higher compared to established forests, where growth tends to slow down.

Monetary valuation of the carbon sequestration service has been undertaken for each major type of forests: closed, open, and mangrove. Valuation is based on the social cost of carbon (SCC).

The SCC estimates the value of economic damages associated with a small increase in CO_2 emissions, conventionally 1 metric ton, in a given year. Conversely, this figure also represents the value of damages avoided for small emission reductions.

The SCC strongly depends on the discount rate used to value the potential future impacts of climate change. At 3% social discount rate, the SCC is pegged at US$32 or 1,344 pesos per ton of CO_2 while the SCC at 5% is estimated to be US$11 or 462 pesos per ton of CO_2 (US Environmental Protection Agency, 2013).

The appropriate method to calculate the costs of carbon emissions is still being discussed by the ecosystem accounting community. One question that still has to be resolved is the degree to which the SCC represents an exchange value required for accounting to conform to the SNA.

Table 4.2 presents input data used for the calculation of carbon stocks and carbon sequestration rates. As with the land account, where the classes "open forest", "shrubland", and "wooded grassland" are merged because they cannot be properly distinguished from one another, based on the remote-sensing image taken in 2003, similar aggregations have been carried out for the carbon account.

Consequently, carbon stocks and carbon sequestration rates are determined for the new class "open forest," which merges these three classes. These three combined make up comparable proportions of the "open forest" class. As their relative contribution strongly varies across the three years under study (i.e.. 2003, 2010, 2014), the average carbon stocks and carbon sequestration rates of the three classes have been used to estimate the carbon stock and sequestration in the merged class.

Table 4.2. Assumptions and Data Used (from the 2003 Forest Management Bureau Forest Resources Assessment Report)

Ecosystem unit	Gross timber volume	Carbon stock	Average annual growth rate	Average annual carbon sequestration rate
	(m^3/ha)	(ton C/ha)	(ton dry matter/ ha/year)	(ton CO_2/ha/ year)
Closed	200.07	68.25	2.10	4.61
Open	111.43	37.73	3.50	7.63
Shrub	8.23	2.96	1.50	3.47

Ecosystem unit	Gross timber volume (m³/ha)	Carbon stock (ton C/ha)	Average annual growth rate (ton dry matter/ha/year)	Average annual carbon sequestration rate (ton CO_2/ha/year)
Wooded Grassland	30.01	10.78	1.50	3.47
Average (Open, Shrub, Wooded Grassland) – used for open forests	49.89	17.15	2.17	4.86
Mangrove	173.60	93.12	5.20	12.02

Results

Carbon stock in Southern Palawan

The biomass and carbon account presents the carbon stock in 2003, 2010, and 2014. Table 4.3 presents only the biomass and carbon data on forest cover, particularly for closed, open and mangrove forests. The forest biomass takes into account the stem, aboveground, belowground, and total tree biomass (excluding soil carbon for lack of data).

Biomass in closed forests in Palawan is relatively low compared to other forests in a more humid climate. This may also reflect the existence of logging in these forests in the past. The carbon stock in Southern Palawan forests stood at 16 million ton C in 2003, 9.2 million tons C in 2010, and 9.4 million tons C in 2014 (see Table 4.3).

The decrease in the first period can be attributed to the decline in the area and volume of closed forests and the wide-range conversion of closed forest to other land cover. The rise of carbon stock in the period 2010-2014 was due as well to the increase of area and timber volume in open and closed forests.

Table 4.3. Carbon Storage in Southern Palawan in Three Ecosystem Units

Ecosystem unit	2003			2010			2014		
	Area (ha)	Carbon stock (in ton C per ha)	Carbon stock (in million ton C)	Area (ha)	Carbon stock (in ton C per ha)	Carbon stock (in million ton C)	Area (ha)	Carbon stock (in ton C per ha)	Carbon stock (in million ton C)
Closed Forest	130,121	68.25	8.88	28,025	68.25	1.91	33,206	68.25	2.27
Open Forest	305,086	17.15	5.23	334,713	17.15	5.74	322,817	17.15	5.54
Mangrove Forest	16,297	93.12	1.52	17,020	93.12	1.58	17,054	93.12	1.59
Total	451,504		15.63	379,758		9.24	373,077		9.39

Carbon sequestration in Southern Palawan

Table 4.4 presents calculations of carbon storage in Southern Palawan. Among the three forest types, mangroves have the lowest total carbon sequestration due to their relatively lower areal coverage for the period 2003-2014 compared to the other two forest types. In general, the year 2003 had the lowest carbon sequestration, while sequestration gradually increased again between 2010 and 2014.

Table 4.4. Carbon Sequestration in Physical Units (tons CO_2/year)

Palawan	Carbon sequestration per hectare	2003		2010		2014	
	(ton CO_2/ha/ year)	Area	Carbon sequestration (1000 ton CO_2/year)	Area	Carbon sequestration (1000 ton CO_2/year)	Area	Carbon sequestration (1000 ton CO_2/year)
Closed Forest	4.61	130,121	600	28,025	129	33,206	153
Open Forest	4.86	305,086	1,481	334,713	1625	322,817	1,567
Mangrove Forest	12.02	16,297	196	17,020	205	17,054	205
Total		451,504	2,277	379,758	1,959	373,077	1,926

The monetary value of carbon sequestration in Southern Palawan (in pesos per year) can be calculated using the marginal costs of 1 unit of CO_2 captured by forest vegetation. As discussed, it is tentatively assumed that this amount can be approximated using SCC, where future damages of climate change have been discounted at either 3% or at 5%. Based on the results shown in Table 4.5, it is assumed that the SCC is pegged at 1,344 pesos (US$28.87) per ton of CO_2 at a discount rate of 3%, or 462 pesos (US$9.92) per ton of CO_2 at a discount rate 5% (based on the US Environmental Protection Agency, 2013, as explained above).

Table 4.5. Carbon Sequestration in Monetary Units (billion pesos/year)

Southern Palawan	2003			2010			2014		
	Carbon sequestration (1000 ton CO_2/year)	Annual value (SCC = 1344 pesos/ton CO_2); billion pesos	Annual value (SCC = 462 pesos/ ton CO_2); billion pesos	Carbon sequestration (1000 ton CO_2/year)	Annual value (SCC = 1344 pesos/ton CO_2); billion pesos	Annual value (SCC = 462 pesos/ ton CO_2); billion pesos	Carbon sequestration (1000 ton CO_2/ year)	Annual value (SCC = 1344 pesos/ ton CO_2); billion pesos	Annual value (SCC = 462 pesos/ ton CO_2); billion pesos
Closed Forest	600	0.81	0.28	129	0.17	0.06	153	0.21	0.07
Open Forest	1,481	1.99	0.68	1,625	2.18	0.75	1,567	2.11	0.72
Mangrove Forest	196	0.26	0.09	205	0.28	0.09	205	0.28	0.09
Total	2,277	3.06	1.05	1,959	2.63	0.91	1,926	2.59	0.89

Carbon storage and sequestration in Pulot watershed

Following the methodology explained above, the same computation was made in Pulot watershed, which covers only a small portion of Southern Palawan. Tables 4.6 and 4.7 show carbon storage and carbon sequestration in the watershed, respectively.

Overall, there were no major changes in carbon stocks in the period 2003-2014 (see Table 4.6). However, as shown in Table 4.5, the total carbon sequestration in tons of CO_2/year in the watershed rose between 2003 and 2014.

Data on Pulot watershed indicate a conversion from closed to open forest, in particular between 2003 and 2010. On a per hectare basis, open forests have a higher carbon sequestration rate owing to their regrowth. This does not mean, however, that conversion of forests to open types is positive for carbon balance, since regrowth involves compensation for carbon that was previously lost in the ecosystem.

Between 2010 and 2014, the total forest area in the watershed appears to have increased. This is remarkable given the increase in plantations in the area, where further ground truthing and testing of the apparent increase are required. A stakeholder workshop conducted in the watershed indicated that local people also had the impression that deforestation continued to increase in the area. Yet, the inaccuracy of the remote sensing images (20%) means that the observed increase in forest cover was not significant. Hence, it is too early to conclude that the forest cover increased between 2010 and 2014.

Table 4.8 presents the monetary value of carbon sequestration in the forests of Southern Palawan. Using a discount rate of 5% and a 20-year discounting period, the values presented in the table yield a net present value of 50,000 pesos (US$1,074.11)/ha, 54,000 pesos (US$1,160.04)/ha, and 54,100 pesos (US$1,162.19)/ha for 2003, 2010, and 2014, respectively. These calculations assume that sequestration rates remain constant relative to the calculation period (i.e., 20 years). This is obviously a simplification, since sequestration is relatively low when a piece of land is denuded, and higher during intermediate stages in mature forests.

Table 4.6. Carbon Storage in Pulot Watershed (million ton C)

Southern Palawan	2003			2010			2014		
	Area (ha)	Carbon stock (in ton C per ha)	Carbon stock (in 1000 ton C)	Area (ha)	Carbon stock (in ton C per ha)	Carbon stock (in 1000 ton C)	Area (ha)	Carbon stock (in ton C per ha)	Carbon stock (in 1000 ton C)
Closed Forest	1,417	68	97	91	68	6	95	68	6
Open Forest	6,356	17	109	7,689	17	132	7,884	17	135
Mangrove Forest	22	93	2	15	93	1	5	93	0
Total	7,795		208	7,795		139	7,984		142

Table 4.7. Carbon Sequestration in Pulot Watershed in 2003, 2010, 2014, in tons of C/year

Ecosystem unit	2003			2010			2014		
	Area (ha)	Carbon sequestration (in ton CO_2 per ha per year)	Carbon sequestration (in ton CO_2 per year)	Area (ha)	Carbon sequestration (in ton CO_2 per ha per year)	Carbon sequestration (in ton CO_2 per year)	Area (ha)	Carbon sequestration (in ton CO_2 per ha per year)	Carbon sequestration (in ton CO_2 per year)
Closed Forest	1,417	4.61	6,536	91	4.61	420	95	4.61	438.20
Open Forest	6,356	4.86	30,861	7,689	4.86	37,333	7,884	4.86	38,280
Mangrove Forest	22	12.02	264	15	12.02	180	5	12.02	60
Total	7,795		37,662	7,795		37,933	7,984		38,778

Table 4.8. Carbon Sequestration in Monetary Units (million pesos/year)

Pulot watershed	2003			2010			2014		
	Carbon sequestration (1000 ton CO_2/year)	Annual value (SCC = 1344 pesos/ ton CO_2); billion pesos	Annual value (SCC = 462 pesos/ton CO_2); billion pesos	Carbon sequestration (1000 ton CO_2/year)	Annual value (SCC = 1344 pesos/ton CO_2); billion pesos	Annual value (SCC = 462 pesos/ ton CO_2); billion pesos	Carbon sequestration (1000 ton CO_2/ year)	Annual value (SCC = 1344 pesos/ ton CO_2); billion pesos	Annual value (SCC = 462 pesos/ ton CO_2); billion pesos
Closed Forest	6,536	8.8	3.0	420	0.56	0.19	438	0.59	0.20
Open Forest	30,861	41.	14.3	37,333	50.2	17.3	38,280	51.4	17.7
Mangrove Forest	265	0.36	0.12	180	0.24	0.08	60	0.08	0.03
Total	37,662	50.6	17.4	37,933	51.0	17.5	38,778	52.1	17.9

To facilitate comparison of carbon stocks and carbon sequestration, the summary account in the beginning of this report expresses carbon sequestration in terms of tons of C/year. This is obtained by dividing the amount of sequestered CO_2 by 3.67 (relative molecular weight, as explained in the methodology discussed earlier). In view of the high uncertainties surrounding monetary valuation, monetary values are not provided in the summary account for policy makers.

Evaluation

The accounts show that the overall deforestation in Southern Palawan in the period 2003-2010 also had major consequences for the carbon stock in its forests. The stock declined from 16 million tons C to 9 million tons C in the three ecosystem units, namely, closed forests, open forests, and mangroves.

The slight increase in carbon stock in Southern Palawan in the period 2010-2014 was much smaller compared to the decrease in the preceding period. This indicates that over the longer term the forest resources in Southern Palawan have not been sustainably managed.

This situation also illustrates the challenges of implementing forest policies in Palawan, especially the ban on commercial logging as well as the regulation on the possession, ownership or use of power chainsaws within the province (DENR Administrative Order NO. 49, dated November 6, 1992).

Enforcement of these policies remains a challenge. The continuing pressure on the forests shows the rationale of a clear and well-funded forest protection and law enforcement program including strict implementation of forest policies such as EO 23, and policies related to community-based forest management and integrated forest management agreement, among others. The impacts of such programs and policies were evident in the average annual increase in carbon stock between 2010 and 2014.

Ecosystem accounting supports forest management by identifying areas that are subject to rapid land use change (such as in Pulot watershed) and also those where illegal logging has had an impact on overall forest cover. There is thus a need to update the data regularly (at least every two years) to support forest monitoring, planning and implementation.

It is also important to strengthen frontline forestry services and equip concerned personnel with the necessary logistics for ground monitoring and evaluation, especially since the remote sensing imagery cannot differentiate between different types of closed and open forests.

"Overall deforestation in Southern Palawan in the period 2003-2010 also had major consequences for the carbon stock ... (which) declined from 16 million tons C to 9 million tons C."

Efforts to establish estimates of the economic values of the forest ecosystem are already a big step toward establishing a clearer understanding of the real value of the country's forest resources. This can be used as a basis for innovative financing policies, especially payments for environmental services schemes, which serve as incentives for farmers who manage their land to provide ecological services.

At present, valuing forest beyond timber benefits shows the importance of understanding the carbon sequestration potential of forests. It also sends a message to the public that forests' value lies beyond the provision of timber. The specific forest value, however, is strongly dependent on assumptions. The monetary value differs by almost a factor of 3, depending on the discount rate applied.

Highlights of Carbon Account

- The carbon account captures the changes in carbon stock and sequestration for the whole of Southern Palawan for the years 2003, 2010, and 2014. Two key findings of the account stand out.
- First, deforestation in Southern Palawan during the period 2003-2010 had major impacts on carbon stock in its forests with stocks dropping from 16 million tons C to 9 million tons C during the period. The modest recovery of closed forests between 2010 and 2014 only led to a slight increase in carbon stock that was not sufficient to offset the preceding decline, indicating that forest resources were not sustainably managed.
- Second, despite these land cover changes the carbon account shows that the forests of Southern Palawan are an important carbon sink. There is thus potential for advancing the implementation of the Reducing Emissions from Deforestation and Forest Degradation Plus (REDD+) mechanism in Palawan.

5| Ecosystem Condition Account

Introduction

The ecosystem accounts require the use of a range of condition indicators, which are grouped into three categories[10]:
1) geomorphological, 2) environmental state, and 2) condition indicators. These are in line with recent discussions on the new Technical Recommendations for Ecosystem Accounting that was released as a draft in 2015 by the UN Statistics Division.

Geomorphological indicators

The geomorphological indicators express the physical parameters that define the landscape, which are exogenous to the system. These typically do not change significantly at time scales of relevance (i.e., several decades) for the accounts.

Examples of these indicators are slope and basic soil type, as well as average climatic variables such as rainfall and temperatures. Since these indicators do not change significantly a year after their generation, they are part of the underlying data in the accounts. But there is usually no need to report them to policy makers on a regular basis.

Environmental state indicators

These reflect abiotic environmental conditions that are relevant to the account, in particular for analyzing regulating services. Examples are indicators reflecting air or water pollution levels. These may change from one year to the next, and potentially within accounting periods (e.g., air pollution concentrations can vary on a daily basis). They are in themselves often also policy-relevant and are therefore included in the accounts, where appropriate.

Ecosystem condition indicators

These reflect the state of the ecosystem and its components, processes, and functioning (and, potentially, other elements of ecosystem such as resilience). They include biotic indicators such as standing biomass, and species composition or net primary production; and abiotic indicators like soil organic matter.

The difference between environmental condition and ecosystem condition indicators is that the former shows the overall environment in which ecosystem services are generated. On the other hand, ecosystem condition describes the overall characteristics, i.e. quality of a specific ecosystem asset such as forest. For example, the air filtration service provided by the forest ecosystem is dependent on the its quality which may be measured in terms of vegetation characteristics (e.g. leaf area index, biomass index), biodiversity (e.g. species richness, relative abundance), carbon (e.g. net carbon balance, primary productivity). They are especially relevant to the analysis of the benefits resulting from ecosystem services. For instance, air pollution concentrations (often expressed as particulate matter concentrations) are an environmental condition indicator that facilitates understanding of the air filtration service provided by vegetation. Without air pollution, there can be no capture of air pollutants by vegetation.

Terrestrial condition account

This account aims to record a number of key variables that reflect ecosystem components and functioning in Pulot watershed. It consists of the following variables:

- Geomorphological indicators, namely, elevation, precipitation, evapotranspiration, slope
- Environmental state indicators, namely, hazards and soil loss

Note that land cover, including vegetation, is already covered in the land account, which is discussed earlier in this report.

The foregoing indicators have been selected because, in addition to land cover, they are important for understanding the services provided by the uplands. The hydrological

[10] The forthcoming SEEA-EEA Technical Recommendations distinguish the same three categories of indicators, but do not provide a specific name for each.

services are crucial in maintaining water supply throughout the year for paddy fields in the lowlands. According to some stakeholders, land cover change in the uplands (including loss of forest for plantation development and shifting cultivation plots) could lead to changes in hydrology and water availability.

Indicators are grouped into three categories: geomorphological, environmental state, and ecosystem condition (as reported in the sections below). Data availability is a significant concern. In the future, a more elaborate analysis of the specific indicators (and the corresponding data) that should form part of the condition account is required.

The data collected for the foregoing indicators came from international and local sources, as specified below for each dataset.

The opening of new mines and expansion of existing ones have been mentioned as an important land use change that has taken place in Southern Palawan, including Pulot watershed, in recent decades. This may affect ecosystem services in a number of ways such as through land cover change (as explained in the section on land account) and changes in water quality in both rivers downstream of mining operations and coastal zones, where these rivers flow into the sea. Data on water quality were not available at the time of the study.

Results

Geomorphological indicators

Annex 5 reports on the geomorphological state indicators, including rainfall, evapotranspiration rates, soil texture, and slope. These are important biophysical properties of the ecosystem and are used to model the hydrology and the erosion rates of the ecosystem.

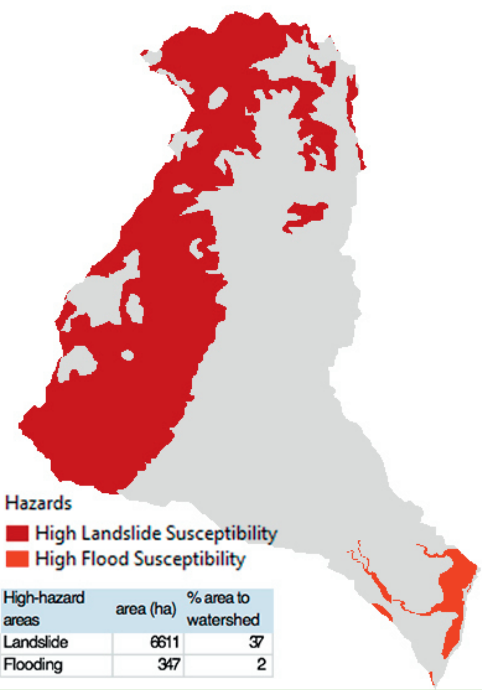

Figure 5.1. High-hazard areas: flooding and landslide (2010)

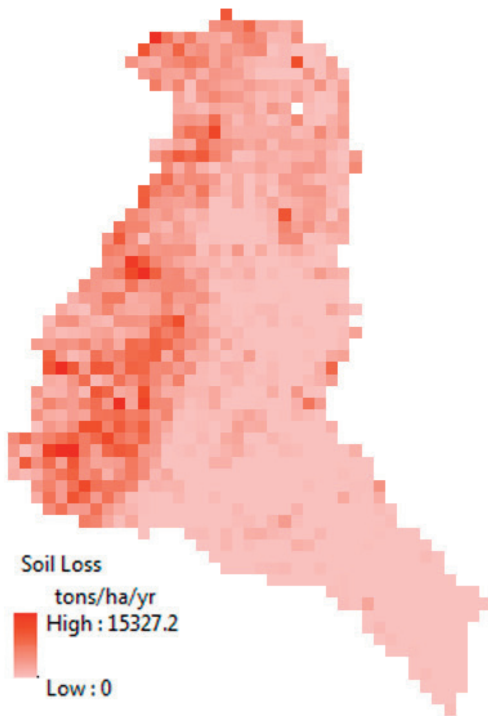

Figure 5.2. Soil loss derived using RUSLE (based on 2010 land cover data)

Environmental state indicators

Two indicators are included in the condition account, both indicating environmental degradation processes, with potential economic repercussions. One is the risk of hazards based on susceptibility models generated by the DENR. The hazards include both the risks of landslides in the uplands and risks of flooding in the lowlands (see Figure 5.1).

The other indicator is soil loss, which is modelled in the study. Soil loss under current land cover conditions has been derived using the Revised Universal Soil Loss Equation (RUSLE). It is expressed in tons/hectare/year (see Figure 5.2). Soil loss is also a primary input in modelling sedimentation for the watershed.

Evaluation

The terrestrial ecosystem condition is currently described in terms of land cover and vegetation type, and key hydrological parameters and landscape processes. Land cover is also required to model other ecosystem services in terms of supply and capacity. It provides insights relevant to ecosystem management, in particular land use change and issues such as encroachment in protected areas and forest reserves.

Hydrological condition indicators are required for the hydrological model, but by themselves do not provide any specific policy-relevant information. Much, if not all, of the terrestrial condition information is also available for Southern Palawan, and this part of the account could easily be scaled up.

However, the analysis of ecosystem condition indicators conducted for this study shows that information is missing on river and coastal water quality. (See the succeeding section on coastal condition account.) Also, the river flow measurement stations in Pulot River are no longer operational — a situation that will increasingly be a constraint for modelling and monitoring the impacts of land use change on water availability and those on coastal ecosystems.

Coastal condition account

The coastal resources making up the account are coral reefs, seagrass beds, and mangrove forests. These three key coastal ecosystems support the generation of fishery production services and others such as buffer from storm surges and tsunamis and in the case of adequately stocked mangrove forests protection from flooding of low lying coastal areas against rising river waters during heavy rains. They are also important resources for an archipelagic country like the Philippines that is dependent on fisheries as sources of protein and livelihood. These resources are also crucial to the Philippines' growth as a tourist destination.

In 2012, the sector contributed 193.7 billion pesos (US$4.1 billion) (1.8%) at current prices to the Philippine GDP (Philippine Fisheries Profile, 2013; Fisheries Situationer, January-December 2012). Its contribution is derived from commercial, aquaculture, and municipal fishery production systems.

The Philippine coastal zone has been under intense pressure from overfishing, with fish capture believed to have exceeded the optimal catch levels to ensure maximum productivity of fish stocks some 20 years ago (Llarina, 2000). The near-shore fish stocks have been fished most heavily. The capture of small and juvenile stocks along with bigger fish has exacerbated this condition, further slowing down the natural recovery of the fish stocks.

"Fish capture (is) believed to have exceeded the optimal catch levels to ensure maximum productivity of fish stocks some 20 years ago (Llarina, 2000)."

Compounding the situation is the country's rising population, which increases the demand for marine products, primarily for food. Adding to the fishery sector's woes are the destruction and degradation of coral reefs, mangrove forests, seagrass beds, as well as the declining water quality in many parts of the country (Alino et al., 2004; White and De Leon, 2004).

The accounts presented in this section cover environmental state indicators and ecosystem extent and condition indicators, which include mangroves, coral reefs, and seagrass within the municipal waters of Sofronio Española.

Environmental state indicators

The coastal environmental state indicators revolve around pollution loading in the coastal zone of Sofronio Española municipality. The corresponding pollutants are selected based on 1) their potential discharge from mining operations and land use in the watershed; 2) their potential impacts on coastal ecosystems, notably coral reefs; and 3) data availability.

Data on pollution loads, which are collected by the Bureau of Mines and Geosciences, cover nickel, copper, lead, and total suspended solids. Arsenic and iron concentrations were analyzed but not included in the pilot account, since their concentrations are consistently below detection limits of the laboratory equipment, and owing to low toxicity for marine ecosystems at the sample concentrations.

If future samples show significantly higher concentrations of these pollutants, then these could still be included in an expanded account using additional tables.

Ecosystem extent

The development of the land cover ecosystem account focuses on the key coastal/marine ecosystems located within the municipal waters of Sofronio Española. These include mangrove forests, seagrass beds, and coral reef ecosystems.

Ecosystem condition indicators

Mangroves

Studies show that the Philippines has a long history of mangrove degradation. The country originally had an estimated area of mangrove forests of 500,000 ha in 1918 (Brown and Fisher, 1920). A recent estimate for the year 2000 put the figures at 256,185 ha (Long and Giri, 2011). The same study reported that in 2000, Palawan had the highest mangrove forest cover in the country, representing 22% of the total mangrove ecosystems in the Philippines.

The latest data indicate that mangrove forest accounts cover around 63,532 ha in Palawan (PCSD 2015 Updates). Municipalities with evident increases (exceeding 1,000 ha) in mangrove forests since 1998 are Bataraza, Culion, Roxas, and Taytay.

While overall mangrove forests in Palawan have expanded, some municipalities have seen a decline in this ecosystem. These are Dumaran, Sofronio Española, Quezon, San Vicente, and Jose Rizal.

The persistent conversion of mangrove areas into fishponds or salt ponds in some parts of the province has not affected the overall mangrove stand in Palawan. The natural regeneration of certain mangrove forests is believed to compensate for mangrove loss arising from fishpond conversion and accounts for the slight expansion of mangrove areas.

Coral reefs

The Philippines has an estimated 27,000 km^2 of coral reefs, with over 70% in poor or fair quality and quantity. Of the remaining cover, only 5% is in excellent condition (Gomez et al., 1994). Coral reefs contribute between 8% and 70% to the total fisheries production for some island reefs (Alino et al., 2004).

Meanwhile, approximately 1 million small-scale fishers representing 62% of the population living along coastal areas are directly dependent on reefs for their livelihood (Barut et al., 2004).

Coral reefs in Palawan are under high pressure and are declining rapidly as a result of overfishing, destructive fishing, and rising pollution. The most recent monitoring report (2004) for the province covering 305 sites in 19 municipalities shows that only 1.1% of the coral reefs of the province are in excellent condition (75-100% live coral cover), 19% in good condition (50-74.9% live coral cover), 34% in fair condition (25-49.9% live coral cover), and 45% in poor condition (less than 25% live coral cover) (State of the Environment 2004, PCSD).

Seagrass fields

Seagrasses are submerged flowering marine plants adapted to live in saline waters. A seagrass bed is one of the most productive components of the marine ecosystem, being ecologically significant and as important as corals and mangroves by serving as nursery, feeding, and breeding grounds for a variety of marine organisms. Seagrasses are associated with mangrove forests and coral reefs and are considered as an ecotone (or transitional zone) between the two ecosystems. In the Philippines, 18 species of seagrass have been recorded (Fortes, 2010), of which 14 species have been found in Palawan (2004).

Case study area

The choice of Sofronio Española as the case study area complements the development of the accounts for the lowland and upland areas of Pulot watershed.

The decision to depart from the catchment as the ecosystem accounting reporting unit for the coastal condition account was primarily due to the interconnectedness of the dynamics and processes in the coastal marine ecosystem that functionally link the key coastal ecosystems beyond the catchment.

Given the complexity and high spatial variability of the three types of coastal ecosystems included in the accounts, a relatively fine spatial grain is needed to understand the condition of these ecosystems. Therefore, this experimental ecosystem account focused on one municipality: Sofronio Española. The account covers three ecosystems, namely, mangroves, coral reefs, and seagrass fields in this municipality, aided by maps (provided by the ESA project) and tables from surveys. Due to limited data, the period 2001-2010 was included to obtain information on trends in ecosystem condition changes.

Methodology

Environmental state indicators

The coastal environmental state indicators focus on pollution loading in the coastal zone of Sofronio Española, including nickel, copper, lead, and total suspended solids (TSS)[11]. (See Annex 6 for the location of the sampling points.) Heavy metal concentrations were examined using atomic absorption spectophotometry; TSS through gravimetric analyses was conducted by CRL Environmental Corporation, a private full-service laboratory in the Philippines.

Ecosystem extent indicators

Mapping

The land cover accounts representing the spatial extent of the three coastal ecosystems condition characterization was produced from images generated and interpreted by the European Satellite Agency from unsupervised classification[12].

The methods used followed the protocol outlined in Green et al. (2000) with contextual editing to correct misclassifications based on reef donation (Mumby et al., 1998). Processing was done using radiative transfer model inversion applied to data from multiple sensor configurations.

Validation to ascertain accuracy was done using in-situ point data collected in 2010 (PCSDS, 2011) on benthic cover, which consists of relative (percentage) live coral cover at 25 locations across the study area.

[11] Total suspended solids are particles that are larger than 2 microns found in the water column. Anything smaller than 2 microns (average filter size) is considered a dissolved solid.

[12] Unsupervised classification involves categorization of digital image data by computer processing based solely on the image statistics without the availability of training samples

A dataset of six points of seagrass cover was also available but was not used due to its insufficiency for the conduct of a statistical test of any power. Accuracy assessment was based on a determination of whether the coral-containing classes in the habitat map coincided with the data points of high coral cover. Classes "reef flat," "reef crest," and "reef slope" corresponded to habitats expected to contain live coral and were evaluated using in-situ data points. Table 5.1 shows the habitat classification and description.situation that will increasingly be a constraint for modelling and monitoring the impacts of land use change on water availability and those on coastal ecosystems.

Table 5.1. Habitat Classification Scheme Details

Code	Name and description
0	Unprocessed – no data, pixel unprocessed or invalid
1	Land – above water during image acquisition
2	Deep water – bottom cannot be seen in image
3	Sand or bare substrate – bright substrate of sand or rubble may contain a small amount of thin vegetation or soft or hard corals
4	Sand with thin vegetation – sand or rubble with some seagrass and/or macroalgae cover but not sufficient to obscure the visibility of the sand substrate
5	Dense vegetation – dense cover of seagrass or macroalgae potentially obscuring the substrate below
6	Reef flat/coral and rubble field – habitat that may contain coral in a relatively sheltered environment, typically behind the reef crest and at the edge of the lagoon
7	Reef crest/high coral cover – places where coral is found in highest density, typically at the edge of the reef and top of the reef slope
8	Reef slope/deep reef – regions that slope up to the reef crest from deeper water and also more deeply submerged reef mounts that are visible in satellite imagery but difficult to characterize. These regions contain hard and/or soft corals.

Ecosystem condition indicators

The condition account for mangroves, seagrass beds, and coral reefs have been developed based primarily on data from the Coastal Resource Monitoring Report 2011 for Sofronio Española (PCSDS 2011). Detailed information on sampling methodology and data processing can be found in ANNEX 12 of this report. These reports are prepared on a regular basis, typically once every three years, but require two reporting cycles, or six years, to complete the full monitoring cycle for all municipalities in Palawan. It is important to note that area (ha) as one of the indicators of ecosystem condition for mangroves was determined using land cover datasets for 2003 (unvalidated) and 2010 from NAMRIA.

Results

Environmental state indicators

Data have only been made available for two points in time, and are insufficient to use for an analysis of the potential impacts of pollution on coastal ecosystems. (Data corresponding to several years would be preferable[13].)

[13] These data have been requested from the Bureau of Mines and Geosciences.

Hence, Tables 5.2 and 5.3 provide the set-up of the environmental state indicators of the ecosystem account, including four pollutants: nickel, copper, lead, and total suspended solids (TSS). The first three may be present in the runoff from the mines and ore deposits located in the lower part of Pulot watershed. The fourth (TSS) is linked to mining operations, deforestation, and land use change.

Table 5.2. Annual Average Heavy Metal Concentrations in Nine Sample Locations in Pulot River and Adjacent Coastal Zone (in mg/l)

	2013						2014						2015 (Jan - Apr)					
	As	Cu	Fe	Pb	Ni	TSS	As	Cu	Fe	Pb	Ni	TSS	As	Cu	Fe	Pb	Ni	TSS
Method Detection Limits	***0.02***	***0.04***	***0.08***	***0.08***	***0.03***		***0.02***	***0.04***	***0.08***	***0.01***	***0.03***		***0.02***	***0.04***	***0.08***	***0.01***	***0.03***	
East of Causeway	0.01	0.06	0.57	0.57	0.61	26	0.01	0.04	0.31	0.14	0.56	9	0.01	0.03	0.37	0.05	0.57	6
West of Causeway	0.01	0.05	0.54	0.54	0.58	22	0.01	0.04	0.24	0.14	0.51	12	0.01	0.03	0.47	0.05	0.60	6
Infront of Causeway	0.01	0.06	0.50	0.50	0.60	24	0.01	0.03	0.28	0.14	0.54	11	0.01	0.03	0.37	0.05	0.67	7
Pulot River Delta	0.01	0.02	0.74	0.74	0.03	21	0.01	0.02	0.35	0.09	0.03	10	0.01	0.01	0.23	0.05	0.03	11
Pulot River Bridge	0.01	0.02	0.76	0.76	0.03	19	0.01	0.02	0.70	0.07	0.03	11	0.01	0.01	0.50	0.05	0.03	13
Maribong River Spillway	0.01	0.02	0.40	0.40	0.03	9	0.01	0.02	0.33	0.09	0.03	11	0.01	0.01	1.75	0.05	0.03	14
Pasi River	0.01	0.02	0.38	0.38	0.03	6	0.01	0.02	0.30	0.09	0.03	7	0.01	0.01	0.18	0.05	0.03	12
Confluence Maribong & Pasi	0.01	0.02	0.35	0.35	0.03	7	0.01	0.02	0.50	0.14	0.03	8	0.01	0.01	0.73	0.05	0.03	12
Tagusao River	0.01	0.02	0.45	0.45	0.03	9	0.01	0.02	0.34	0.07	0.03	10	0.01	0.01	0.26	0.05	0.03	14
Average	0.01	0.03	0.52	0.52	0.22	16	0.01	0.02	0.37	0.11	0.20	10	0.01	0.02	0.54	0.05	0.22	11

LEGEND — ***As = Arsenic*** | ***Cu = Copper*** | ***Fe = Iron*** | ***Pb = Le ad*** | ***Ni = Nickel*** | ***TSS = Total Suspended Solids***

Ecosystem extent account

Maps

The spatial accounting of the coastal ecosystem of Sofronio Española yielded a total area estimate of 28,813 ha (see Table 5.3 and Figure 5.3). The largest part is composed of the coastal/marine waters comprising 10,125 ha, measured from the seaward limits administratively defined by the Philippine government as 15 kilometers offshore from the highest tide.

The other land-water cover ecosystem units comprising the highest to lowest areas include seagrass beds/macroalgae, sand or bare substrate, coral reefs, and mangrove forests. A discrepancy was noted between the map produced by the ESA and the local inventory of mangrove cover.

The ESA map shows a mangrove cover of 1,330 ha in 2014 while the local survey puts it at 1,092 ha in 2010. Given the decline of the mangroves in earlier years, it is doubtful that the cover increased by around 20% during this four-year period. Such discrepancy shows the level of uncertainty over the currently available land cover data.

Table 5.3 Coastal-Marine Land/Water Account, Sofronio Española, Palawan, Philippines, August 2014

	Area (ha)	Percent % of Total
Total Coastal Ecosystem Accounting Unit	28,813	100
Coastal/Marine deep waters	10,125	35.1
Land/Island	119	0.41
Sand or bare substrate	4,663	16.2
Seagrass beds and Macroalgae	8,323	28.9
Thin vegetation	8,254	28.7
Dense vegetation	69	0.24
Coral reefs	4,253	14.8
Reef flat/coral and rubble field	2,201	7.6

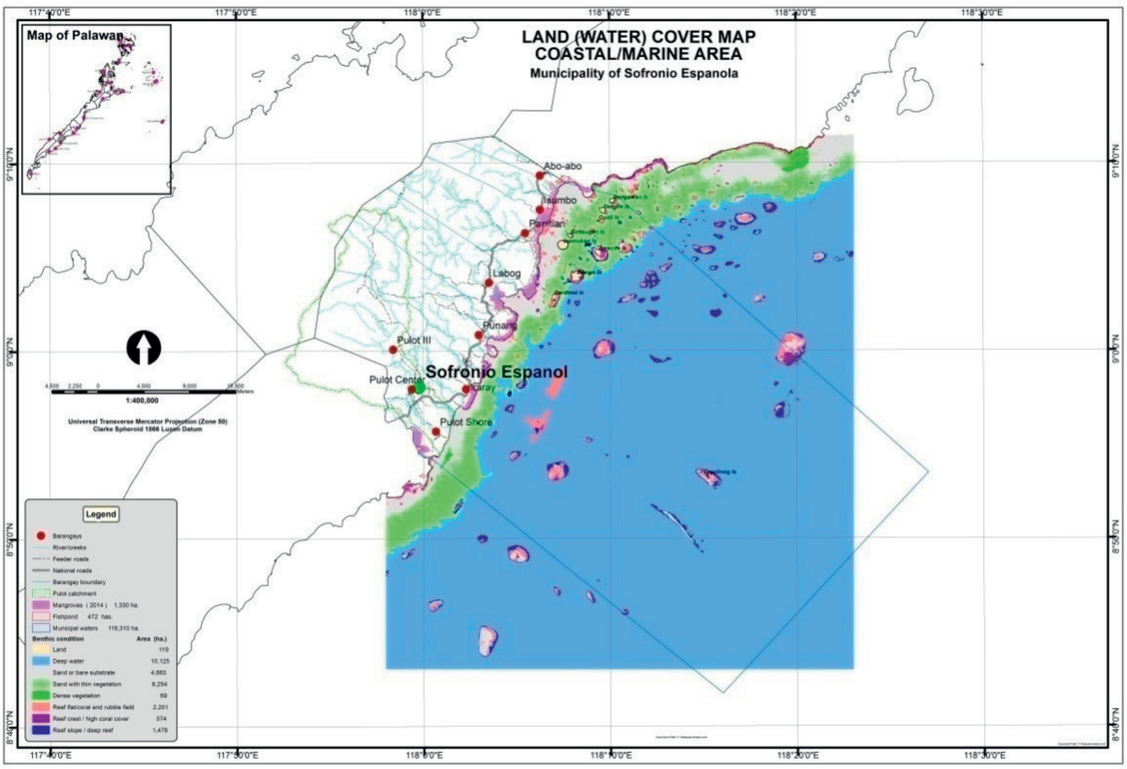

Figure 5.3. Coastal/Marine Ecosystem Extent Map. Municipality of Sofronio Española, Palawan, Philippines, 2014.

Highlights of Coastal Condition Account

- The coastal condition account covers mangrove forests, seagrass beds, and coral reefs which support the generation of fishery production services and other services such as coastal defense, sequestration of nutrients and pollutants in organic and inorganic sediments, and recreation. The study covered the period 2001-2010.
- Overall decline in the condition of mangrove forests, seagrass beds and coral reefs in the municipality of Sofronio Española.
- The extent of mangrove forest showed a net decrease of 684 ha (38.51%) and the overall volume declined by 147,401 ha (43.73%) in just nine years. A number of factors may have contributed to this disturbing pattern, including land conversion to fishponds, and localized cutting and clearing.
- There have been dramatic declines in coral reef quality in 86% of the sites and a lack of survey sites with very good and excellent coral cover condition in 2010. The decline was attributed to the persistence of destructive activities such as illegal fishing methods (primarily cyanide and dynamite fishing), and the use of active fishing gears.
- There was a general decline in seagrass percentage cover in 83.3% of the sites and decrease in density (shoots/square meter) across all surveyed sites. This was brought about by disturbances caused by natural wave action, boat docking, and sediment loading from the adjacent terrestial zone. Other reasons cited were trawl fishing-related boat activities.

Ecosystem condition indicators

Mangroves

The ecosystem condition of the mangrove forest of Sofronio Española was characterized using six indicators (Table 5.4), namely, area (ha), species diversity (H'), number of species, density (trees/ha), total volume (m^3), and seedlings/saplings (individuals/ha).

The data showed a net decrease in the mangrove forest extent of 684 ha. The highest rate of deforestation was found in Isumbo, Pinataray, Pinataray River, Labog 1, and Labog 2/Ingiaran Point (Table 5.5).

The decline was attributed to cuttings, conversion into fishponds and patches of clearings, which were observed during the 2011 monitoring survey. The community residents were found to have used mangrove poles and piles for their fish pens as well as for construction and domestic uses. The fall of mangrove cover may be linked to the decrease in the overall volume of trees from 337,053 m^3 to 189,652 m^3 (Table 5.6).

There was also a decline in the number of average seedlings/saplings — from 1,114 individuals/ha to 730 individuals/ha — and a slight increase in the number of trees per hectare from 1,322 to 1,458 trees. The decrease in seedlings/saplings can be attributed to the loss of mother trees as mangrove forests are converted into other land uses and trees are utilized by the communities.

Meanwhile, species composition was relatively stable (albeit with some decrease recorded) in Pinataray, Pinataray River, Labog Island, and Inamukan/Lamukan Island.

Table 5.4. Key Ecosystem Condition Indicators, Mangrove Forest, Sofronio Española, 2001 and 2010

SURVEY STATION	2001						2011					
	Area, ha	Species diversity	Species	Density, trees/ha	Total Vol (m^3)	Seedlings/ saplings/ individuals per ha	Area, ha	Species diversity	Species	Density, trees/ha	Total Vol (m^3)	Seedlings/ saplings/ individuals per ha
Punang 1	329	0.52	7	512	73,415	1,250	334	1.7	7	1,250	57,124	550
Crawford Cove		1.44	5	1,488		2,250		1.45	5	1,450	4,636	1,750
Punang 2	31	2.06	9	1,230	5,276	1,600	27	1.93	9	1,000	8,075	960
Pulot Shore	63	1.19	6	1,288	10,654	980	47	1.29	6	1,400	69,310	1,650
Isumbo	1,110	0.38	4	1,138	206,300	750	387	0.61	4	1,250		150
Pinataray		0.68	4	875		1,100		0.99	7	1,900		850
Pinataray River		1.59	8	1,608		990		1.68	5	1,733		765
Labog 1		1.82	10	1,150		875		2	8	1,175		600
Labog 2/Ingiaran Point		0.68	4	2,062		1,800		0.63	4	2,100		1,300
Gardiner Island	13	0.86	4	1,538	2,199	760	28	0.95	4	1,500	4,719	200
Bintaugan Island	11	1.56	8	1,206	1,829	900	17	1.66	8	1,250	2,871	300
Inamukan/Lamukan Island	58	1.9	9	1,627	9,841	1,225	69	1.86	10	1,757	11,711	814
Bessie Island	43	1.25	6	910	7,320	690	72	1.35	6	940	12,303	200
Karasanan River	0	1.59	7	1,450	0	700	39	1.72	7	1,600	6,585	400
Karasanan	80	1.47	6	1,758	13,633	850	72	1.62	6	1,566	12,318	466
TOTAL/AVERAGE	**1737**	**1.3**	**6.5**	**1322**	**330468**	**1115**	**1092**	**1.43**	**6.4**	**1458**	**189652**	**730**

Source: Coastal Resource Monitoring, Municipality of Sofronio Española, Palawan, Philippines, 2010 and 2001. 2003 (unvalidated) and 2010 Land Cover datasets, NAMRIA

Table 5.5. Mangrove Condition Account, Extent (ha), Coastal-Marine Ecosystem, Sofronio Española, Palawan, Philippines, 2001 and 2010

	Punang 1, Crawford Cove	Punang 2	Pulot Shore	Isumbo, Pinataray, Pinataray River, Labog I, Labog II/Ingiaran Point	Gardiner Island	Bintaugan Island	Inamukan/ Lamukan Island	Bessie Island	Karasanan River	Karasanan	TOTAL
Opening Condition (2001), Areal extent (ha)	329	31	63	1110	13	11	58	43	39	80	1776
Addition to condition											
Regeneration, natural (net of normal losses)	5.2				15	6	11				
Regeneration, through human activity											
Reclassification											
Total addition to condition	5.2				15	6	11	29			66
Reduction/Deterioration of condition											
Reduction due to ongoing human activity		-3.8	-15.2	-724						-8	
Catastrophic losses due to human activity											
Catastrophic losses due to natural event											
Reclassifications											
Total reduction in condition		-3.8	-15.2	-724						-8	-750
Revaluation											
Closing condition (2010), Area (ha)	334	27	47	387	28	17	69	72	39	72	1092

Table 5.6. Mangrove Condition Account, Total Timber Volume (m^3), Coastal-Marine Ecosystem , Sofronio Española, Palawan, Philippines, 2001 and 2010

	Punang 1, Crawford Cove	Punang 2	Pulot Shore	Isumbo, Pinataray, Pinataray River, Labog I, Labog II/Ingiaran Point	Gardiner Island	Bintaugan Island	Inamukan/ Lamukan Island	Bessie Island	Karasanan River	Karasanan	TOTAL
Opening condition (2001), Areal extent (ha)	73,415	5,276	10,654	206,300	2,199	1,829	9,841	7,319	6,585	13,633	337,053
Addition to condition											
Regeneration, natural (net of normal losses)					2,519	1,041	1,871	4,983			
Regeneration, through human activity											
Reclassification											
Total addition to condition					2,519	1,041	1,871	4,983			10,415
Reduction/Deterioration of condition											
Reduction due to ongoing human activity	-16,291	-640	-2,579	-136,990						-1,314	
Catastrophic losses due to human activity											
Catastrophic losses due to natural event											
Reclassifications											
Total reduction in condition	-16,291	-640	-2,579	-136,990						-1314	-157,815
Revaluation											
Closing condition (2010), Area (ha)	57,124	4,636	8,075	69,309	4,719	2,871	11,711	12,303	6,585	12,318	189,652

Seagrass beds

Three indicators have been selected to show the seagrass ecosystem conditions. These include the following:

- Biodiversity — measured in terms of Shannon-Weiner Biodiversity Index and number of species
- Abundance — measured in terms of percent vegetative cover
- Density — measured in terms of shoots per m^2

The above are frequently used indicators for assessing ecosystems, and have been identified as potentially suitable indicators for ecosystem accounting in the recent World Conservation Monitoring Centre report on biodiversity accounting (World Conservation Monitoring Centre, 2015).

Comparisons for 2010 and 2001 of the ecosystem condition of seagrass beds across six monitoring sites showed very low seagrass biodiversity index for all sites (Table 5.8, Figure 5.4). One site, Sand Bar, recorded a significant seagrass decline, while one species assessed in 2001 was not included in the 2010 survey.

However, two additional species were recorded in 2010, thus increasing the net number of species from nine to ten (Table 5.9). Species composition in seagrass beds can change over time due to natural fluctuations. But these changes cannot be considered as an indicator of degradation.

Three out of six sites registered a decrease in density (shoots/square meter) (see Table 5.8, Figure 5.5). The general decline in seagrass cover and condition is also summarized in Table 5.7, and Figure 5.6.

The decline in coastal water quality, degradation of environment and resources, and human-induced disturbances threaten seagrass communities (Fortes, 2008). Seagrass has been destroyed due to siltation or sedimentation, pollution, eutrophication, nutrient loading, dredging, and unsustainable fishing practices. Other site-based threats are oil pollution, influx of tourists, and boat scour. In the last 50 years, about 30% to 40% of seagrass areas in the Philippines have been lost. The loss of seagrass cover in the surveyed sites in Sofronio Española can be attributed to a number of causes, according to a PCSD study. These include disturbances due to natural wave action, boat docking, and sediment loading from the adjacent terrestrial zone. Other reasons cited were trawl fishing and fishing-related boat activities.

Table 5.7. Seagrass Condition Indicators, Municipality of Sofronio Española, Palawan, Philippines, 2001 and 2010

Survey station	COORDINATES		2001				2010			
	Latitude	Longitude	Species diversity	# of species	Density shoots/m^2	Cover %	Species diversity	# of Species	Density shoots/m^2	Cover %
Bessie Island	90 03' 56.95"	1180 07' 51.69"	1.32	5	332	37.7	1.21	6	114	3.5
Bintaugan Island	90 06' 10.32"	1180 07' 41.80"	0.64	3	206	16.6	1.27	4	281	17.3
Gardiner Island	90 02' 49.73"	1180 06' 50.61"	1.61	9	927	53.5	1.66	7	482	9.7

Survey station	COORDINATES		2001				2010			
	Latitude	Longitude	Species diversity	# of species	Density shoots/m²	Cover %	Species diversity	# of Species	Density shoots/m²	Cover %
King's Paradise Island Resort	90 05' 22.74"	1180 09' 20.65"	1.33	8	922	58.4	1.77	7	666	21.4
Punang	90 00' 14.13"	1180 03' 50.31"	No data			13.5	0.74	3	146	8.0
Sand Bar (near King's Paradise Island Resort)	80 54' 16.23"	1180 00' 48.95"	1.01	5	812	45.2	0.16	2	307	7.7
Average			1.182		639	37	1.1		333	11

Source: Coastal Resource Monitoring, Municipality of Sofronio Española, Palawan, Philippines, 2011 and 2001

Table 5.8. Seagrass Ecosystem Condition Indicator, Species by Survey Period, Municipality of Sofronio Española, 2001 and 2010

Sea grass Species	2001 Baseline Survey	2011 Monitoring Survey
Cymodocea rotundata	✓	✓
Cymodocea serrulata	✓	✓
Enhalus acoroides	✓	✓
Halophila beccarii	✓	
Halophila ovalis	✓	✓
Halophila spinulosa		✓
Halodule pinifolia	✓	✓
Halodule uninervis	✓	✓
Syringodium isoetifolium	✓	✓
Thalassia hemprichii	✓	✓
Halophila decipiens		✓
Total number of species	***9***	***10***

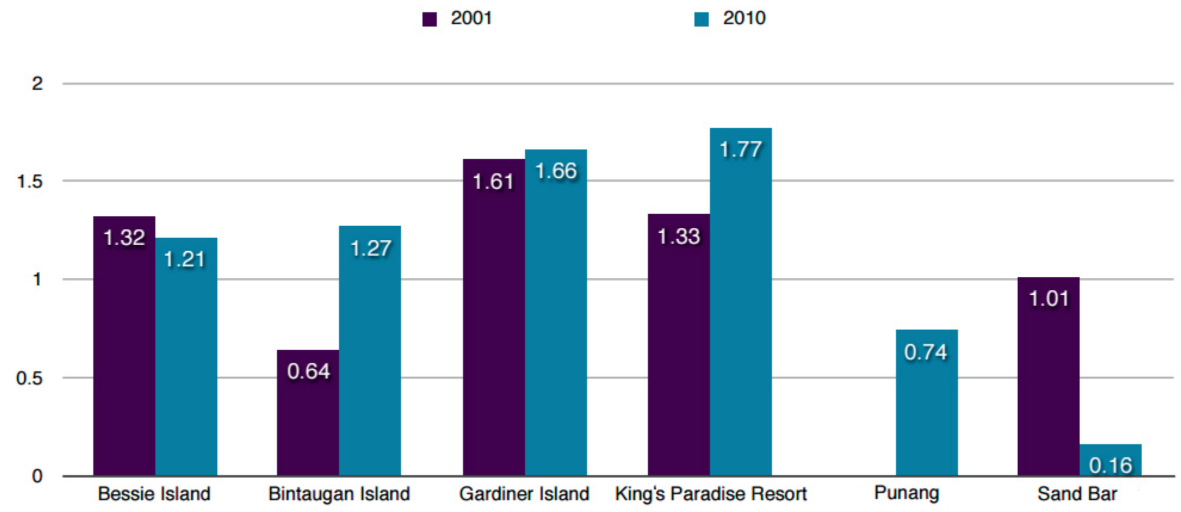

Figure 5.4. Seagrass Ecosystem Condition, Species Diversity (Shannon-Weiner Biodiversity Index), Per Monitoring Sites, Municipality of Sofronio Española, Palawan, Philippines, 2001 and 2010

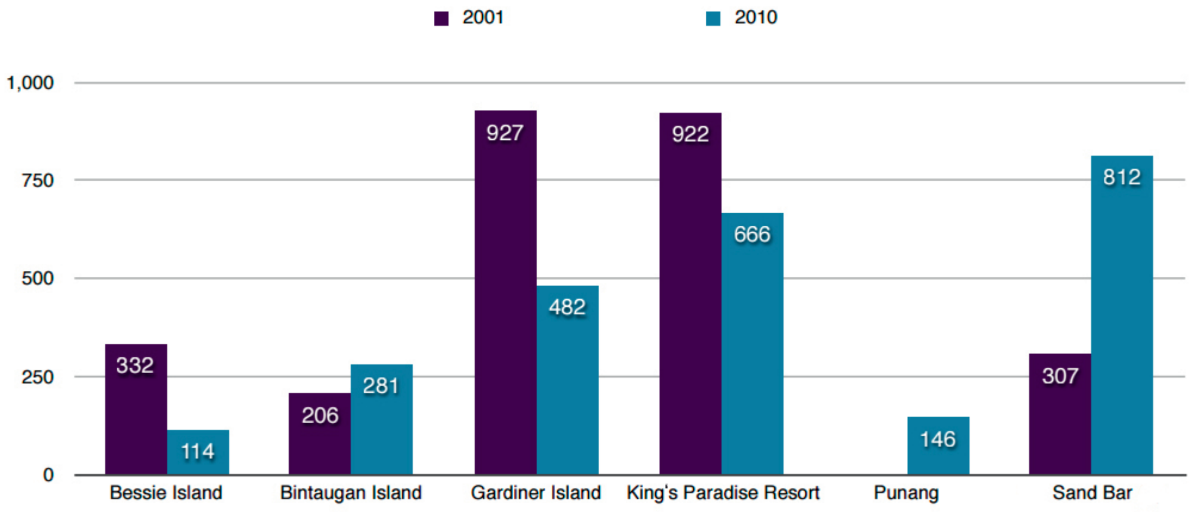

Figure 5.5. Seagrass Ecosystem Condition, Species Abundance (shoots/square meter), Per Monitoring Sites, Municipality of Sofronio Española, Palawan, Philippines, 2001 and 2010

Coral reefs

The 2011 monitoring survey results on Sofronio Española for coral reefs are presented in Table 5.9. The original 26 sites are collapsed into 14 areas by merging the results within the same location.

Overall, coral condition declined in the past 10 years with 12 sites registering a reduction in live coral cover (Figure 5.7). An issue that is of particular significance is the absence of survey sites under very good and excellent coral cover condition in 2010 (Figure 5.8). The data shows a consistent and strong decline in coral reef condition in a relatively short period (10 years).

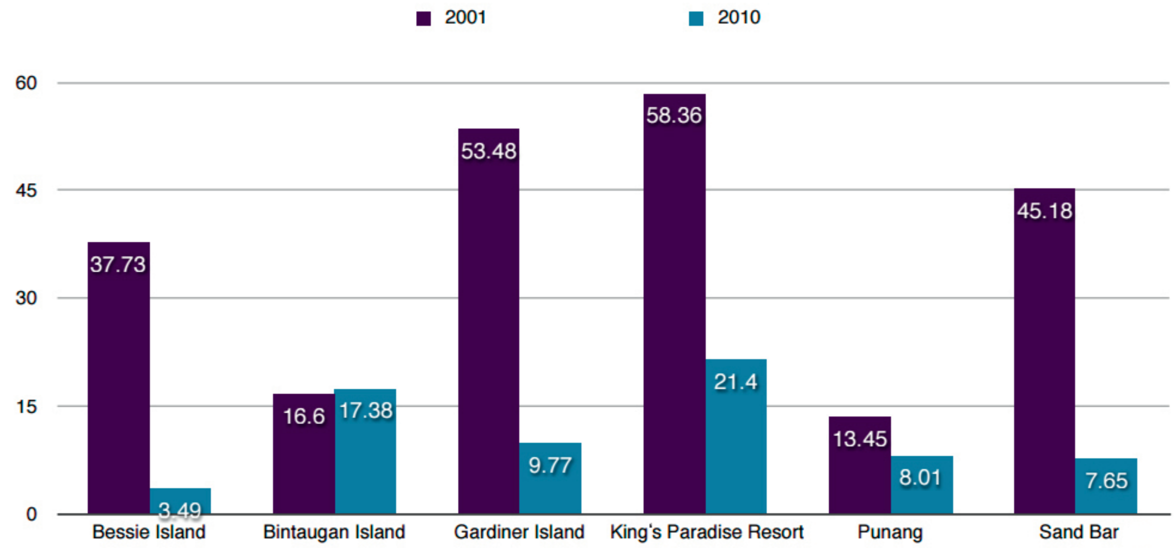

Figure 5.6. Seagrass Ecosystem Condition, % Cover, Municipality of Sofronio Española, Palawan, Philippines, 2001 and 2010

The Philippines has the third largest coral reef area in the world — estimated at 25,060 km^2, next to Indonesia and Australia (Spalding et al., 2001).

The country's coral reefs are considered as one of the most threatened in the world due to overfishing, destructive fishing practices, and sedimentation (Burke et al., 2002). Other identified threats include coastal development, population pressures, tourism-related activities, pollution, and crown-of-thorns starfish infestations.

The 2011 PCSD report attributed the decline in coral cover to the persistence of destructive activities such as illegal fishing methods (primarily cyanide and dynamite fishing), and the use of active fishing gears. Areas such as Inamukan/Lamukan I and Panitian near Malalong were found to have been significantly affected by fishing activities because of their proximity to fishing grounds.

Table 5.9 Coral Reef Ecosystem Condition, % Live Coral Cover (Hard and Soft Corals), Sofronio Española Municipality, Palawan, Philippines, 2001 and 2010

	No. of Monitoring Sites	2001 % cover	2010 % cover	% cover change
King's Paradise	3	42	30	-12
Bintaugan Is	1	61	35	-26
Inamukan/Lamukan I	3	53	15	-38
Sand Bar near Bessie Is	1	50	22	-28
Bessie Is I	5	53	43	-11
Gardiner I	3	30	46	16
Scott's Point	1	46	47	1
Punang	1	50	44	-6
Panitian near Malalong	1	54	7	-47
Sand Bar near King's	2	38	21	-18

	No. of Monitoring Sites	2001 % cover	2010 % cover	% cover change
Caramay	1	45	46	1
Karasanan	1	55	45	-11
Bessie submerged	1	33	23	-10
Gardiner submerged I	2	42	34	-8

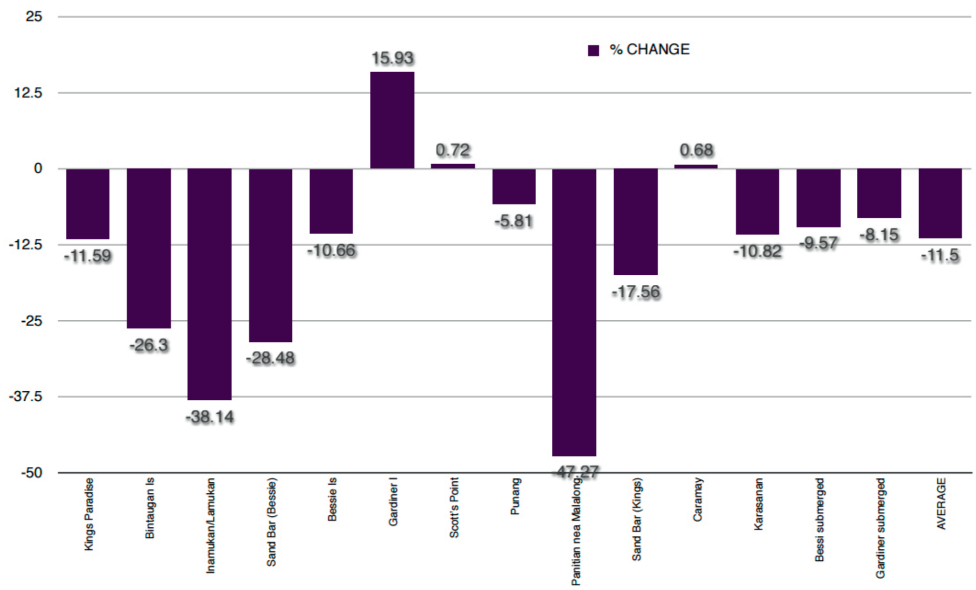

Figure 5.7. Coral Reef Ecosystem Condition, % Change in Live Coral Cover, Municipality of Sofronio Española, Palawan, Philippines, 2001 and 2010

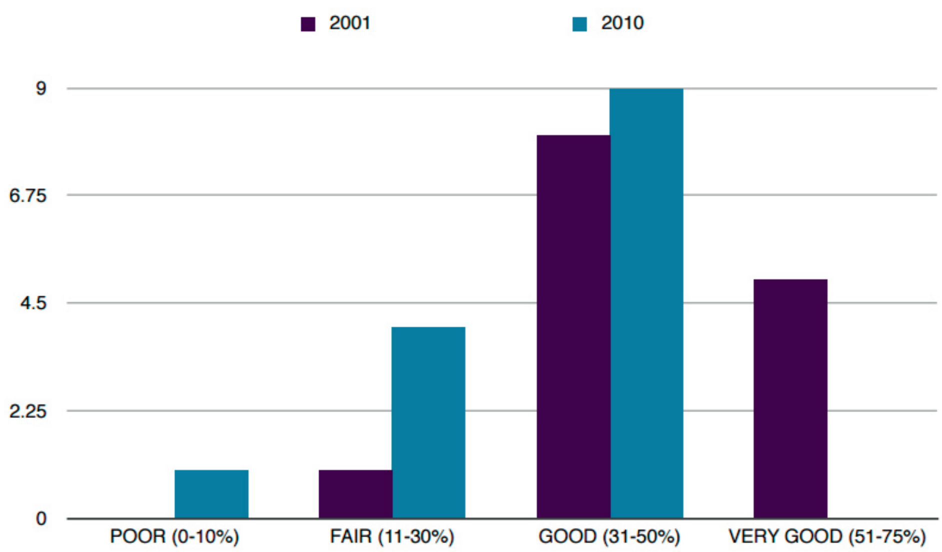

Figure 5.8. Coral Reef Ecosystem Condition, Number of Reef Sites by Category, Municipality of Sofronio Española, Palawan, Philippines, 2001 and 2010

Evaluation

The coastal ecosystem condition account shows a general decline of three ecosystems based on select key indicators. These include mangrove condition indicators in terms of area (ha), density (trees/ha), total volume (m^3), seedlings/saplings (individuals/ha); seagrass condition indicators in terms of density (shoots/square meter); and seagrass cover as a measure of species abundance, and cover categories for coral reefs.

The decline of the extent and condition of the coastal/marine ecosystem in the municipality of Sofronio Española reflects the state of their management. It is also shows how certain activities in the adjacent lowland and upland ecosystems are being managed.

While policies exist to ensure a sustainably managed coastal/marine ecosystem, the translation of these policies into programs and projects with corresponding fiscal allocations remains a challenge. With limited enforcement of policies and programs, ecosystem services continue to be treated as an open-access resource, with no incentives toward conservation.

The initial findings from the accounting pilot highlight the need to review the implementation of policies pertaining to land use and natural resource utilization and management. Specific policies include the Strategic Environmental Plan for Palawan Act (Republic Act 7611), the Mangrove Forest Policy for Palawan (Presidential Proclamation 2152), the Philippine Fisheries Code RA (RA 8550), the Local Government Code (RA 7160), and the country's Foreshore and Shore Land Management Policies such as the Special Land Use Permit, Bathing Establishment Permit, Forest Land Use Agreement for Tourism Purposes or FLAgT, sanctuary permits, and their present or future implications on coastal marine protection, among others.

The development of the account will have potential contributions to improving the Comprehensive Land and Water Use Management Planning, Environmentally Critical Areas Network, Project Evaluation under the Philippine Environmental Impact Statement System, Conservation Financing, the policy of increasing fish production for food security, and the National Fisheries Development Plan.

Meanwhile, there is a need to link the development of the account with the existing environmental monitoring system such as what is being implemented by the PCSD and the LGU, and capacitation at all levels of engagement, the implementation of the National Fish Stock Assessment of the Bureau of Fisheries and Aquatic Resources under the Department of Agriculture, and Mangrove Assessment by the DENR and NAMRIA.

"Translation of (coastal/marine ecosystem) policies into programs and projects with corresponding fiscal allocations remains a challenge."

Finally, it is important to link the ecosystem condition account with other accounts following the ridge-to-reef framework, an ecosystem-based approach to biodiversity conservation.

The paucity of data for specific indicators remains a challenge in developing the accounts, particularly considering the data link between the development of Fishery Food Provisioning Service, and the development of accounts for lowlands and uplands. There is a need to establish the Fishery Stocks and monitor key water quality indicators, and link these with other ecosystem accounts.

The availability of data for other municipalities in Palawan offers opportunities to scale up the development of the account to the provincial level. Institutionally, local partners want to be involved in the development of the account beyond the provision of data.

6| Ecosystem services supply account

Introduction

The ecosystem services supply and use account records the flow of ecosystem services in physical and monetary terms. For the pilot ecosystem account, the following services were identified: 1) carbon sequestration, 2) water regulation, and 3) the ecosystem's contribution to palm oil production, rice production, coconut production, and fisheries.

These services were selection based on their relative importance to the local economy, and data availability. Physical and monetary values were analyzed across all services. Carbon sequestration service is covered in the carbon account.

An initial analysis was also performed to assess the standing volume of timber. As timber logging is prohibited in Palawan based on existing regulations (albeit the reality might show otherwise), the service timber harvesting is excluded owing to measurement difficulties. Cultural services that are especially vital to indigenous people occupying upland forests are also highly relevant to ecosystem management. However, they have not been included in the accounts due to inadequate data.

Crop production (rice, coconut, oil palm)

Rice

In 2014, Philippine agriculture sector gross earnings amounted to 111.6 trillion pesos (US$2.39 trillion) at current prices, with rice contributing 24% (PSA statistical data). Total rice production in the Philippines, as well as in the province of Palawan, has increased over the years.

As shown in Figure 6.1, the country's production output in 1991 was 9.67 million tons, of which 102,374 tons (1.1%) came from Palawan. This volume doubled in 2013, with a recorded national output of 18.44 million tons, to which Palawan contributed 256,394 tons (1.4%).

Despite this positive trend, the Philippines remains a rice-importing country (International Rice Research Institute, 2015). In contrast, the province of Palawan has been a net exporter of rice to other provinces for years, having a rice sufficiency average level of 161% (2009-2013), as reported by the Office of the Provincial Agriculturist in Palawan.

Rice-harvested areas in Palawan covered 44,820 ha in 1991 and expanded to 70,548 ha in 2010, and to 75,544 ha in 2013. This trend indicates that yields went from 2.28 tons per hectare (t/ha) in 1991 to 3.39 t/ha in 2013, a considerable increase but well below potential yields for irrigated rice.

"Problems affecting production (e.g., pest and diseases) have reduced coconut oil supply to the global market."

Coconut

The Philippines is the world's largest producer of coconut oil and desiccated coconut. Larger demand for coconut oil based on its essential properties has been driving the increase in its exports over the last decade.

However, problems affecting production (e.g., pests and diseases, natural calamities, aging plantations, and harvest of coconut timber) have caused a reduction of coconut oil supply to the global market. Pressure on the supply of coconut oil is further compounded by competing demands for fresh nuts and desiccated coconut — products that command higher prices in the global market.

Highlights from Ecosystem Services Supply Account – Crop production

- For the pilot ecosystem account, the selected ecosystem services were studied for their contribution to palm oil production, rice production, coconut production in the Pulot watershed for 2010 and 2014.
- The key findings are:
  - Rice production covers about 570 ha of land in Pulot watershed. Between 2010 and 2014, irrigated paddy fields decreased while rainfed sites increased significantly, indicating that irrigation water supply could not meet the demands of paddy production.
  - While coconut is a key plantation crop in Palawan, its average yield of 1.28 tons per ha is very low compared to the reported national average of 4.6 tons per ha. The low average yield can be the result of underestimating coconut production, damage from pests and diseases, or poor management of the plantations.
  - The conversion of land to oil palm plantations in Palawan began in 2007 and is currently expanding across Pulot watershed. However, resource rent of oil palm production in 2014 was found negative due to a very low yield. Many plantations have either zero or low production due to insufficient water supply to enable palm fruit production. This is related to rainfall being too low for oil palm at certain times of the year and the sensitivity of oil palm to dry periods.

Although the world price of coconut oil is influenced by those of other edible oils like palm oil and soya oil, coconut oil prices have steadily increased over the last few years, exceeding those of palm oil and soya oil.

Production of coconut in the Philippines increased from 11.3 million metric tons (MT) of coconut produced in 1991 to 15.4 million MT in 2013. In the same period, coconut production in Palawan showed a proportionally larger increase, from 0.11 MT in 1991 to 0.36 MT in 2013 (PSA, 2015).

Palm oil

Oil palm has emerged as a plantation crop in the Philippines in recent decades. The United Nations Conference on Trade and Development, citing 2010/2019 agricultural forecasts from the FAO and Organization for Economic Co-operation and Development, projects that global consumption of vegetable oil will increase by nearly 40% between 2010 and 2019 due to population growth and rises in average incomes in developing countries. The Philippines is among the Asian countries that has invested in oil palm development. But the country's production is marginal compared to Malaysia and Indonesia. In the last decade, plantations that started in Mindanao have expanded to Palawan, particularly in its southern part.

Rice, coconut, and palm oil represent specific types of ecosystem units (EUs) and are normally grown in monocultures, except in the initial years of oil palm and coconut plantation, when there may be intercropping with maize or vegetables. In view of the importance of these crops to Southern Palawan, and the increasing trends in plantation crops, these crops have been selected for the ecosystem account.

Methodology

Data collection

Secondary data were gathered from government offices, private companies, farmers' associations, and cooperatives. The base map was provided by NAMRIA. To obtain information on farm income and operational expenses, collection of primary data from the farmers was piggybacked on the focus group discussion conducted for hydrological services.

Among others, data was collected on crop yields, inputs to and costs of crop production. For all crops, the amount of hectares grown, and harvests expressed in terms of kg/ha (kilograms per hectare) for each crop per year were calculated.

Mapping

A land cover-based mapping using look-up tables (LUT), consisting of cross-references linking index numbers to output values, was applied to map the provisioning services with a distinct value of the average yield of production from data collection using ArcGIS ModelBuilder, a visual programming language.

The modelling of provisioning services requires four steps, namely: 1) delineation of the study area; 2) extraction of the land-use of interest; 3) conversion of data formats; and 4) assigning EUs the average production (yields/ha)

There may in reality be differences in productivity within different EUs. But there is yet no data available to quantify these differences and therefore the LUT approach, which involves attributing average figures to each EU, was applied to this study.

The delineation of the area of study involves the use of the Analysis tool "Clip" to isolate the boundaries of Pulot watershed. The Clip tool was further used to delineate the different barangays within the watershed. These feature maps were then converted to raster formats using the Conversion Tool "Polygon to raster," which yielded a raster map defined by the barangay boundaries.

Finally, assigning of the average yield of production to each pixel of the map was done using the Spatial Analyst Tool "Reclassify". Each pixel within Pulot watershed that is defined by its barangay boundaries was assigned the corresponding average production yield based on the average yield obtained during the data gathering.

Valuation

In ecosystem accounting, different approaches can be used to assess the monetary value of ecosystem services. In the case of provisioning ecosystem services like rice, coconut, and oil palm, the per hectare resource rent is used as an indicator of the value provided by the ecosystem.

Below is the formula to compute the resource rent. Note that adjustments should be made to specific taxes and subsidies. However, these were generally non-existing or very low in the cases of the examined crops, and therefore were excluded from this analysis[14]. The return to produced assets was assumed to be 15%, in line with the NEDA guidance for cost-benefit analysis. All data on costs were obtained from farmer interviews (see Table 6.2).

$$RR = TR - (IC + CE + CFC + RP)$$

Where:

RR = resource rent

TR = total revenue

IC = intermediate consumption

CE = labor costs or compensation for employment (CE)

CFC = consumption of fixed capital

RP = return to produced assets

[14] An exception is coconut, which is the subject of a planting subsidy. There is no data, however, indicating the number of farmers that have benefited from this scheme.

Findings and Analysis

Ecosystem services analysis

As explained above, the account includes the main crops grown in Pulot watershed — rice, coconut, palm oil, and corn. These were analyzed based on data from the PSA, a field survey, and the maps provided by NAMRIA and the ESA.

The NAMRIA 2010 map classifies crops into annual and perennial only. Hence, further disaggregation was carried out based on field visits (to delineate paddy rice, oil palm, and coconut areas) and the ESA map.

Findings in Pulot watershed are not representative of the province of Palawan. Pulot comprises a large area used for oil palm, facilitated by the nearby oil palm mill (since oil palm fruit must be processed within 24 hours after harvest). In other parts of Palawan, coconut production posted the strongest increase among the crops in the last decade (see Chapter 3). Table 6.1 presents the physical supply of the main crops in the watershed in 2010 and 2014. It also shows the supply of ecosystem services, expressed in tons of produce.

Users of these services are farmers who rely on the biophysical environment (including fertile soil, water, microorganisms in the soil, etc.) to produce their crops. The three ecosystem units (coconut, oil palm, and paddy) are described below.

Table 6.1. Ecosystem Services Supply Account for the Main Provisioning Services: Rice, Coconut, and Oil Palm for 2010 and 2014[15]

Ecosystem unit	2010			2014		
	Area	Yield	Production in Pulot watershed	Area	Yield	Production in Pulot watershed
	(ha)	(ton/ha/year)	(ton/year)	(ha)	(ton/ha/year)	(ton/year)
Rainfed Rice	57	2.6	146	150	3.2	481
Irrigated Rice (paddy-paddy)	446	7.4	3,277	398	7.4	2,923
Irrigated Rice (paddy-corn-paddy)	27	7.4	197	60	7.4	444
Corn		2.9	77		3.0	183
Coconut	1,315	1.3	1,724	1,455	1.3	1,907
Oil Palm	901	9.7	8,711	1,012	9.7	9,783

Paddy rice production. Rice is the staple food in Pulot watershed. Its production covers about 570 ha of land in the Pulot watershed.

There are three distinct cropping systems for paddy. The first involves unirrigated or rainfed paddy (one crop per year); the second, irrigated paddy with two crops per year; and the third, two irrigated crops of paddy and one crop of corn as dry season crop.

[15] Note that the figures in different columns are rounded off. Therefore multiplications over different columns do not always match.

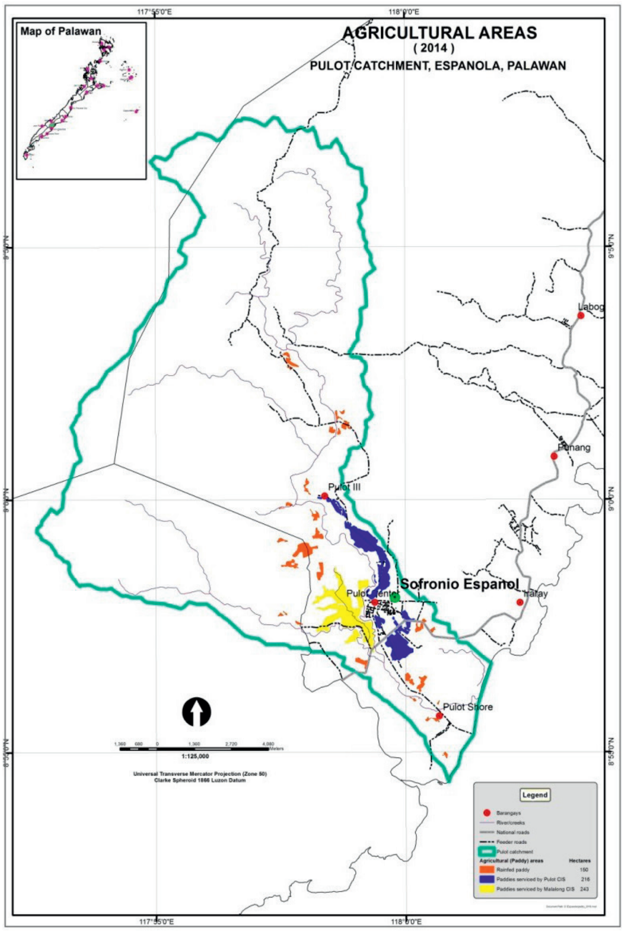

Figure 6.1. Rice production areas in Pulot watershed

The first system can be spatially distinguished, but the other two systems are mixed, with farmers deciding on an annual basis whether they will plant corn as dry season crop or not. There are some variations within this system: One out of 30 surveyed farmers said they grow three crops of paddy per year in a portion of their land, and only the main cropping systems are included in the account. There are also variations in crop yield among farmers. (Table 6.2 presents the average yields based on the survey.)

To illustrate the variations, for irrigated rice, the minimum yield encountered in the survey is 3.9 (tons/ha/yr) and the maximum yield is 4.8 (tons/ha/yr). There is yet no data linking information from the condition account (e.g., soil type) to yields.

Figure 6.1 shows the location of the paddy fields. Rainfed and irrigated paddy fields are distinguished from one another. There are two irrigation schemes in the watershed, Malalong and Pulot, which is larger than the former.

The link between forest cover, water regulation in the watershed, and paddy production in Pulot irrigation scheme is analyzed below. A comparison of production areas in 2010 and 2014 shows that the irrigated area decreased while the rainfed area significantly increased during the period. This may be an indication that irrigation water supply does not meet the requirement of existing irrigated paddies (as further discussed below).

Coconut production

Coconut is a key plantation crop across Palawan and elsewhere in the country. It is therefore not surprising that the Philippines is one of the world's largest exporters of copra.[16] (See Table 6.3 for data on copra production.)

The average yield of copra, based on a focus group discussion with 29 coconut farmers, is 1.28 tons per hectare. The production of copra within the watershed has an average yield of only 1.45 tons per hectare. This is very low compared to the reported average yield of the country — 4.6 tons per hectare.

Production between farms shows a variation. Based on the survey of farmers, copra yields ranged from 1.27 (tons/ha/yr) to 1.45 (tons/ha/yr). (Figure 6.2 presents the coconut production map.)

There are three possible explanations for this low value. First, it may be that farmers did not respond truthfully in the questionnaire. Second, pests and diseases may have hit the study area in Palawan more than other areas in the country. Several respondent farmers reported infestations of coco kulisap (Aspidiotus rigidus Reyne [Hemiptera:

[16] Dried 'meat' or endosperm from the nut of coconut from which oil is expelled.

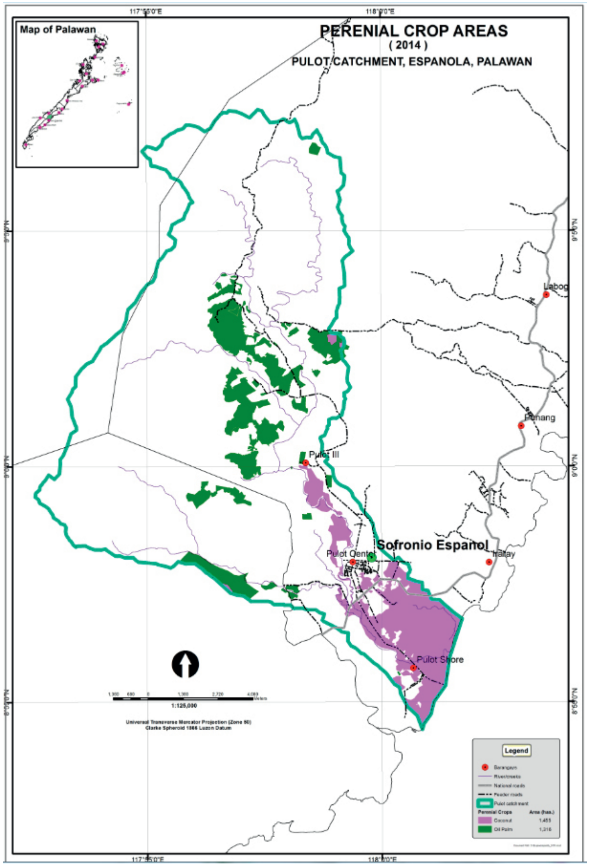

Figure 6.2. Coconut and oil palm fruit production areas

Diaspididae]). Third, poor management of the plantations may have contributed to the low coconut production. Among the 29 farmers interviewed, only one said he uses fertilizer.

Palm oil production

The conversion of land to oil palm plantations started in 2007 and is currently expanding within Pulot watershed. Farmers have either a production, technical and marketing agreement or a land lease agreement with a private company through cooperatives.

Currently (2014) the area covered by palm plantations is 1,012 ha. The average fresh fruit bunch harvest is 9.7 (tons/ha/yr). This yield covers relatively many young plantations with low production due to the age of the trees.

Newly planted oil palm is not yet productive and does not yield any oil palm yet. Plants start producing fruits after three to five years depending on plantation management and the variety of oil palm used. (Figure 6.2 presents a map of areas where oil palm is grown.)

Monetary values of ecosystem service supply

The resource rent generated by the crops is calculated across all three ecosystem units. Tables 6.2 and 6.3 show the resource rent in 2010 and 2014. Based on the data presented, the paddy-corn-paddy cropping system yields the highest resource rent.

On the other hand, unirrigated (rainfed) rice paddies produce the lowest resource rent per hectare. This reflects the significance of irrigation water in rice production. The resource rent from coconut production, however, is still lower compared to unirrigated rice paddy. Note that the resource rent from minor crops planted within coconut lands is not included in the accounting, which could have contributed to a higher resource rent.

Another point to consider under this account is the zero value of the resource rent from oil palm production. Although oil palm trees in Pulot watershed were already productive around 2010, there was no benefit derived yet during this period since the palm oil milling plant in the area only began its operations in 2011.

In 2014, the value of the flow of ecosystem services in oil palm production was found negative due to a very low yield.

How plantation crops can best be included in the accounts needs to be examined. It is likely that when a longer cultivation period is considered, the net present value of oil palm production could potentially be positive.

Table 6.2. Monetary Account for Provisioning Services of Rice, Corn, Coconut, and Oil Palm for 2010

Ecosystem unit	Area	Production costs per hectare				Yield	Farmgate Price	Resource rent/ha	Resource rent
		Intermediate consumption	Compensation to employees	Taxes and subsidies	User Costs of Produced Assets/1				
	(ha)	(Pesos)	(Pesos)	(Pesos)	(Pesos)	(ton/ha)	(Pesos/kg)	(Pesos)	(million Pesos)
Annual Crop Ecosystem, Rice and Corn	**529**								**26.8**
Rainfed Rice	57	6,963	13,182	-	0	2.6	12	10,787	0.6
Irrigated Rice (paddy-paddy)	446							53,421	23.8
1st Cropping		7,342	13,182	-	0	4.0	12	28,214	
2nd Cropping		6,720	12,981	-	0	3.3	14	25,207	
Irrigated Rice (paddy-corn-paddy)								87,019	2.3
Yellow Corn	12	7,252	12,714	124	296	3.0	11	12,824	0.1
White Corn	15	7,252	12,714	124	296	2.8	15	20,774	0.3
Coconut	**1,315**	909	6,738	-		1.3	13	9,690	12.7
Oil Palm	**901**	26,054	10,264	-	5, 448			0	

1/ includes consumption of fixed capital (depreciation) + return to produced assets

Table 6.3. Monetary Values of Provisioning Services of Rice, Corn, Coconut, and Oil Palm for 2014

Ecosystem unit	Area	Production costs per hectare				Yield	Farmgate Price	Resource rent/ha	Resource rent
		Intermediate consumption	Compensation to employees	Taxes and subsidies	User Costs of Produced Assets/1				
	(ha)	(Pesos/ha)	(Pesos/ha)	(Pesos/ ha)	(Pesos/ ha)	(ton/ha)	(Pesos/kg)	(Pesos)	(million Pesos)
Annual Crop Ecosystem, Rice and Corn	**608**								**35**
Rainfed Rice	150	8,531	16,150	-	0	3.2	15	22,696	3.4
Irrigated Rice (paddy-paddy)	398							65,447	26
1st Cropping		8,995	16,150	-	0	4.0	15	34,447	14
2nd Cropping		8,233	15,904	-	0	3.3	17	30,882	12
Irrigated Rice (paddy-corn-paddy)								99,682	6.0
Yellow Corn	40	9,183	16,519	141	4,269	3.0	13	12,421	0.5
White Corn	20	9,183	16,519	141	5,209	3.0	16	21,815	0.4
Coconut	**1,455**	1,271	9,421	-	2,424	1.3	18	13,547	20
Oil Palm	**1,316**	36,424	14,350	-	5,168	9.7	5	- 6,709	-8.83

Ecosystem unit	Area	Production costs per hectare				Yield	Farmgate Price	Resource rent/ha	Resource rent
		Intermediate consumption	Compensation to employees	Taxes and subsidies	User Costs of Produced Assets/[1]				
	(ha)	(Pesos/ha)	(Pesos/ha)	(Pesos/ ha)	(Pesos/ ha)	(ton/ha)	(Pesos/kg)	(Pesos)	(million Pesos)

Note: Production costs, corn data from BAS MIMAROPA Corn: Updated Average Production Costs and Returns by Type, Geolocation, Item, Season and Year; Corn production area and yield data from the Municipality of Sofronio Española MAO Report Corn; Price data from BAS Palawan Cereals: Farmgate Prices by Geolocation, Commodity, Period and Year

1/ includes consumption of fixed capital (depreciation) + return to produced assets

Findings and Analysis

Data availability and quality

Several factors constrained production of the ecosystem accounts. Some of these revolved around data availability and quality.

For instance, the use of Pulot watershed as an accounting unit complicated matters. While data was available for administrative units, there was none for physical watershed boundaries. Data at the barangay level was aggregated to the municipality level but not to smaller units such as purok (district), sitio[17], or individual plots.

In addition, the TWG was not experienced in collecting statistical data and there was no clear data collection format. Closer collaboration with, and/or support from, the PSA will help overcome this constraint.

Then, too, the standard NAMRIA land cover classification did not distinguish between different types of crops even if the ESA, along with NAMRIA, provided maps covering different plantation crops as a service to this ecosystem account.

Finally, for plantation crops, data access was limited, especially with respect to private companies, which were under no obligation to regularly submit data that they were generating to government agencies. Government units, on the other hand, often charged fees for data requests. In the end, data from NAMRIA and ESA were combined along with the results of GIS analysis.

Policy and methodological lessons

The case of the lowland provisioning services reinforces the importance of having access to accurate and detailed land cover data, as well as data on crop production and production costs. Selecting administrative rather than physical boundaries is particularly helpful in provisioning services.

The study also showed a rapid expansion of oil palm plantations in the uplands of Pulot watershed, helped along by the presence of an oil palm mill in the area. (Fresh oil palm fruit needs to be processed within 24 hours to maintain quality.)

[17] Similar to a purok or district, but usually far from the center of the barangay.

The study also revealed a major lack of data on the location of new plantations. Other problems identified were the non-compliance with relevant government regulations, and existence of land conversion on slopes that were otherwise reserved for forest cover and in the designated forest reserve. Such practice is facilitated by the cadastre, which titles land without sufficient consideration for applicable regulations restricting land conversion.

Water regulation

The Pulot municipal irrigation scheme supplies irrigation water to around 500 ha of rice paddies, and domestic water to eight barangays. Yet only a portion of this area size is actually irrigated due to water deficiencies.

Pulot watershed has a dam that has been regulating water supply since 1989, thus increasing rice production in the area. Before the dam was built, the farmers were relying only on rainfed farming.

An existing Level III Water System serves two barangays, Pulot Center and Pulot Shore, by supplying domestic water to around 780 households and establishments. This domestic water supply has not been included in the account.

Sediment deposition is partly the cause of reduced water supply in the dam. Sediments come from soil losses in upstream hill slopes, riverbanks, and gullies. Sediments are trapped within the dam in Pulot, which makes the reservoir shallower, thus decreasing its storage capacity.

As a result, there is water shortage in a number of rice paddy areas, especially in the summer months. Sediments can reach irrigation canals and even rice paddies. During the field validation, the head of the irrigators' association[18] revealed that in the past decade, sedimentation had worsened primarily due to land use changes, in particular conversion of forests bare land, within the upstream of Pulot watershed.

Sediments can also cause problems downstream such as damage to coral reefs and pollution. A similar study (Becira, 2002) on the reefs of Honda Bay in Palawan found that sedimentation rates during dry and wet seasons are relatively high. These were estimated at 3.5 and 10.0 mg/cm^2 (square centimeters)/day, respectively. Moreover, increased suspended sediment reduces primary production by planktonic and benthic algae, ultimately reducing the food and oxygen available to fish and benthic invertebrates.

Flooding affects the lowland part of the watershed, particularly in Pulot Center. Overflowing of Pulot River, which happens during rainy seasons, could worsen with continuous sediment deposition.

Land cover is a major factor in controlling soil erosion. Forest soils are generally less vulnerable to erosion because they are covered with ground vegetation and mulch, which reduces the impacts of rainfall and increases infiltration. But bare soils are most vulnerable to soil erosion.

Moreover, forests help maintain a good hydrologic balance by acting as a buffer that absorbs water during the rainy season and gradually releases it during the dry season. Currently, the area is dominated by forests and other land cover types like shrubs and woody perennials. However, there has been significant land use change in Pulot over the decades, including the conversion of forests into other uses.

The effect of land use changes on streamflow is highly location-specific and scale-dependent. In general, the total annual streamflow increases to some extent when forests are cut.

[18] Cecilia C. Castro

However, runoff from forests is much faster since vegetation and soils can no longer absorb and store water as much as it they used to. This leads to higher peak flows and lower base flows during the dry season. This means that in the Pulot irrigation scheme, the resupply of the water basin is less regular, particularly during the dry season when water is needed most.

The objective of the account is to model two hydrological ecosystem services of Pulot watershed: water regulation and sedimentation control. Water regulation supplies water to irrigated rice paddies in the watershed while sedimentation control reduces siltation of the irrigation reservoir, leading to lower sediment loads in coastal coral reefs. Forest services in terms of water supply and soil retention are modelled by comparing results to those of a non-forested scenario.

Methodology

Sedimentation modelling

The ecosystem service sediment control is defined as the amount of avoided sediment owing to vegetation. More specifically, it refers to the reduction in sediment generated compared to bare soil.

Sediment control is an intermediate ecosystem service, contributing to sustained production of irrigated rice by avoiding excess sedimentation in the Pulot irrigation reservoir. The SedNet model was used to quantify the sediment inputs and outputs (i.e., source and deposition) of the watershed in kilotons (kt) per year. It provides a summary budget containing all parameters generated from the model. The exportable results were then post-processed in GIS software.

Spatial inputs include a digital elevation model (DEM) to define the stream and create sub-catchments; soil loss based on a combination of rainfall erosivity (R), soil erodibility (K), slope length (L), and slope steepness (S) factors based on RUSLE; climatic factors, namely, annual average rainfall, PET[19]/rainfall ratio; and streamflow for flow regionalization.

The methodology for each input data is shown in Annex 3. Two DEMs (SRTM and IFSAR) and land cover (2010 and 2014) were used to model and compare two periods.

Sediment trapping was used to capture sediments within the reservoir or dam. The sediment trapping efficiency (i.e., proportion of supplied load that is trapped) is calculated by an updated version of the empirical Brune rule, which expresses sediment trap efficiency (TE, %) as a function of the storage volume of the reservoir and the mean annual input discharge.

Base scenarios were derived using two periods of land uses. Results served as a baseline to depict the percentage changes temporally. A "no vegetation" scenario was then derived by modifying the corresponding cover management (or C-) factor[20] of vegetated land covers to capture the sediments avoided. All vegetation was converted into bare soil (C=1) to determine the sedimentation influx.

A separate model at the sub-catchments of the dam upstream was applied to account for the sediments suspended at the dam, and possible exports, including irrigation canals, flood plains, and even coastal areas. Sediments exported through these export channels are not covered in this study.

Hydrological modelling

The Hydrologic Engineering Center—Hydrologic Modeling System model (HEC-

[19] Potential evapotranspiration, or the amount of water that could potentially be lost to evaporation in a vegetated area based on prevailing meteorological conditions
[20] According to the Michigan State University, "C represents the effects of plants, soil cover, soil biomass, and soil disturbing activities on erosion."

HMS)[21] was used to simulate inflow and outflow accounting parameters of water loss from rainfall to the discharge (Figure 6.3) of water from the Pulot dam using rainfall data from three stations of PAGASA[22] in Southern Palawan in a 13-year period (2000-2013).

Pre-processing of raw rainfall data was done manually using MS Excel. Missing data were supplied using interpolation and were imported in a GIS software to compute for the required Thiessen weights and area.

Hydrologic loss assumptions were computed by reference to commonly used assumptions and within the Palawan context. The soil conservation service (SCS) loss method was used for the transform method, while standard curve numbers were used to depict losses from forest and soil types with respect to land use and soil hydrological groups in different antecedent moisture conditions (AMC) and hydrological setup.

Routing used the Muskingum-Cunge method, which accounts for river characteristics and slope parameters. Loss estimation from sub-surfaces via infiltration and percolation was based on local soil texture. The actual rates of such parameters are very limited and not easily available in soil reports on the Philippines. The rate at which evaporation takes place in the reservoir was computed using average temperatures raster and the empirical Blaney-Criddle formula.

Dam discharge was determined using elevation-storage-discharge-area relationships. These parameters are known as 'paired data' based on the HEC-HMS software, and are primary inputs for simulating reservoir discharges. Elevation and area were measured using GPS readings of the dam surface relative to dam depth (i.e., actual reading minus water depth). Storage was computed using bathymetry of the dam and its surface area. The dam annual average discharges were based on data form the National Irrigation Administration.

The modelling approach poses a number of limitations. First, this study does not model water deficiency due to siltation of the irrigation canals, which also leads to water shortage in paddies. Second, oil palm plantations also extract water upstream of Pulot dam (such as through the use of pumps to pump water out of the river for irrigating oil palm trees). Since there is no data on such extraction, this process is not covered in this study.

Third, dam volume was modelled in only one period due to lack of historical bathymetry records. Finally, for base flow, proxy parameters were used in the absence of data and due to limited studies in the Palawan context. These limitations affect the accuracy of the model. Yet the model outcomes (in terms of water provided to the paddy fields) are well within the relevant actual measurements by the people managing the irrigation scheme.

Field work / key informant interviews

Part of the field work involved measuring the Pulot Dam to determine its dimensions and volume. Yet another effort made was to prepare a sketch of the dam (Annex 11). Assumptions on rice paddy water consumption were based on information provided during key informant interviews and published studies. Dam volume was modelled in only one period for lack of historical bathymetry records.

[21] HEC-HMS is designed to simulate the complete hydrologic process of dendritic watershed systems. The program features an integrated database, data entries tools, computation tools, and result reporting tools

[22] Stands for the Philippine Atmospheric Geophysical and Astronomical Services Administration, the main government agency responsible for assessing and forecasting weather conditions in the Philippines.

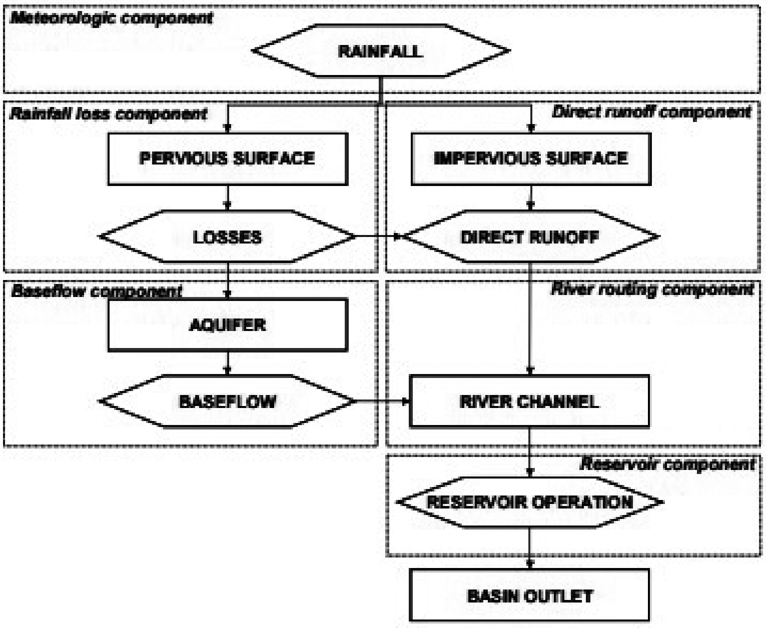

Figure 6.3. Rainfall to discharge pattern

Results

Pulot dam

Currently, the reservoir has an average depth of 2.7 meters (m), including dead storage (see Table 6.4). Beyond this depth, water spills to an adjacent river during heavy rains. The dam has an available maximum water storage capacity of around 3,949 m^3 with an average discharge ranging from 0.4-0.5 m^3/sec, according to NIA data. It has a controllable outlet measuring 1x1 m.

Pre-processing of raw rainfall data was done manually using MS Excel. Missing data were supplied using interpolation and were imported in a GIS software to compute for the required Thiessen weights and area.

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Table 6.4. Specifications of Pulot Dam

Meter above sea level	Water level (m) (above dead storage)	Storage volume (m^3)	0 discharge (m^3/s)
42.25	0	(dead storage)	0
42.95	0	(dead storage)	0
43.95	1	1,974	0.43
44.75	1.8	3,554	0.46
44.95	2	3,949	0.5-1

Water supply

In the past decade, the irrigation water deficit in the facility has evidently been increasing. There are two reasons for this: sediment trapping of the dam, which reduces the facility's storage volume for available water and changes in stream flow related to land use change; and land use change, specifically deforestation, which has helped reduce the water buffering capacity of the vegetation and a lower baseflow during the dry season.

Both factors have led to a reduction in water available for irrigation. In theory, changes in forest cover could be offset by huge increases in the storage capacity of the reservoir. But such an increase will require large-scale constructions in a remote location, which is likely to be expensive. Also, storing water leads to increased evaporation rates from the irrigation reservoir.

Around 50 ha was not irrigated during the period 2000-2005. This unirrigated area almost doubled to 96 ha in the period 2006-2010. Water inflows were particularly deficient between 2008 and 2009. Potential farmer responses to a reduced water supply vary. These include increasing the efficiency of irrigation, providing slightly less water to each hectare of land, switching to less water-demanding crops. None of these were carried out in the irrigation scheme, based on observations during the field survey and discussions with farmers.

Table 6.5. Average Computed Deficit in Volume and Area

YEAR	Annual Average Deficit	
	m^3	ha (deficit compared to full operation of the irrigation scheme [500 ha])
2000	13,054	71.3
2001	17,050	93.2
2002	4,883	26.7
2003	11,724	64.1
2004	377	2.1
2005	7,700	42.1
2006	8,481	46.4
2007	15,582	85.2
2008	21,820	119.2
2009	26,353	144.0
2010	15,937	87.1

Monthly average water supply can inform water usage in a cropping period. In a two-cropping per-annum system, water shortage is experienced during the first to second months, and in the second to fourth months. Water usage is higher during the first and third months of cropping, with 41% and 30% water usage, respectively. A negative deficit (in between brackets) indicates a water surplus. Note that rather than the annual average deficit, it is the deficit in the growing season that matters most to the rice farmers, as analyzed below.

Table 6.6. Average monthly water deficit

Cropping months per cropping cycle	Months	Average Deficit	
		m^3	ha (deficit compared to full operation of the irrigation scheme [500 ha])
	March	46,646	5
	April	35,184	192
1	May	14,950	82
2	June	1,567	8.6
3	July	- 1,976	- 11
4	August	- 5,827	- 32
	September	- 5,476	- 30
	October	- 11,426	- 62
1	November	- 12,833	- 70
2	December	11,478	63
3	January	48,413	265
4	February	54,781	299

Sedimentation pressure

Total suspended sediment of the whole watershed was around 50 kt/year in 2014 based on the land cover data and DEM.

Results from the model show that approximately 35 kilotons (kt)/year, or around 70% of the total suspended sediments, come from six sub-catchments upstream from the dam, almost all of which from hillslopes (see Figure 6.4). Most sediments are trapped in the reservoir, with a minor portion deposited in the river during spill-over, and in the irrigation canals every time water is released. Figure 6.5 shows pictures taken in 2015 of siltation in the reservoir, decreasing the facility's storage capacity.

Existing land use

The headwaters of the dam are predominantly covered by forests, shrubs, and perennial crops, which are mostly oil palms (see Figure 6.6). There is also an area of bare soil in one of the sub-catchments (see encircled parts in red of the Figure 6.5), which is a main source of sediments as indicated by the model.

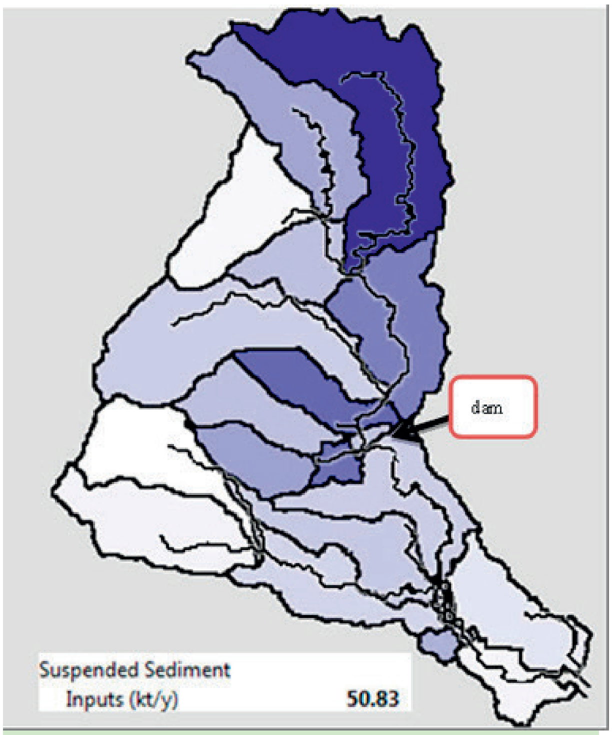

Figure 6.4. Relative importance of sub-catchment as a source of sediment

Figure 6.5. Siltation within the dam due to sediment trapping

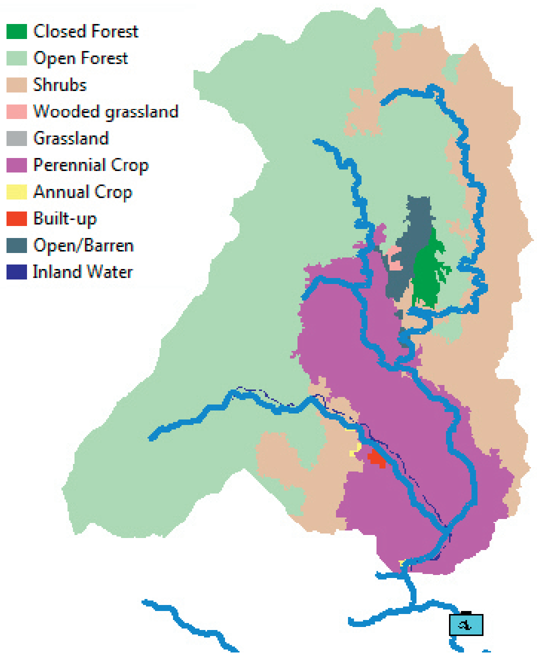

Figure 6.6. Land cover in the area providing water to the irrigation scheme

Table 6.8 Land Cover in Pulot Watershed

Land cover, 2014	Area (ha)
Annual Crop	11
Built-up	16
Closed Forest	95
Inland Water	26
Open Forest	5,330
Open/Barren	151
Perennial Crop	2,105
Shrubs	2,388
Wooded grassland	14
Grand Total	**10,136**

Ecosystem service modelling

The sediment regulation ecosystem service can be determined by converting all vegetation into bare soil, thus giving a projection of the sediments avoided for the whole watershed. The model reveals that around 703 to 745 kt/year is retained by forests based on 2010 and 2014 land cover data.

Table 6.9 Ecosystem Service in a Non-vegetated Scenario Showing Avoided Sediments

Land Cover Period	Area (km²)	Sediment generated under 2010 land cover (kt/year)	"No Vegetation" Scenario (conversion of all vegetation into bare soil except crops (kt/year)	Ecosystem service (avoided sediments, (kt/year))
2010	180	37	740	703
2014	180	53	798	745

Water regulation is modelled using a hydrological model. The ecosystem service provided by forests is generated by analyzing how water flows change in the absence of forest, as explained earlier. Results show that deforestation leads to a change in the timing of water flowing into the irrigation reservoir.

In particular, if forests are lost, water levels in the river feeding into the dam increase during the rainy season, particularly after rainfall, but decrease during the dry season. This means that there is less resupply of water during the dry season, and the overall capacity of the reservoir to feed the irrigation scheme decreases if forests are lost.

Water regulation is analyzed by aggregating the water available for irrigation during the two growing seasons (May-August and November-February) for paddy. That is, before and after forests are lost and replaced by bare land.

Table 6.10 shows the deficit avoided because of the presence of forests. The deficit is defined as the amount of hectares that cannot be irrigated in the 500 ha irrigation scheme due to a lack of water. The corresponding amount of water available for irrigation is 108.4 thousand m^3 in the absence of forests, and 281.8 thousand m^3 under the current land cover.

Table 6.10.A "Non-forest Scenario and Deficit Avoided Ecosystem Service[23]

MONTH	Average deficit in absence of forest		Avoided deficit /1 (ha)
	m³	ha	
March	55,920	306	51
April	51,629	282	90
May	22,893	125	43
June	4,569	25	16
July	1,293	7.1	18
August	- 184.26	- 1.0	31
September	9,552	52	82
October	- 4,866.58	- 27	36
November	5,578	30	101
December	20,773	114	51
January	61,466	336	71
February	65,602	359	59

Key: /1 compared with the deficit under current land cover

This system is valued by comparing the crops that can be produced with irrigation water, depending on the forest cover, to those that can be produced where irrigation water is otherwise not available. In the latter case, only one rainfed crop would be possible. It is assumed that water needs to be available during each month of the growing season to facilitate irrigation. Therefore, the monthly average water availability is analyzed.

Table 6.11 shows rice production under the current forest cover and rice produced on bare soil. The difference is a rice production of 4 (t/ha) * (418-375 ha) = 172 tons in the first cropping season, and 3.3 (t/ha) * (201-141 ha) = 198 tons in the second cropping cycle, for a total 370 tons of paddy per year (see Table 6.11).

As shown in Table 6.3, both physical production and resource rent are different across the first and second cropping cycles, which may be explained by the different amounts of water available in the respective months. The model used shows that Pulot irrigation scheme was already water-deficient under current circumstances (see Table 6.6), in particular during the second cropping season. This was confirmed by the farmers during interviews.

[23] The deficit avoided represents the amount of ha that can be irrigated because of the water regulation service of the forests upstream of Pulot watershed.

Table 6.11. Analysis of the Water Regulation Service

Cropping system	Gross revenue (1000 pesos/ha)	Irrigated area under current (2014) forest cover (ha)	Gross revenue rice farming (1000 pesos)	Irrigated area if forest were to be lost (ha)	Gross revenue rice farming if forest were to be lost (1000 pesos)[/1]
First crop	60	500-82=418	418*60 = 25,080	500-125 = 375	375 * 60 = 22,500
Second crop	56	500-299=201	201*56 = 11,256	500-359 = 141	141 * 56 = 7,896
Total (2 cropping seasons)		619	36,136	516	30,396

[/1] assuming no price changes

Hence, water regulation generated by the forests in the upper part of Pulot watershed facilitates around 6 million pesos (US$128,893.66) per year of paddy production, in the small irrigation scheme of Pulot. In other words, around 20% of the rice production of the irrigation system would be lost if the forest would disappear.

Note that the watershed is also a source of water for the Pulot drinking water scheme. But water quantity and quality may be affected by deforestation. In particular, if the forest would be replaced by plantation crops, there is a risk that agrochemicals would end up in the inlet of the drinking water scheme. This effect is in addition to the calculated effect of deforestation on paddy production.

This case study shows that an assumption needs to be made of the ecosystems that generate the water regulating service. The study assumes that only forests contribute to water regulation. This is not correct, as other types of ecosystems (except bare soil) also contribute, albeit at much lower per hectare rates, to water regulation.

Whether some of the intermediate service should be attributed to the dam and the reservoir does not seem to be the case, based on this study. Water flows were modelled with the dam under different forest covers. This means the water regulation service was analyzed with the irrigation reservoir in place and based on the current level of sediments in the dam.

Evaluation

The account shows the annual value generated by the different ecosystem services, including water regulation in forest lands and paddy cultivation (Table 6.3).

Note that there is an issue of double counting here. The value of the water regulation service was analyzed based on its contribution to rice production. The value of the intermediate service 'regulation of water flows' cannot be added to the value of irrigated rice production, as doing so would lead to double counting. This could be overcome by deducting the value of the intermediate service water regulation from the value of the service 'providing an environment for irrigated crop production', which was valued using the resource rent approach.

Note that the value of the ecosystem services is relatively low compared to the value of carbon sequestration, which ranges from 37,000 pesos (US$792.97) to 44,000 (US$ 835.83) (in 2010 and 2014) pesos/ha/year in Pulot watershed. The high social cost of carbon and the exclusion of any management costs of the forest partly explain the causes underlying this large difference.

Nevertheless, the approach shows the feasibility of including a broad range of provisioning and regulating services in the accounts. Efforts must be made to determine how the results specific to Pulot watershed can be scaled up to other parts of Palawan, which have comparable

Highlights from Ecosystem Services Account – Water Regulation

- The Pulot Municipal irrigation scheme supplies irrigation water to about 500 ha of rice paddies. However, in terms of water supply, the irrigation water deficit has been increasing due to sediment trapped in the dam and deforestation. The latter has caused a reduction in the water buffering capacity of vegetation.
- Land use changes including deforestation have led to worsening sedimentation within the upstream of Pulot watershed.
- In the past decade, the water deficit in the Pulot irrigation scheme has been increasing owing to sediment trapping in the dam and land use change, specifically deforestation.

geomorphology and land use, although the land cover varies per watershed.

Fisheries

Introduction

Fisheries are an important ecosystem service in Palawan. Yet there is little quantitative data for this service beyond those collected by the PSA at the provincial level. (Fisheries services refer to the opportunities provided by the ecosystem to harvest fish.)

Since the PSA fisheries statistics did not cover all information required to calculate the local resource rent, an analysis was made instead of the fisheries service based on a survey carried out in the context of the Phil-WAVES program.

The survey aimed to collect the required information to analyze the fisheries services in physical and monetary terms, using resource rent as the value indictor.

Users of the fisheries services are the fishermen of the coastal villages of Sofronio Española. Given the mobility of some of the fish species, the most ecologically sound way of producing the ecosystem account for fisheries was to produce it at the scale of Palawan island province.

Where this service is concerned, this ecosystem account should be seen as a pilot undertaking, with more work at larger scales to follow when the accounts are scaled up.

Methodology

Data on the number of fishermen were obtained from the Barangay Fisheries and Aquatic Resource Management Council (BFARMC). In addition, a draft survey questionnaire was prepared by the TWG and reviewed by the PSA. Subsequently, a survey was carried out by the TWG in July 2015. The collected data was processed in Excel with the assistance of the national Phil WAVES consultant. (The survey questionnaire is presented Appendix 9.)

The survey was conducted in the coastal zone of the municipality of Sofronio Española, corresponding to the study area of the pilot ecosystem account. A total of 31 fishermen were interviewed, representing three barangays — Pulot Shore, Iraray, and Punang — in approximately equal proportions.

Results

Based on the BFARMC record, there are a total of 266 fishermen across the town's eight coastal barangays, namely, Punang, Pulot Shore, Isumbo, Aboabo, Iraray, Labog, and Panitian. The minimum number of fishermen recorded in a barangay was 21 (Aboabo) and the maximum 57 (Panitian).

Annex 10 provides the details and lists the species caught in the municipal waters of Sofronio Española as well as the average prices at which the fishermen's catch is sold at the local market. Table 6.12 presents the estimated total catch and the gross sales value of fisheries in Sofronio Española.

Based on the total coastal ecosystem accounting unit count, the eight barangays cover a total of 28,813 ha, of which 10,125 ha are coastal or marine deep waters. The total catch by all fishermen, extrapolated based on the survey, amounts to 1,665,853 kg/year. The gross sales value of this yearly catch is 41,144,818 pesos (US$883,884).

The fishermen use a variety of gear depending on the fishing season (Table 6.12).

For purposes of simplicity, all municipal fishermen were assumed to be fishing in the coastal waters of the municipality and that no other fishermen were fishing in these waters. In reality, however, the large majority of fishermen stay close to shore and fish in the waters of the municipality as confirmed by the field survey.

When the ecosystem accounting approach in Palawan is scaled up to the whole island province, these effects will be reduced since the accounting unit will be the province at large, and migration of fish between marine habitats in a specific municipality will not affect the overall account.

Table 6.12. Estimation of the Total Catch and Gross Sales Value in Sofronio Española

By Gear (type 1)	Average Price of Fish, (pesos/kg)	Total Catch in kg/day	Number of Gears	Average of Number of Fishing Days Per Year	Total Catch kg	Gross Value of Total Catch (pesos)
Gillnet	62.6	540	17	201.1	108,594	6,797,984
Hook and line	60.6	198.5	10	152.8	30,331	1,838,046
Katihan	50	17.5	1	252	4,410	220,500
Kitang	73.3	17.5	1	220	3,850	282,205
Longline	135.8	52.5	1	50	2,625	356,475
Unrecorded	70	150	1	319	47,850	3,349,500
Total	**64.5**	**976**	**31**	**186.7**	**197,660**	**12,844,711**
By gear (type 2)						
Gillnet	54.2	60	3	178.7	10,722	581,132
Hook and line	102.2	120.5	8	179.3	21,606	2,208,097
Kitang	0.7	750	1	167	125,250	87,675
Pana	68.3	-	1	-		
Pusit jigger	62.1	35	1	224	7,840	486,864
Sipag	60	30	1	252	7,560	453,600
Sodsod	0.9	1,500.00	1	112	168,000	151,200
Unrecorded Gear	68.3	32.5	15	20.5	666	45,505
Total	**72.5**	**2,528.00**	**31**	**97.8**	**341,644**	**4,014,074**
By gear (type 3)						
Gillnet	61.7	-	1	196		
Hook and line	70	67.5	2	211	14,243	996,975

Table 6.12. Estimation of the Total Catch and Gross Sales Value in Sofronio Española (cont'd)

Kati	50	9	1	156	1,404	70,200
Octopus	65	5	1	Not reported		
Pusit jigger	115	10.5	1	41	431	49,508
Sodsod	0.2	2,000.00	3	51.3	102,600	20,520
Unrecorded gear	42.5	205	21	28.3	5,802	246,564
Unrecorded gear	70	24	1	44	1,056	73,920
Total	**53.4**	**2,321.00**	**31**	**53.6**	**125,535**	**1,457,686**
By gear (type 4)						
Unrecorded Gear	22.6	3,021.50	30	330	997,095	22,534,347
Pusit jigger	75	17.5	1	224	3,920	294,000
Total	**40.1**	**3,039.00**	**31**	**554**	**1,001,015**	**22,828,347**
Grand Total for Sofronio Española					**1,665,853**	**41,144,818**

Subsequently, the resource rent for the fisheries service in Sofronio Española is calculated (see Table 6.13). The average resource rent per kg of fish is estimated at 42 pesos (US$0.90)/kg (Table 6.13). The total catch by all fishermen in the municipality is valued at 1,665,853 kg/year (see above). Hence the total resource rent generated by fis heries across the town is estimated at 42 pesos/kg * 1,665,853 kg/year = 70 million pesos (US$1.5 million)/year. This is a preliminary indication of the value of the ecosystem service 'providing fish for fisheries', and therefore requires further work to confirm it.

Table 6.13. Calculation of Fisheries Resource Rent Per kg Among Fishermen Included in the Survey

Barangay	Total Annual Catch (kg)	Gross Sales from Gear Catches	Total Compensation of Employees (CE) (pesos)	Total Intermediate Consumption/ year (pesos)	Total Consumption of Fixed Capital (pesos)	Total Consumption of Fixed Capital (pesos)	Total Resource Rent (pesos)	Resource Rent, pesos/ kg
Iraray	12,048	722,348	74,756	4,180	5,738	5,738	634,051	45
Pulot Shore	144,692	642,512	122,146	9,764	4,571	4,571	502,950	41
Punang	7,384	398,006	64,914	4,437	3,235	3,235	323,260	46
Weighted average		637,372	116,092	9,114	4,597	4,597	504,490	42

Highlights of Fisheries Account

- There are a total of 266 fishermen in the eight different coastal villages of the municipality (Punang, Pulot Shore, Isumbo, Aboabo, Iraray, Labog, Panitian), The total Coastal Ecosystem Accounting Unit counts 28,813 ha of municipal waters, of which 10,125 ha consist of coastal/ marine deep waters.
- Based on extrapolations made using a survey for the project, the total catch by all fishermen amounts to 1,665,853 kg/year. The gross sales value of this catch is 41,144,818 pesos (US$883,884)/Year (42 pesos/kg * 1,665,853 kg/year).
- Preliminary estimate of the value of fishery production ecosystem service generated by the coastal marine ecosystems in Sofronio Española, measured in terms of resource rent, is calculated at 42 pesos (US$0.90)/kg or a total of 70 million pesos (US$1.5 million)/year (42 pesos/kg * 1,665,853 kg/year) for the municipality. .

7| Asset Account for Crop Production

In Southern Palawan, an asset account was developed only for crop production. The specific methodology to create the asset account is still under development. (Please see footnote 4 on page 6.) The asset account developed for crop production serves as a pilot mechanism to determine how the said asset could be quantified in ecosystem accounting.

The UN guidelines specify that assets can be analyzed in physical terms (i.e., extent and condition) and in monetary terms (i.e., NPV of the resource rent of the expected flow of ecosystem services). This set-up is followed in this pilot ecosystem account. In physical terms, assets were analyzed based on cropland acreage. In monetary terms, the NPV of the resource rent generated by crop production was calculated.

In line with the above, the principle applied in terms of the boundaries between produced and non-produced assets posits that the ecosystem provides soil, substrate, water holding capacity, among others, that is used by farmers.

For provisioning services, "capacity" is a relevant concept to consider for the asset account. For individual ecosystem services, capacity is defined as the ability of the ecosystem to generate a basket of ecosystem services under current ecosystem condition and uses at the maximum sustainable yield that does not lead to a decline in condition of the ecosystem'' (Hein et al., 2015).

Capacity can change over time — from one ecosystem accounting period to the next — due to changes in ecosystem conditions. It is measured for the ecosystem "as it is," i.e. irrespective of whether sustainable use at a higher extraction rate is possible under different management regimes or with, for instance, a different species composition in the ecosystem. If the flow of ecosystem services exceeds the capacity of the ecosystem to provide that specific service, the flow of services can be expected to decline over time.

The capacity of an ecosystem to generate a provisioning service would normally depend on the (re)growth of the service involved (e.g., timber or fish) — with (re)growth in itself usually a function of, among others, stock (in relation to carrying capacity) and ecosystem condition (Hein et al., 2015).

For crop production, it is generally assumed that current flows of the product also indicate the capacity to grow the crop (Remme et al., 2014 and Schröter et al., 2014). Therefore, the assets for crop production relate to both the area used for growing specific crops, and the actual harvests that are achieved, under current farming systems.

Hence, in this pilot, current flows for agriculture are assumed to express as well the capacity to generate the crop.

As explained in Chapter 2, it is assumed that soil degradation does not happen to the degree that it affects crop production. However, this assumption is not applicable to upland crops such as cassava, and therefore must be verified for the crops studied for this pilot.

Table 7.1 shows the results of compiling data to form the asset account, specifically for the years 2010 and 2014. As earlier explained, the asset is quantified based on hectares in the physical account.

The opening area in 2010 for coconut and oil palm was determined based on the 2010 ESA land cover map, while the area covered by irrigated and unirrigated rice paddies was found based on the 2010 NAMRIA land cover map, which in turn was analyzed along with the 2005 PCSD map.

The closing areas in 2014 were all based on the 2014 NAMRIA land cover map. Cropland areas of interest were disaggregated by interpreting 2013-2014 Google Earth images and using spatial data from a private company managing the oil palm farms and operating the milling plant.

Table 7.1 presents a summary of the asset account, with more detailed accounts, disaggregated by barangay and land tenure (see Appendix 6 for details). It is assumed that crop yields remain static at 3.9 tons/ha for rice and 1.3 tons/ha for coconut (hence the absence of change in ecosystem condition in agricultural lands). Note, however, that this assumption is not appropriate for uplands, where croplands are under heavy threat from erosion.

For the generally flat paddy lands and coconut plantations, this assumption seems more realistic. However, it will need to be tested further when the accounts are scaled up. For oil palm, this is an unlikely assumption given the young age of the plantations and since this crop is not included in the monetary asset account.

Table 7.1. Biophysical Asset Account for Rice, Coconut, and Oil Palm and Ecosystem for 2010 and 2014, Pulot Watershed

	Land Cover: area (in hectares)					
	Rice (classified as)			Coconut	Oil palm	Total
	Rainfed	Irrigated	Irrigated + corn			
Opening (2010)	57	446	27		901	2,745
Addition to stock				1,315		
Regeneration, natural (net of normal natural losses)						
Regeneration, through human activity	93		34	140	415	634
Reclassification						
Total addition to stocks	**93**		**34**	**140**	**415**	**634**
Reductions in stock				140		
Reductions due to ongoing human activity		-48				
Catastrophic losses due to human activity						
Catastrophic losses due to natural events						
Reclassifications						
Total reductions in stocks		**-48**				
Revaluations						
Closing stocks (2014)	150	398	60	1,455	1,316	3,379

In monetary terms, the asset account is calculated based on the NPV of the expected flow of ecosystem services per hectare. In line with UN et al., (2014a.) the resource rent is used to indicate the value of the ecosystem service. In computing the NPV of each crop system, much consideration was given to determining the applicable discount rate.

The SNA (UN et al., 2009) specifies that a real discount rate should be used when the future flows are expressed based on current period prices, as used in the calculations. The SNA is less specific in terms of indicating how the appropriate real discount rate can be established. An option that is aligned with the overall SNA approach is to use the real market lending rates applicable to the asset owner — in this case, the farmers. These rates, however, may be high in a rural, developing country setting, given that the local money market may not be very efficient. It is also not always straightforward to deduct inflation from the nominal lending rates, since inflation rates can vary strongly from year to year.

Another consideration is alignment with relevant national guidelines. NEDA estimates the values of the shadow discount rate, reflecting the true opportunity cost of money, which is estimated to be 15% (NEDA et al., 2007). Therefore, the asset value for three different discount rates (i.e., 10%, 12%, and 15%,) have been analyzed. (Table 7.2 uses a discounting period of 20 years.)

For oil palm, the asset account could not be completed in the absence of conclusive information on the production of oil palm throughout one planting cycle, which generally takes around 25 years. A more detailed analysis of the asset value generated with specific cropping systems is provided in Annex 7.

Table 7.2. Monetary Account for Ecosystem Assets in Irrigated Rice and Coconut Production for Pulot Watershed[24]

Ecosystem Unit	Area	Resource Rent, Pulot Watershed	Net Present Value at Discount Rates		
			10%	12%	15%
	(ha)	(million pesos)	(million pesos)	(million pesos)	(million pesos)
2010					
Rice	529	26.8	251	224	193
Coconut	1315	12.7	119	106	91
2014					
Rice	608	35.5	332	297	256
Coconut	1,455	19.7	184	165	142

[24] The NPV of irrigated rice production includes the PV generated by growing corn in the dry season on the same land.

8| Synthesis and Conclusion

Findings and recommendations for policy makers

The accounts can support policy making in different ways. First, they can inform policy makers of the status, uses, and monetary values of ecosystems, especially during policy formulation. For instance, the accounts can indicate sensitive areas such as where there are concerns on ecosystem conditions, or areas that are crucial to supplying ecosystem services.

Second, the accounts make information available in an aggregated and coherent way. They include information that is usually dispersed in different agencies and line departments. Hence they lead to easier access to an integrated dataset and help generate new insights resulting from data consolidation. The accounts also make clear what data are missing in order to have a good understanding of environmental change and its impacts on people's livelihoods.

Third, they can alert policy makers to trends in ecosystems and the services they supply. In some cases, ecosystem degradation may already have affected the people's livelihood. In other cases, such information can be used to forecast potential future impacts. This applies, for instance, in cases where the underlying ecosystem condition and capacity to generate services is deteriorating even if there is no corresponding decline in the actual supply of services owing to increased harvest efforts. By monitoring trends in ecosystems over time, the accounts can also provide information on the effectiveness of specific policies.

"By monitoring trends in ecosystems over time, the accounts can also provide information on the effectiveness of specific policies."

The accounts, however, will not be complete in the foreseeable future. For one thing, some information that is vital to decision making on ecosystems is not included in these accounts. In Palawan, for instance, there is no information on the use of ecosystems for cultural practices (in particular among indigenous communities), the harvest of non-timber forest products, the cultivation of other crops (e.g., vegetables), among others.

For another, the accounts are inadequate to deal with issues such as risks and critical thresholds in ecosystems. It may well be that there are thresholds, for instance, in coral reef functioning or forest cover, which, if surpassed, would have major implications for ecosystem processes and ecosystem service supply. Yet, such thresholds may not show up in the accounts due to a lack of knowledge on the processes involved, or overall lack of data. The accounts, therefore, need to be interpreted with caution.

The Southern Palawan ecosystem accounts provide a number of insights that are relevant to policy makers.

1. There has been a strong expansion of oil palm plantations in the watershed in the past decade, facilitated by the development of a palm oil mill. This expansion may not bring economic benefits to farmers.

Oil palm expansion in Palawan, specifically in Pulot watershed, has been very rapid (see Figure 8.1). In the entire province, oil palms cover an estimated 3,852 ha, or 11% of the land devoted to oil palm plantation at the national level. In Palawan, approximately 16,979 tons of fresh palm fruits were produced in 2014 (PSA 2015).

A significant share (around a third) of oil palm in Palawan is grown in Pulot watershed and adjacent watersheds, where oil palm covers a total of 1,316 ha. Based on these data Pulot

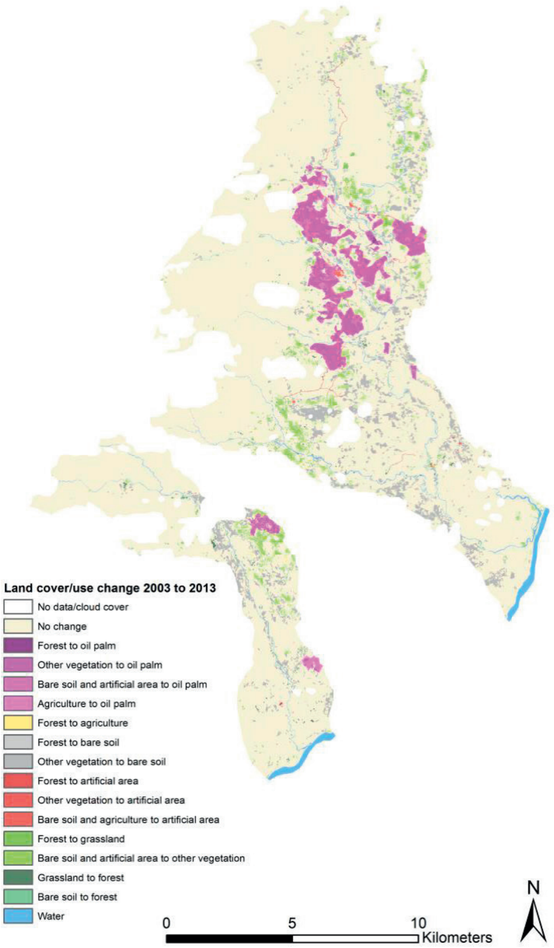

Figure 8.1. Expansion of oil palm plantations and other land cover change in the period 2003-2010, as identified by GeoVille.

watershed is not representative of Palawan in terms of oil palm plantations, but it provides important insights into the potential future land use change on the island.

The field survey and the analysis of land cover change (see Figure 8.1) shows that conversion to oil palm has taken place in different land cover types including bare soil, cropland, shrubland/open forest, and forest. Part of the conversion has taken place in forest areas and on steep slopes, where such conversion is not legally allowed. This situation highlights the need for greater care in the registration and allocation of land for plantations in the other parts of Palawan.

Surveys indicate that farmers growing palm oil were generating lower incomes than what they had expected from the crop. This finding is reinforced by low productivity and low income data that have been generated so far. As there is as yet no mature and fully productive oil palm in Pulot, this fact is not yet reflected in the asset account.

The income situation of the farmers points to a need to assist them in interpreting potential contracts that they may enter into with plantation companies. A particularly relevant concern for farmers is the length of the lease agreement, usually up to 25 years.

Extending support to the farmers will help forestall the negative impacts of palm oil production on local stakeholders, and prevent them from clearing other land areas because of low returns from land that has been converted to oil palm. Several of the oil palm farmers interviewed indicated that they also have problems with crop management, including getting an adequate supply of fertilizers for their crop.

Oil palm requires more water than is available in Palawan. It also needs evenly distributed rainfall of 150 millimeters (mm)/month or 2,500-4,000 mm/year. Yet the available rainfall available only averages 1,780 mm per year. This water deficiency was confirmed by reports that oil palm farmers were using river water aided by pumps and trucks to irrigate their crop. This practice puts river water users downstream, including paddy farmers, at a disadvantage.

Given the prevalent rainfall conditions and the fragmented landscape of Palawan, it is highly doubtful if oil p alm produced in Palawan can compete internationally. Oil palm does not seem to generate the highest possible farm income and make the best use of natural resources in Palawan.

Policy makers should issue new permits for oil palm cultivation sparingly, at least until water availability for new areas proposed for oil palm has been analyzed and that it has been confirmed that spare irrigation water is available to grow oil palm. These issues are currently being explored in a policy scenario. Otherwise, the promotion of oil palm will have few positive economic impacts on Palawan due to low productivity and is likely to lead to negative incomes for local farmers, more pressure on upland forests due to additional clearing, and conflicts around the use of scarce water.

2. Deforestation in Southern Palawan was reversed during the period 2010-2014.

The land account produced by NAMRIA for the entire Palawan province suggests high forest loss in the period 2003-2010, and a small net gain in areas covered with dense forest between 2010 and 2014. The area covered with closed forests increased by around 5,000 ha or about 6% of the land surface area of Southern Palawan (see Chapter 3). Further analysis and field verification is needed to fully confirm the results.

However, given the uncertainty rate yielded by remote sensing analysis (with 80% accuracy), it is too early to conclude that deforestation has been arrested. The stakeholders in Pulot watershed expressed belief that deforestation continued in the period 2010-2014. The land account shows no major changes in the watershed in this period and no increase in forest cover either. Continued enforcement of the logging ban seems an important prerequisite for forest recovery. But, as explained earlier, the future potential pressure on the forests may also come from, say, land conversion to oil palm plantations.

3. There have been significant negative changes in coral reef quality in the period 2001-2010.

The ecosystem condition account showed that coral reefs declined strongly in the period 2001-2010. The number of coral reefs in good or very good condition dropped from nine to one in this period, while those in poor or fair condition increased from four to 10.

Although coral reefs are of different sizes and may have varying degrees of importance to coastal protection, the sheer size of the change (as indicated above) clearly indicates rapid degradation of this type of ecosystem. It is also worth noting that this decrease also took place in a relatively short time span — nine years. Among the potential causes are increased sedimentation due to economic activities in upper parts of watersheds, leading to higher erosion rates and, in particular, the use of dynamite and cyanide for fishing. (This is further discussed on page 74.) Loss of coral reefs will have a number of consequences, including reduced fishery production and storm protection. With the current ecosystem account, these potential impacts cannot be assessed just yet. However, policy scenarios are being developed to study these impacts.

4. Mangrove and seagrass ecosystems also showed a strong decline in ecosystem condition.

The overall volume of mangroves in the study area for the condition account decreased significantly from 206,300 m^3 in 2001 to 69,310 m^3 in 2010. This represents a decline of over 60% in just nine years.

Several potential causes can be identified including land conversion and logging. Given the importance of mangroves to coastal protection and as nursery areas — two ecosystem services that have not yet been analyzed in Southern Palawan — there is an urgent need to improve mangrove conservation.

Seagrasses are more resilient than coral reefs to pressures from sedimentation and runoff. Seagrass fields are dynamic and generally able to recover from damages due to sedimentation. However, they can also be affected by changes in water clarity, which in turn affects photosynthesis.

The condition account also shows that while there are no major impacts on the species composition of seagrass fields, the density of these coastal ecosystems significantly declined in the period 2001-2010. The percentage cover also decreased considerably during this period.

5. The declines in coastal ecosystems may be related to dynamite fishing and increased sediment loads in coastal waters.

The latest data on coral, seagrass, and mangrove ecosystem conditions are for 2010, so it is not known if the rapid degradation that transpired in the period 2001-2010 had persisted. Spot checks by the ecosystem accounting team in October 2015, however, did indicate ongoing destruction in the ecosystems visited in Honda Bay.

There are several reasons for the destruction of the three types of coastal ecosystems. Dynamite fishing is still causing coral reef degradation. This destructive fishing method (and cyanide fishing to almost the same degree as the former) is the worst way of extracting natural capital and leads to immediate and prolonged economic loss.

Yet dynamite fishing reportedly persists. Policy makers should make it their top priority to stop this illegal activity, which leads to immediate and prolonged loss of income from coral reef fisheries, loss of storm protection and tourism potential.

A second major cause of coastal ecosystems is sedimentation. Land use conversion, including deforestation and mining, has increased the area of bare soil, leading to higher runoff and sediment loads in coastal areas.

An additional source of sediments is mine deposits, including ore storage sites located near the shore. Seagrasses are vulnerable to prolonged sedimentation, as high sediment loads reduce the amount light available for photosynthesis. Coral reefs are highly vulnerable to sedimentation as they are affected by smothering that deprives them of sunlight, and reduction in water clarity, which is vital to optimal coral growth.

Another potential cause of coastal ecosystem degradation is runoff of heavy metals from mining operations — either from the mine itself or from the ore deposition point close to the harbor.

Several water quality samples show that the risk of runoff from the ore deposition site is higher compared to the hazards posed by mining operations upstream. This means that concentrations close to the harbor significantly exceed those found in the river delta. This finding shows the need to improve the management of runoff and drainage from the ore deposition site.

Samples taken once a month cannot adequately capture the environmental effects of ore deposition. It is during incidents such as typhoons accompanied by heavy rains, strongly increased runoff or breakthrough of sediment deposition storage that increased levels of pollution are generated.

Due to data limitations, only annual average data based on one sample per month are presented in this report.

6. The forests of Southern Palawan are an important carbon sink.

The total carbon stock contained in Southern Palawan's forests declined from 12 million ton C in 2003 to 9.3 million ton C in 2014. The decrease can be attributed to the decline in the area and volume of closed forest and the wide-range conversion of closed forest to other types of land cover.

There is also important sequestration of carbon in the forests. The annual sequestration of carbon is about 4.6 ton C per ha in closed forest and 4.9 ton C per ha in open forest. Sequestration is generally higher in open forest, where the mean annual increment of wood is generally greater since forest growth tends to slow down in established forests.

7. The forests of Southern Palawan are important to maintain water supply to irrigated paddy fields

The hydrological modelling conducted for the ecosystem account shows that water is a main concern among farmers, although part of the Pulot irrigation scheme is not used for cropping because of insufficient water to irrigate the full area of the irrigation scheme.

Cutting down forest trees reduces water supply to the irrigation scheme. Without forest cover, rainwater is very rapidly drained from the watershed. Moreover, forests act as buffer by storing and gradually releasing water throughout the year. The accounts show that if the forests upstream of the irrigation scheme were lost, paddy production in the irrigation scheme would drop by around 17%. Given the continuous threat from illegal logging and illegal land conversion, this requires sustained attention from policymakers.

8. There are important trade-trade-offs in ecosystem management in Palawan that can be revealed through an ecosystem accounting approach.

Significant trade-offs in land and resource management are shown in the ecosystem accounts. Such trade-offs indicate that ecosystem resources are under high pressure in Southern Palawan in spite of a relatively low population density. This is reflected in the dramatic decline in forest cover, coral reefs, mangroves, and seagrass. Such decline may have begun in 2000, or possibly earlier. It must be noted that the scope of the account starts with the year 2001.

Land used for both coconut and oil plantations also increased. The latter was observed to a limited degree on the island as a whole but substantially in Pulot watershed.

However, the number of people benefiting from the new plantations is limited, however. Many of the farmers in Pulot watershed complain that they earn less from oil palm compared to foregone income from converting their land. (This has been confirmed in this account, which shows a negative resource rent.)

Coconut plantation expansion may have been partly driven by the grant of a planting subsidy during much of the period covered in the account. As this ecosystem account shows, the monetary value generated per hectare (resource rent) from coconut is comparable to the resource rent from rainfed rice.

The accounts also show that safeguarding the remaining forests of Palawan is paramount. Forests are essential for maintaining water supply for rice production, especially since the province is one of the main rice-producing areas in the country. In addition, it is likely (although this has not been explicitly examined) that forests will play an important role in the new local government's plan to tap water from upstream parts of local rivers to supply drinking water in a decentralized manner to the communities of Palawan.

Forests are also an important carbon sink, as quantified in the account. The potential of the forests to provide other ecosystem services, in particular ecotourism (such as in the form of mountain biking, hiking, etc.), could be explored.

Findings relevant to ecosystem accounting

The pilot ecosystem account completed by the TWG with support from national and international experts demonstrates a number of important points.

First, ecosystem accounting fills a crucial information gap in provincial- and municipal-level ecosystem management. More importantly, it consolidates data from different disciplines (hydrology, ecology, soil sciences, economics), covering different environmental compartments (uplands, lowlands and coastal ecosystems). This is important given the linkages between these different ecosystems: land uses in uplands influences water quality and availability in lowlands and the status of coastal ecosystems.

The pilot also shows that different agencies use different databases and are not always sufficiently aware of information in other departments or agencies. For instance, in numerous cases new land titles given out in Pulot watershed cover slopes too steep for agricultural activities, potentially because the land agency was not aware of the existence of such slopes in these areas.

Second, the pilot shows that data required for analyzing many ecosystems was available in various line agencies, and data availability was much higher than anticipated. But since these data are distributed across many agencies, accessing them is time-consuming.

A significant data constraint is that the river flow measurement stations in Pulot River are no longer operational, which made it necessary to use data from the late 1990s and early 2000s to calibrate the hydrological model. This will increasingly be a constraint for modelling and monitoring the impacts of land use change on water availability as well as on coastal ecosystems.

The pilot also demonstrates the need to apply high standards in data collection and recording. At times, different data sources (e.g., different classifications of remote-sensing images compared to land cover data from other sources such as the PSA) were not 100% aligned. This shows uncertainties in data collection methods and illustrates the need to have clear logbooks for data collection efforts and surveys, and well-defined procedures for data collection to retrace the steps in data collection and analysis.

Overall, the comprehensive ecosystem accounts produced in a span of around 18 months cover a range of condition, asset, and services indicators. Some of these are in physical and monetary terms, and include several complex ecosystem services such as water regulation.

Third, it has also become apparent that compiling the accounts entailed enormous time and effort, as well as the participation of a number of staff from the PCSD and DENR alongside national and international experts who supported the pilot ecosystem account.

A key bottleneck for developing the accounts was that the TWG members had other responsibilities outside of the Phil-WAVES project, making their work on the ecosystem accounts an even bigger challenge. The conduct of an expansive analysis using a broad dataset led to considerable capacity building for the TWG. Around 20 of the group took part in a total of four hands-on training sessions, three of which were on ecosystem accounting and one on land accounts. The TWG members conducted most of the analysis themselves.

Fourth, an important part of the value of the accounts lies in showing trends in ecosystem condition, asset, and service flows. This means that the accounts should be regularly updated — a task that relies on available resources, both in terms of time the TWG members can devote to the task and the budget for field work and data collection.

Given the capacities built and the lessons learned in the process of developing the accounts, the cost of updating them in the future should be much lower compared to establishing them. Potentially, given the rate of ecosystem change in Palawan, updates should take place once every, say, two or three years. But this depends as well on the demand for information on ecosystem and ecosystem use from policy makers and other stakeholders. Presumably, if the demand is sufficiently high, then it will be possible to provide resources for updating the accounts.

Fifth, the pilot provided a number of lessons on the appropriate scale of the accounts. In hindsight, Pulot watershed was too small a scale for some of the analysis (crop production, ecosystem condition), because with relatively little more effort, much larger areas can be analyzed.

For marine resources, a potentially better scale is the entire Palawan, since fisheries data are collected province-wide and marine ecosystems in Palawan are linked together. Such a scale would also help in identifying the impacts of local disturbances (like those from mining) on the ecosystem. Trends in ecosystem downstream of mining areas can then be compared with those in areas that are not affected by mining.

For hydrological services, however, the scale of the watershed is appropriate. How such services can be efficiently analyzed for larger areas such Palawan province must be examined further.

Sixth, the pilot study shows the need for a proper and well-designed system to store and share information including GIS maps. At present, these data are stored only on the personal laptops of the experts that analyzed them. This makes it difficult to implement accounting in the long term, especially when these individuals move to other organizations.

The TWG should identify two storage options (one in each implementing agency) apart from the personal data repositories of the concerned personnel. There should also be a proper file explaining in detail how the data were collected and would need to be interpreted.

Seventh, the ecosystem accounting approach shows the key data gaps for information required for environmental management. In particular, there is a need to analyze water quality in mining areas, and biodiversity and forest uses in the upland areas. (See Chapter 6 for more details on water quality and mining.)

Eighth, during the development of the account it became clear that there was a need to further consider how the value of carbon sequestration could be estimated in an accounting context. The social costs of carbon, as used in this pilot, do not necessarily represent an exchange value (for instance, because it includes elements of consumer surplus), which is not aligned with an accounting approach to valuation. Another question that needs further discussion is whether a private or a public discount rate should be used in analyzing carbon sequestration.

Ninth, it is important to consider lessons that can be drawn from the case study for national environmental and environmental-economic data. This could be done jointly with the PSA. Eventually, an integrated system will be preferable, where some key variables are analyzed at the national level while other environmental-economic statistics, which are more context-specific, will be examined at the local (e.g., provincial) scale.

Data quality standards should be uniformly high for both sets of data, and there should be room for an increasingly important contribution from the PSA in terms of ensuring data quality. Further analyses are needed to identify which statistics should be collected at the relevant scales.

Lastly, the institutionalization of NCA is critical. It is important that NCA units are established in government agencies to create and update a comprehensive set of ecosystem accounts at the national and sub-national levels. These accounts must be replicated in other parts of the country. There is also a need to continuously develop government expertise for NCA and creating ecosystem accounts.

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Annex 1 Major policies affecting land and resource uses in Palawan

National Policy	Policy feature needing ecosystem-related accounts	Issue relevant to ecosystem accounts
1. Republic Act 7611 or the Strategic Environmental Plan for Palawan Strategic (enacted in 1992)	Identify Environmentally Critical Area Network (ECAN) and regulation of land use in ECAN zones.	ECAN zones with inconsistent land uses.
2. Republic Act (R.A. 7160) or An Act Providing for a Local Government Code of 1991	Under this act, local government units have the mandate to undertake Comprehensive Land Use Planning as basis for local zoning.	CLUP zone boundaries overlap and inconsistent land uses with other land classification i.e. NIPAS areas, ancestral domains, and public forest lands.
3. Presidential Decree 705, PD 1559, and DENR Administrative Order 2008-24 or The Guidelines for Forest Land Boundary Delineation and Assessment	Defines and classifies lands as forestlands and alienable and disposable lands; forestlands cannot be alienated or titled	The four-decade old PD 705 remains as the only law that defines forest boundaries, and resource uses but other land use laws such as NIPAS, IPRA, further declared public forest lands.

Annex 2A Land cover change matrices of Southern Palawan, 2003-2010

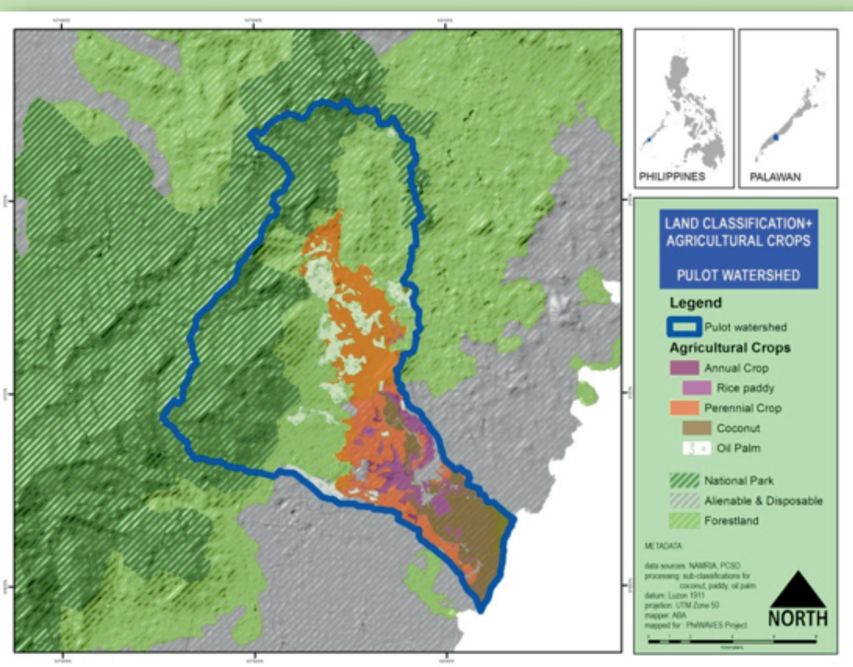
Opening Closing		Land Cover 2010 (ha)											
Land Cover 2003 (ha)	Annual Crop	Built-up	Closed Forest	Fish pond	Greenland	Inland water	Mangrove Forest	Open Forest	Open/Barren	Perennial Crop	Shrubs	Wooded Grasslands	Grand Total
Annual Crop	22,441	2,406		262	169	504	186	617	33	18,947	6,895	410	52,869
Built-up	56	517				2	8			127			709
Closed Forest	149	0	25,162		175	443	41	91,978	135	812	11,048	178	130,721
Fishpond				489		8	160			63			720
Grassland	4,549	589		105	30	419	602	8.057		23,032	38,717		76,100
Inland Water	6	100								47	41		193
Mangrove Forest	108	98		313	3	279	13,386	13		1,838	247	13	16,297
Marshland/ Swamp	12,638	970		5	50	87	288	5,212		13,773	9,321	519	42,862
Open Forest	126		2,827		6	301	9	62,030		1,361	19,796	136	86,593
Open/ Barren	21	125		36	25		11	130	710	208	117		1,383
Perennial Crop	3,786	1,644		135	118	324	1,367	719	80	27,228	9,742	987	46,130
Shrubs	796	14	22		22	131	205	3,614	3	3,919	21,556	270	30,552
Wooded Grassland	3,274	503	15	95	282	200	756	11,866		22,381	28,716	891	68,979
Grand Total	47,950	6,966	28,025	1,440	881	2,696	17,020	184,235	961	113,735	146,192	3,403	553,508

Annex 2B Land cover change matrices of Southern Palawan, 2010-2014

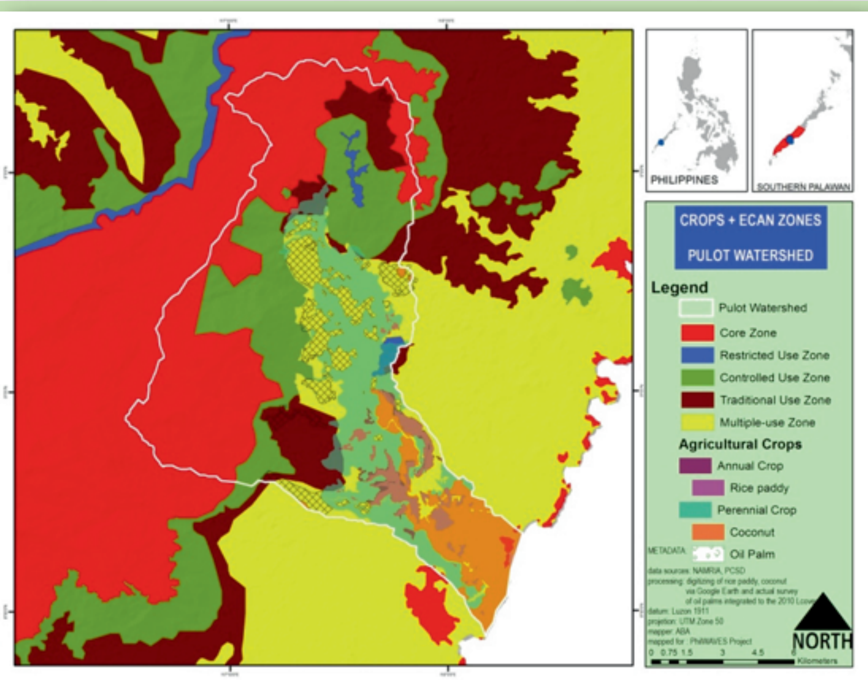
	LAND COVER CHANGE MATRIX OF SOUTHERN PALAWAN (Mainland)														
2010 Land Cover Classification	Closed Forest	Open Forest	Mangrove Forest	Fallow	Shrubs	Wooded Grasslands	Grasslands	Annual Crop	Perennial Crop	Open/ Barren Land	Built-up	Marshland/ Swamp	Fishpond	Inland Water	2010 Total Area (has)
Closed Forest	24,818	3,001			102		1		4	17				82	52,869
Open Forest	8,040	161,645			12,006	154	168	131	939	586	6			561	709
Mangrove Forest			15,177		195	3	1	43	1,183	2	20		214	182	130,721
Shrubs	280	15,664	216		114,779	476	262	3,703	9,865	156	239		4	552	720
Wooded Grassland	2	166	10		580	1,390	515	315	364	27	12			22	76,100
Grassland		13	2		175	39	536	24	67	7	17			2	193
Annual Crop		48	21		2,325	290	11	38,590	5,794	21	732		5	113	16,297
Perennial Crop	3	687	1,315		6,318	37	254	6,579	95,797	86	1,660		205	796	42,862
Open/ Barren		12			57	89	4	1		795	3			1	86,593
Built-up		3	10		148	7	22	758	1,213	59	4,710		1	36	1,383
Marshland /Swamp															46,130
Fishpond			186		9			120	139				975	11	30,552
Inland Water	63	247	117		308	23	47	78	479	8	27		3	1,296	68,979
Grand Total	33,206	181,486	17,054		137,003	2,507	1,821	50,340	115,845	1,761	7,425		1,407	3,653	553,508

Source: NAMRIA 2014

Annex 3 Land cover change by ECAN (Environmentally Critical Area Network) and by type of tenure



LCEU extent by ECAN Zones



LCEU extent by Tenurial Instrument

Annex 4 Pulot watershed land cover statistics based on 2014 NAMRIA map

PRELIMINARY LAND COVER STATISTICS ON PULOT WATERSHED	
CLASSIFICATION	AREA (Has.)
Annual Crop	473.49
Coconut	26.70
Oil Palm	0.08
Rice Paddy	363.09
Remaining Areas	83.62
Built-up	208.77
Coconut	39.44
Rice Paddy	14.89
Remaining Areas	154.44
Closed Forest	92.05
Remaining Areas	92.05
Inland Water	84.09
Coconut	52.45
Rice Paddy	0.56
Remaining Areas	31.08
Mangrove Forest	13.22
Remaining Areas	13.22
Open Forest	7,640.65
Oil Palm	4.71
Remaining Areas	7,635.94
Open/Barren	146.34
Remaining Areas	146.34
Perennial Crop	7,206.61
Coconut	1,319.07
Oil Palm	1,153.8
Rice Paddy	184.27
Remaining Areas	4,549.47
Shrubs	2,216.91
Coconut	16.74
Oil Palm	157.16
Rice Paddy	3.12
Remaining Areas	2,039.88
Wooded Grassland	13.5

Annex 5 Geomorphological indicators

A. Elevation (from Digital Elevation Model)

Elevation was mapped in the form of a digital elevation model (DEM). The 90-meter SRTM DEM (Shuttle Radar Topography Mission-Digital Elevation Model) was used to retrieve elevation in Pulot watershed (Jarvis et al., 2008). Although the elevation data is freely available, worldwide, the accuracy is not extremely high, and fine-scale processes cannot be modelled based on DEM. However, DEM is an input into the SedNet modelling of Pulot watershed. Figure 4.1 presents the DEM for the watershed.

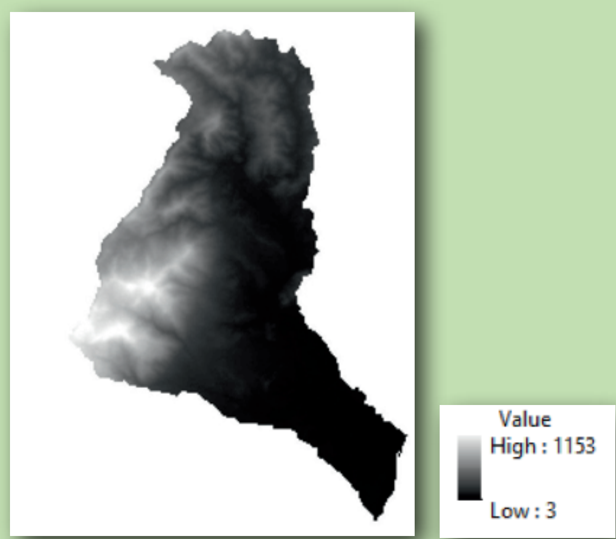


Figure 4.1 Pulot SRTM DEM (meters) (source: Jarvis et al., 2008)

B. Evapotranspiration

Land surface evapotranspiration represents transpiration by vegetation and evaporation from canopy and soil surfaces, expressed in mm/day. The map is derived from National Aeronautics and Space Administration Moderate-resolution Imaging Spectroradiometer (NASA MODIS) satellite imagery and can be downloaded, globally, for free. The resolution is 1 by 1 km, and evapotranspiration (ET) has been estimated for the year 2013. ET presents an input into hydrological models for the watershed.

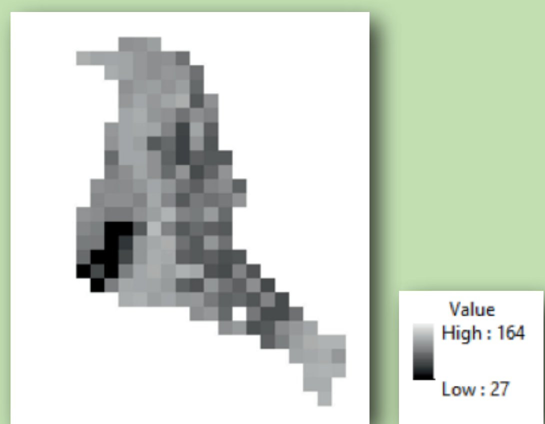


Figure 4.2 Average evapotranspiration (mm yr^{-1}) Source: MODIS Toolbox

Annex 5 Geomorphological indicators (cont'd)

C. Climate and Precipitation

The watershed is within two types of climate: Type 1 and 3. Daily rainfall readings from weather stations of PAGASA in Palawan were averaged annually and interpolated using ArcGIS. Rainfall data were primarily used as input to sedimentation modelling.

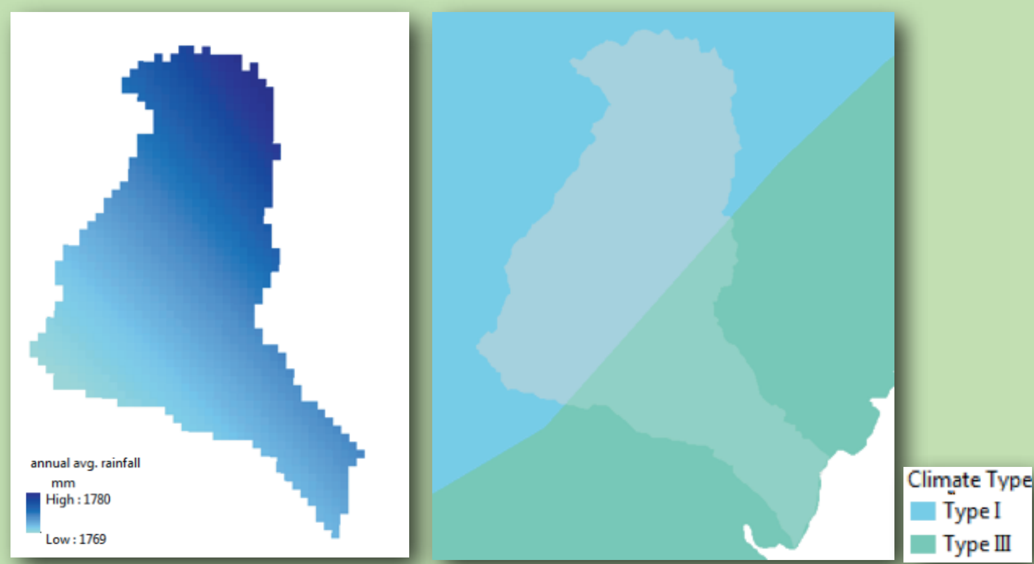
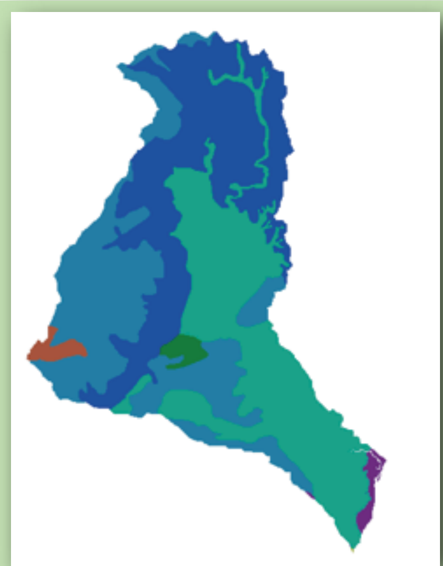
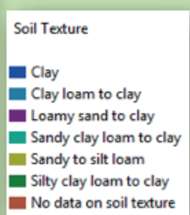


Figure 4.3 Average precipitation (mm yr^{-1})

D. Soil Texture

Soil texture defines the relative proportions of sand, silt, and clay. Texture contributes to the erodibility property of soils, which were used as input for modelling sedimentation. Data came from the Land Management Unit (LMU) of the Bureau of Soils and Water Management (BSWM) with classifications from official soil reports of actual soil tests. The Pulot Watershed is dominated by clayish soils.





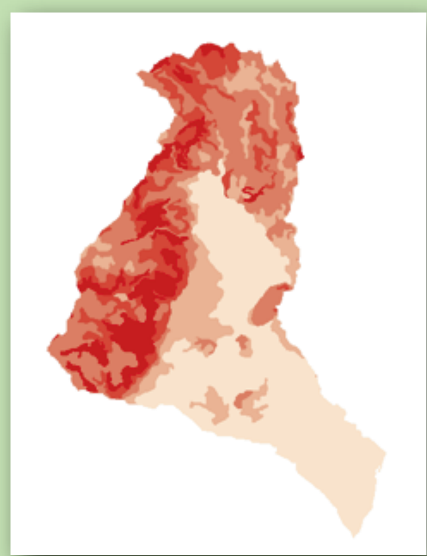
Soil Texture	Area (ha)	% area
Clay	5,751	31.8
Clay loam to clay	5,414	30.0
Loamy sand to clay	186	1.0
Metavolcanic mountain	221	1.2
Sandy clay loam to clay	6,264	34.7
Sandy to silt loam	1	0.0
Silty clay loam to clay	214	1.2
not classified	10	0.1

Figure 4.4 Soil texture classification, BSWM

Annex 5 Geomorphological indicators (cont'd)

E. Slope

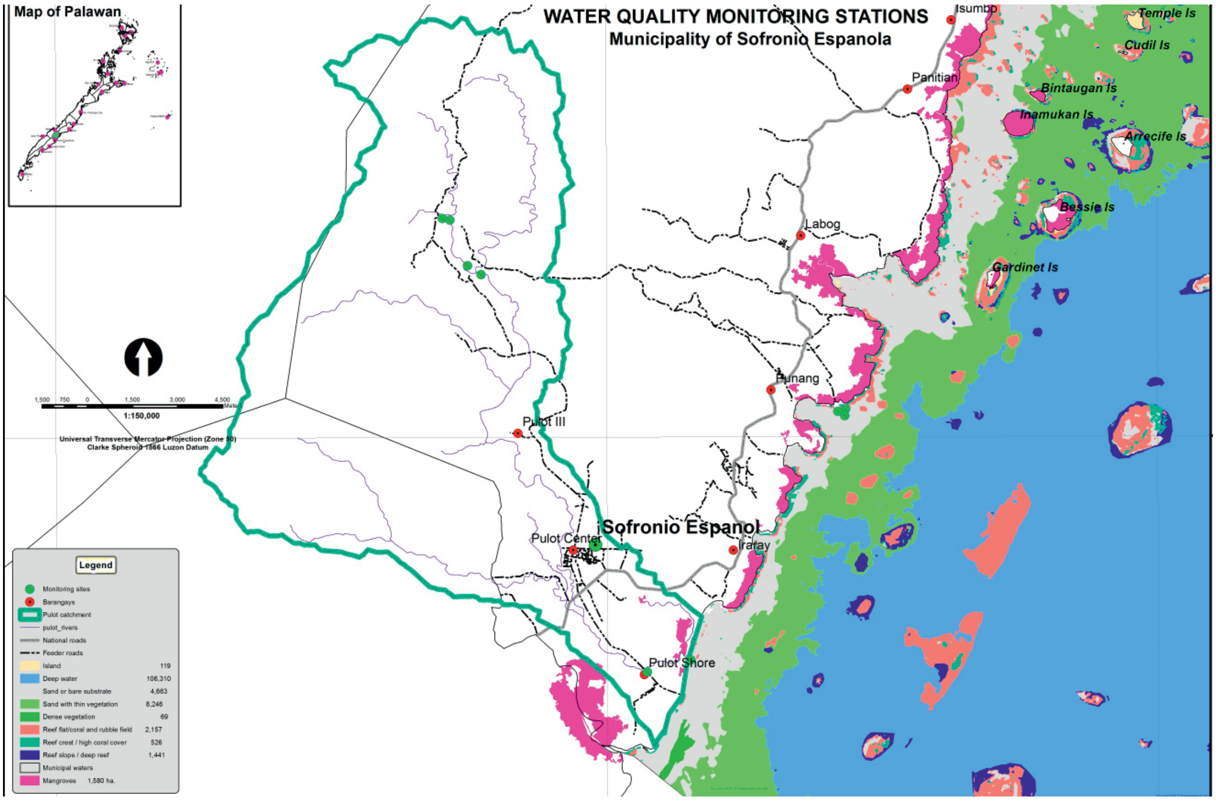
Spatial data came from NAMRIA-DENR with classification of slope in percent rise. Slope defines land classification (PD 705, s.1975) with no alienable and disposable land shall be classified above 18% slope, otherwise, shall be reverted. Moreover, 50% and above shall be considered as protection forests. Slope data were used in modelling soil loss/erosion of the watershed using Revised Universal Soil Loss Equation (RUSLE).



Slope (% rise)	Area, ha	% area
0-8% Slope, Level to Undulating	6,623	37
8-18% Slope, Undulating to Rolling	2,591	14
18-30% Slope, Rolling to Hilly	4,776	26
30-50% Slope, Hilly to Mountainous	2,432	13
Above 50% Slope, Mountainous	1,634	9
Grand Total	**18,058**	**100**

Figure 4.5 Slope classification, NAMRIA-DENR

Annex 6 Location of water quality sample points



Annex 7 Disaggregated asset accounts for crop production, 2010 and 2014

A. Unirrigated Rice Paddy NPV of resource rent per hectare

2010

		Discount Factor			NPV at		
	Resource Rent	5%	10%	15%	5%	10%	15%
NPV					134,431	91,836	67,520
1	10,787	0.95	0.91	0.87	10,273	9,806	9,380
2	10,787	0.91	0.83	0.76	9,784	8,915	8,157
3	10,787	0.86	0.75	0.66	9,318	8,104	7,093
4	10,787	0.82	0.68	0.57	8,875	7,368	6,168
5	10,787	0.78	0.62	0.50	8,452	6,698	5,363
6	10,787	0.75	0.56	0.43	8,049	6,089	4,664
7	10,787	0.71	0.51	0.38	7,666	5,535	4,055
8	10,787	0.68	0.47	0.33	7,301	5,032	3,526
9	10,787	0.64	0.42	0.28	6,953	4,575	3,066
10	10,787	0.61	0.39	0.25	6,622	4,159	2,666
11	10,787	0.58	0.35	0.21	6,307	3,781	2,319
12	10,787	0.56	0.32	0.19	6,007	3,437	2,016
13	10,787	0.53	0.29	0.16	5,721	3,125	1,753
14	10,787	0.51	0.26	0.14	5,448	2,841	1,525
15	10,787	0.48	0.24	0.12	5,189	2,582	1,326
16	10,787	0.46	0.22	0.11	4,942	2,348	1,153
17	10,787	0.44	0.20	0.09	4,706	2,134	1,002
18	10,787	0.42	0.18	0.08	4,482	1,940	872
19	10,787	0.40	0.16	0.07	4,269	1,764	758
20	10,787	0.38	0.15	0.06	4,066	1,601	659

2014

		Discount Factor			NPV at		
	Resource Rent	5%	10%	15%	5%	10%	15%
NPV					282,844	193,225	142,063
1	22,696	0.95	0.91	0.87	21,615	20,633	19,736
2	22,696	0.91	0.83	0.76	20,586	18,757	17,162
3	22,696	0.86	0.75	0.66	19,606	17,052	14,923
4	22,696	0.82	0.68	0.57	18,672	15,502	12,977
5	22,696	0.78	0.62	0.50	17,783	14,093	11,284
6	22,696	0.75	0.56	0.43	16,936	12,811	9,812
7	22,696	0.71	0.51	0.38	16,130	11,647	8,532
8	22,696	0.68	0.47	0.33	15,362	10,588	7,419
9	22,696	0.64	0.42	0.28	14,630	9,625	6,452
10	22,696	0.61	0.39	0.25	13,933	8,750	5,610
11	22,696	0.58	0.35	0.21	13,270	7,955	4,878
12	22,696	0.56	0.32	0.19	12,638	7,232	4,242
13	22,696	0.53	0.29	0.16	12,036	6,574	3,689
14	22,696	0.51	0.26	0.14	11,463	5,977	3,208
15	22,696	0.48	0.24	0.12	10,917	5,433	2,789
16	22,696	0.46	0.22	0.11	10,397	4,939	2,425
17	22,696	0.44	0.20	0.09	9,902	4,490	2,109
18	22,696	0.42	0.18	0.08	9,431	4,082	1,834
19	22,696	0.40	0.16	0.07	8,982	3,711	1,595
20	22,696	0.38	0.15	0.06	8,554	2,374	1,387

Annex 7 Disaggregated asset accounts for crop production, 2010 and 2014 (cont'd)

B. Irrigated Rice Paddy (paddy-paddy) NPV of resource rent per hectare

2010

		Discount Factor			NPV at		
	Resource Rent	5%	10%	15%	5%	10%	15%
NPV					665,740	454,800	334,378
1	53,421	0.95	0.91	0.87	50,877	48,564	46,453
2	53,421	0.91	0.83	0.76	48,454	44,149	40,394
3	53,421	0.86	0.75	0.66	46,147	40,136	35,125
4	53,421	0.82	0.68	0.57	43,949	36,487	30,543
5	53,421	0.78	0.62	0.50	41,856	33,170	26,560
6	53,421	0.75	0.56	0.43	39,863	30,155	23,095
7	53,421	0.71	0.51	0.38	37,965	27,413	20,083
8	53,421	0.68	0.47	0.33	36,157	24,921	17,463
9	53,421	0.64	0.42	0.28	34,435	22,656	15,185
10	53,421	0.61	0.39	0.25	32,796	20,596	13,205
11	53,421	0.58	0.35	0.21	31,234	18,724	11,482
12	53,421	0.56	0.32	0.19	29,747	17,021	9,985
13	53,421	0.53	0.29	0.16	28,330	15,474	7,550
14	53,421	0.51	0.26	0.14	26,981	14,067	7,550
15	53,421	0.48	0.24	0.12	25,696	12,788	6,565
16	53,421	0.46	0.22	0.11	24,473	11,626	5,709
17	53,421	0.44	0.20	0.09	23,307	10,569	4,964
18	53,421	0.42	0.18	0.08	22,197	9,608	4,317
19	53,421	0.40	0.16	0.07	21,140	8,735	3,754
20	53,421	0.38	0.15	0.06	20,134	7,941	3,264

2014

		Discount Factor			NPV at		
	Resource Rent	5%	10%	15%	5%	10%	15%
NPV					815,613	557,187	409,654
1	65,447	0.95	0.91	0.87	2,330	59,497	56,910
2	65,447	0.91	0.83	0.76	59,362	54,088	49,487
3	65,447	0.86	0.75	0.66	56,536	49,171	43,032
4	65,447	0.82	0.68	0.57	52,843	44,701	37,419
5	65,447	0.78	0.62	0.50	51,279	40,637	32,539
6	65,447	0.75	0.56	0.43	48,838	36,943	28,295
7	65,447	0.71	0.51	0.38	46,512	33,585	24,604
8	65,447	0.68	0.47	0.33	44,297	30,531	21,395
9	65,447	0.64	0.42	0.28	42,188	27,765	18,604
10	65,447	0.61	0.39	0.25	40,179	25,233	16,177
11	65,447	0.58	0.35	0.21	38,265	22,939	14,067
12	65,447	0.56	0.32	0.19	36,443	20,853	12,232
13	65,447	0.53	0.29	0.16	34,708	18,958	10,637
14	65,447	0.51	0.26	0.14	33,055	16,234	9,250
15	65,447	0.48	0.24	0.12	31,481	15,667	8,043
16	65,447	0.46	0.22	0.11	29,982	14,243	69,964
17	65,447	0.44	0.20	0.09	28,554	12,948	6,082
18	65,447	0.42	0.18	0.08	27,195	11,771	5,288
19	65,447	0.40	0.16	0.07	25,900	10,701	4,599
20	65,447	0.38	0.15	0.06	24,666	9,728	3,999

Annex 7 Disaggregated asset accounts for crop production, 2010 and 2014 (cont'd)

C. Irrigated Rice Paddy (paddy-corn-paddy) NPV of resource rent per

2010

		Discount Factor			NPV at		
	Resource Rent	5%	10%	15%	5%	10%	15%
NPV					1,084,445	740,839	544,679
1	87,019	0.95	0.91	0.87	82,875	79,108	75,668
2	87,019	0.91	0.83	0.76	78,929	71,916	65,799
3	87,019	0.86	0.75	0.66	75,170	65,378	57,216
4	87,019	0.82	0.68	0.57	71,590	59,435	49,753
5	87,019	0.78	0.62	0.50	68,181	54,032	43,264
6	87,019	0.75	0.56	0.43	64,935	49,120	37,621
7	87,019	0.71	0.51	0.38	61,843	44,654	32,714
8	87,019	0.68	0.47	0.33	58,898	40,595	28,447
9	87,019	0.64	0.42	0.28	56,093	36,904	24,736
10	87,019	0.61	0.39	0.25	53,422	33,549	21,510
11	87,019	0.58	0.35	0.21	50,878	30,500	18,704
12	87,019	0.56	0.32	0.19	48,455	27,727	16,264
13	87,019	0.53	0.29	0.16	46,148	25,206	14,143
14	87,019	0.51	0.26	0.14	43,950	22,915	12,298
15	87,019	0.48	0.24	0.12	41,857	20,832	10,694
16	87,019	0.46	0.22	0.11	39,864	18,938	9,299
17	87,019	0.44	0.20	0.09	37,966	17,216	8,085
18	87,019	0.42	0.18	0.08	36,158	15,651	7,032
19	87,019	0.40	0.16	0.07	34,436	14,228	6,114
20	87,019	0.38	0.15	0.06	32,796	12,935	5,317

2014

		Discount Factor			NPV at		
	Resource Rent	5%	10%	15%	5%	10%	15%
NPV					1,252,297	855,507	628,985
1	100,488	0.95	0.91	0.87	95,702	91,352	87,380
2	100,488	0.91	0.83	0.76	91,145	83,048	75,983
3	100,488	0.86	0.75	0.66	86,805	75,498	66,072
4	100,488	0.82	0.68	0.57	82,671	68,634	57,454
5	100,488	0.78	0.62	0.50	78,735	62,395	49,960
6	100,488	0.75	0.56	0.43	74,985	56,723	43,444
7	100,488	0.71	0.51	0.38	71,415	51,566	37,777
8	100,488	0.68	0.47	0.33	68,014	46,878	32,850
9	100,488	0.64	0.42	0.28	64,775	42,617	28,565
10	100,488	0.61	0.39	0.25	61,691	38,742	24,839
11	100,488	0.58	0.35	0.21	58,753	35,220	21,599
12	100,488	0.56	0.32	0.19	55,955	32,018	18,782
13	100,488	0.53	0.29	0.16	53,291	29,108	16,332
14	100,488	0.51	0.26	0.14	50,753	26,462	14,202
15	100,488	0.48	0.24	0.12	48,336	24,056	12,349
16	100,488	0.46	0.22	0.11	46,034	21,869	10,739
17	100,488	0.44	0.20	0.09	43,842	19,881	9,338
18	100,488	0.42	0.18	0.08	41,755	18,074	8,120
19	100,488	0.40	0.16	0.07	39,766	16,431	7,061
20	100,488	0.38	0.15	0.06	37,873	14,937	6,140

Annex 7 Disaggregated asset accounts for crop production, 2010 and 2014 (cont'd)

D. Coconut NPV of resource rent per hectare

2010

		Discount Factor			NPV at		
	Resource Rent	5%	10%	15%	5%	10%	15%
NPV					120,760	82,497	60,653
1	9,690	0.95	0.91	0.87	9,229	8,809	8,426
2	9,690	0.91	0.83	0.76	8,789	8,008	7,327
3	9,690	0.86	0.75	0.66	8,371	7,280	6,371
4	9,690	0.82	0.68	0.57	7,972	6,618	5,540
5	9,690	0.78	0.62	0.50	7,592	6,017	4,818
6	9,690	0.75	0.56	0.43	7,231	5,470	4,189
7	9,690	0.71	0.51	0.38	6,887	4,973	3,643
8	9,690	0.68	0.47	0.33	6,559	4,520	3,168
9	9,690	0.64	0.42	0.28	6,246	4,110	2,755
10	9,690	0.61	0.39	0.25	5,949	3,736	2,395
11	9,690	0.58	0.35	0.21	5,666	3,396	2,083
12	9,690	0.56	0.32	0.19	5,396	3,088	1,811
13	9,690	0.53	0.29	0.16	5,139	2,807	1,575
14	9,690	0.51	0.26	0.14	4,894	2,552	1,369
15	9,690	0.48	0.24	0.12	4,661	2,320	1,191
16	9,690	0.46	0.22	0.11	4,439	2,109	1,036
17	9,690	0.44	0.20	0.09	4,228	1,917	900
18	9,690	0.42	0.18	0.08	4,026	1,743	783
19	9,690	0.40	0.16	0.07	3,835	1,584	681
20	9,690	0.38	0.15	0.06	3,652	1,440	592

2014

		Discount Factor			NPV at		
	Resource Rent	5%	10%	15%	5%	10%	15%
NPV					168,827	115,334	84,796
1	13,547	0.95	0.91	0.87	12,902	12,316	11,780
2	13,547	0.91	0.83	0.76	12,288	11,196	10,244
3	13,547	0.86	0.75	0.66	11,703	10,178	8,907
4	13,547	0.82	0.68	0.57	11,145	9,253	7,746
5	13,547	0.78	0.62	0.50	10,615	8,412	6,735
6	13,547	0.75	0.56	0.43	10,109	7,647	5,857
7	13,547	0.71	0.51	0.38	9,628	6,952	5,093
8	13,547	0.68	0.47	0.33	9,169	6,320	4,429
9	13,547	0.64	0.42	0.28	8,733	5,745	3,851
10	13,547	0.61	0.39	0.25	8,317	5,223	3,349
11	13,547	0.58	0.35	0.21	7,921	4,748	2,912
12	13,547	0.56	0.32	0.19	7,544	4,317	2,532
13	13,547	0.53	0.29	0.16	7,184	3,924	2,202
14	13,547	0.51	0.26	0.14	6,842	3,567	19,195
15	13,547	0.48	0.24	0.12	6,516	3,243	1,665
16	13,547	0.46	0.22	0.11	6,206	2,948	1,448
17	13,547	0.44	0.20	0.09	5,911	2,680	1,259
18	13,547	0.42	0.18	0.08	5,629	2,437	1,095
19	13,547	0.40	0.16	0.07	5,361	2,215	952
20	13,547	0.38	0.15	0.06	5,106	2,014	828

Annex 8 Water regulating service – physical units

Period	without forest			with forest	
	First cropping season	Second cropping season		First cropping season	Second cropping season
1st month	22,892	5,578		14,950	-12,833
2nd month	4,560	20,773		1,567	11,479
3rd month	1,293	61,466		-1,976	48,413
4th month	184	65,602		-5,827	54,781
TOTAL (both seasons)		**181,990**			**110,553**

Difference, due to forest cover: 71 thousand m^3.

Annex 9 Fisheries survey questionnaire

Department of Environment and Natural Resources (DENR) and
Palawan Council for Sustainable Development (PCSD)

PHILIPPINE WEALTH ACCOUNTING AND VALUATION OFECOSYSTEM SERVICES (Phil-WAVES)

SURVEY QUESTIONNAIRE
(Draft for Review)

Questionnaire No.: __________

(Tala-tanungan blg.)

Name of Interviewer: ___________________________________
(Pangalan ng nagsagawa ng panayam)

Date of Interview: ______________________________________
(Araw ng panayam)

Time of Interview: Start (Simula): ______________________End (Tapos): ________________________
(Oras ng panayam)

Municipality: ____________________________________Barangay: _____________________________
(Munisipyo)

To be filled in by DENR-PCSD:

Checked by: Name of Field Supervisor: ____
(Sinurini: Pangalan ng Punong Tagapangasiwa)

Signature: ___________________________Date:________________________
(Lagda) *(Petsa)*

Encoded by: Name of Encoder: __________________________ Signature: ______________________
(Itinala ni: Pangalan ng tagapagtala) *(Lagda)*

Please introduce yourself and the project:

Good morning, (Sir or Madam). I'm (your name). I am from (state the name of the agency) and part of the team conducting a fishery production survey for the municipality of Sofronio Española. The survey is part of the implementation in Southern Palawan of the Philippine Wealth Accounting and Valuation of Ecosystem Services (Phil WAVES) project being undertaken by DENR and PCSD in partnership with the World Bank. The survey seeks to determine the current state of municipal fisheries in Sofronio Espanola and determine its contribution to local economy.

(Magandang umaga po, (Ginoo o Ginang).Ako ay si (banggitin ang pangalan). Ako po ay taga (ahensya ng gobyerno) at kasama sa grupo na nagsasagawa ng pagtataya ng estadong pangisdaan sa Munisipyo ng Sofronio Española at ang kontribusyon sa local na ekonomiya. Ang gawaing ito ay kaparte ng proyektong Philippine Wealth Accounting and Valuation of Ecosystem Services o Phil WAVES na may layuning alamin ang halagang serbisyo na ibinibigay ng kalikasan sa PIlipinas. Ang proyektong ito ay pinangungunahan ng Department of Environment and Natural Resources [DENR] at Philippine Council for Social Development [PCSD] sa Palawan, sa pakikipagtulungan ng World Bank.)

Your participation in the survey is very important and will provide valuable information on how the government and your community can better manage resources in *Sofronio Española*.

(Ang inyong partisipasyon sa ating "survey" ay magbibigay ng mahahalagang impormasyon para sa mas maayos pang pamamahalan atin at ng ating gobyerno sa likas-yaman ng pangisdaan ng ating munisipyo.)

May I therefore request information based on this survey questionnaire. All your answers will be treated with strict confidentiality and will not be shared with anyone except DENR-PCSD, which will process all information from the survey. We will provide appropriate government agencies all the information gathered already in consolidated form, without reference to you or any particular respondent to the survey.

(This survey form is under review by the Philippine Statistics Authority, among others)

Annex 9 Fisheries survey questionnaire (cont'd)

DENR-PCSD Phil-WAVES Questionnaire No.: __________

(Hinihiling po naming ang inyong pagpayagupang kayo ay maka-panayam at makunan ng mga impormasyon base sa aming "survey questionnaire." Ang inyong mga kasagutan ay hindi ipapaalam kaninuman. Ang DENR-PCSD po lamang ang siyang mag proproseso ng lahat na nakalap na impormasyon mula sa "survey" upang makagawa ng isahang impormasyon para sa inyong munisipyo na siyang amingi babaliksainyo at ibibigay sa mga interesado)

The survey will take about one hour and thirty minutes (1 hour and 30 minutes).
(Ang aming pakikipanayampakikipagkuwentuhan sa inyo ay tatagal ng isang oras at tatlongpung minuto)

Thank you very much.
(Marami pong salamat!)

Annex 9 Fisheries survey questionnaire (cont'd)

Municipal Fishery Survey

1. Name of Respondent *(Pangalan ng kinakapanayam)*: ____

2. Address *(Tirahan)*:
   a. Sitio/Purok*(Sitio/Purok)*: ____________________ b. Barangay *(Barangay)*: __________________
   c. Municipality/City *(Munisipyo/Lungsod)*: ________ d. Province *(Probinsya)*: __________________
   e. Cellphone# *(Numero ng telepono)* .:____________________

3. Age (*Edad*): ___________

4. Gender*(Kasarian)*: 1 - Male*(Lalaki)* 2 - Female*(Babae)*

5. Civil Status*(Katayuang Sibil)*:
   1 – Single *(Walang asawa)* 2 - Married*(May asawa)* 3 - Widower/Widow*(Byudo/Byuda)*
   4 - Separated/Annulled/Divorced (Hiwalay sa Asawa) 5 - Common law/Live-in (May kinakasama)

6. Highest Educational Attainment *(Pinakamataas na antas ng edukasyon na nakamit)* :

1 - Elementary *(Elementarya)*	2 - High School *(Sekondarya)*	3 – College *(Kolehiyo)*	4 - Vocational Course *(Kursong Bokasyonal)*	5 - None *(Wala)*
Grade______ *(Antas)*	Year: _________ *(Antas)*	Level *(Antas)*: __________ Course *(Kurso)*____________ _____	Level *(Antas)*: ____________ Course *(Kurso)*: __________________	

7. Family size *(Bilang ng miyembro ng pamilya)* ___________________

8. Sources of Income (please refer to the accompanying PSA detailed classification) (*Pangunahin at iba pang pinagkakakitaan. Gamitin ang klasipikasyon ng PSA.*)

	Specific Source of income	Classification	
		Primary (*Pangunahing pinagkakakitaan*)	Secondary (*Karagdagang pinagkakakitaan*)
Crop farming and gardening			
Livestock and poultry raising			
Fishing			
Forestry and hunting			
Wholesale and retail			
Manufacturing			
Community, social, recreational and personal services			
Transportation, storage and communication services			
Mining and quarrying			
Construction			
Activities not elsewhere classified			

IMPORTANT!! For Questions 9-10, the enumerator must show the accompanying map to the respondent and indicate the location of fishing grounds with reference to natural landmarks and name of islands.

9. How long have you been fishing in the Municipal waters of Sofronio Española? *(Ilang taon na po ba kayong nangingisda sa Sofronio Española)* ______________________________

10. Location of fishing ground (Saan po kayo nangingisda?)
    1. Within the Municipal Waters of S Espanola (*Sa loob ng dagat ng S. Espanola)*
    2. Outside the Municipal Waters of S Espanola (*Sa labas ng dagat ng S. Espanola)*

11. Compared to the previous years, is there a change in the location of fishing ground? (*Nagbago ba ng lugar ang inyong pinangingisdaan ngayon at noong nakaraang 15 taon?*)
    1. Yes, fish farther (*Oo, palayo na)*
    2. Yes, fish nearer (*Oo, mas malapit na)*

Annex 9 Fisheries survey questionnaire (cont'd)

3. No change (*Walang pagbabago*)

12. Since you started fishing in the municipal waters of S. Espanola, did you observe any changes in the quantity of fish caught? Please encircle the appropriate box but don't read the options to the respondent *(Sa tagal ng panahon na kayo po ay nangingisda sa karagatan ng S. Espanola mayroon po ba kayong napansin na pagbabago sa dami ng mga nahuhulingisda mula ng kayo ay mangisda hanggang ngayon?*
    1. Yes, volume of fish caught is decreasing *(Oo bumababa ang dami ng huling isda*
    2. No change*(Walang pagbabago)*
    3. Yes, volume of fish caught is increasing *(Oo, tumataas ang dami ng huling isda)*
13. Since you started fishing in the Municipal waters of S. Espanola, did you observe any changes in the size of fish caught (Mula ng kayo ay mag-umpisang mangisda sa karagatan ng S. ESpanola*, napansin po ba ninyo kong may pagbabago sa laki ng mga nahuhuling isda mula ng kayo ay umpisang mangisda?)*
    1. Yes, fish size is decreasing *(Oo, lumiliit ang laki ng mga nahuhuling isda)*
    2. No change *(Walang pagbabago)*
    3. Yes, fish size is increasing *(Oo, lumalaki ang mga nahuhuling isda)*

14. If the **answer is Yes (=1) to either Questions 11, 12, or 13** what do you think are the possible causes? Please specify below *(Kong ang sagot ay Oo sa alin man sa tanong bilang 11, 12, 13, o 14 ano-ano po ang sa tingin ninyo ang mga dahilan ng pagbaba ng huli at pag-liit ng mg aisda?)*:

____

____

____

15. Please specify average hours and catch (kg) per trip in recent years, and in the past since you started fishing in the municipal waters of S. ESpanola. *(Tukuyin kung ilang oras ang karaniwang tagal ng pangingisda at ilang kilo ng isda ang karaniwang huli gamit ang inyong pangisdaan sa nakaraang mga panahon at mula ng mag-umpisang mangisda sa karagatan ng S. Espanola)*

. Fishing Gear *(Gamit sa pangingisda)*	Sa panahon ngayon-Karaniwang huli		Simula ng mangisda sa S ESpanola-Karaniwanghuli	
	hours spent/ fishing trip *(Karaniwangoras ng pangingisdanoong nakaraang 5 taon)*	Catch/trip, Kg *(Karaniwangdami ng huli noong nakalipas na5 taon)*	hours spent/ fishing trip *(Karaniwangoras ng pangingisdanoong nakaraang 15 taon*	Catch/trip, Kg *(Karaniwang dami ng huli noong nakaraang 15 taon)*

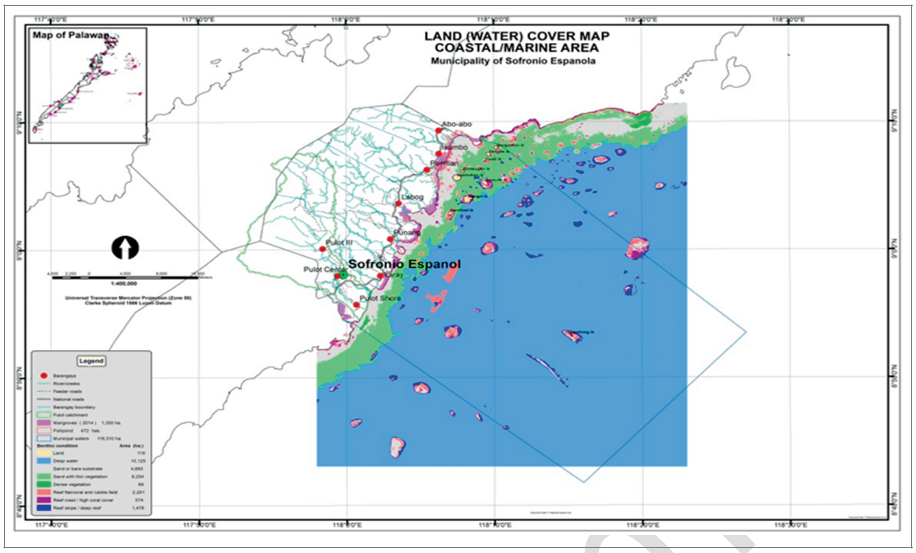
16. Fishing gear used. Rank & / Frequency of use and Fishing Locations. *(Gamit pangisda, dalas ng paggamit, lugar na pinangingisdaan, dalas ng paggamit ayon sa lugar na pinangisdaan)*

Fishing Gear Used (Please select)	Frequency of use in Fishing Ground, ie. daily, (Dalas ng pag-arya sa Klase ng pangisdaan, ie araw-araw, 2x/wk, etc, kunin lamang ang sagot)						
	Mangrove	Seagrass	Coral Reef	Estuary	Fore-shore/ Nearshore	Open water w/in municipal waters (*Laot sa loob ng Munisipyo)*	Open water outside municipal waters (*Laot sa labas ng Munisipyo)*
___1-Gill net (Lambat-lubog, Malaki)							
___2-Gill net (Lambat-lubog, Maliit							
___3-Hook and Line (Kawil)							
___4-Longline (Palanggre)							

Annex 9 Fisheries survey questionnaire (cont'd)

___ 5- Push net for Bangus fry (sodsod)							
___6- Prawn juvenile (sigpaw)Crab pot (bobo)							

Annex 9 Fisheries survey questionnaire (cont'd)



Annex 9 Fisheries survey questionnaire (cont'd)

17. Months,Time spent in fishing and production by fishing gear *(Panahon, tagal at huli ng pangingisda)*

Fishing gears	1-Gill net (Lambat-lubog, Malaki) 2-Gill net (Lambat-lubog, Maliit) 3-Hook and Line (Kawil) 4-Longline (Palangre) 5- Bangus fry (sodsod) 6- Prawn juvenile (sigpaw)	
1. __________ (Gear). Months operated, Encircle (Specify months) (Panahon ng paggamit, Bilugan)	J F M A M J J A S O N D	
	Low (Pinaka-mababa)	High (PInaka-mataas)
FISHING EFFORT (DALAS/TAGAL NG PANGINGISDA)		
Approx Hours to fishing ground (travel time), range		
Aprox Hours of actual fishing/ trip, range		
Approx Number of fishing trips/ day, range		
Approx Fishing days/week, range		
No. of non-fishing days in a year due to bad weather, range		
PRODUCTION (HULIHAN)		
Approximate Total Catch per trip , kg/trip		
Major Species, percentage, and Price per kilo (*Klase ng isda na pinakamaraming nahuhuli, porsiyento at presyo), Php/kilo*		
_____________ %______		
_____________ %______		
_____________ %______		
_____________ %______		
_____________ %______		
_____________ %______		
Other species and Price per kilo (Iba pang *Klase ng isda at presyo), Php/kilo*		
______________________		
______________________		
______________________		
______________________		
______________________		

Fishing gears	1-Gill net (Lambat-lubog, Malaki) 2-Gill net (Lambat-lubog, Maliit) 3-Hook and Line (Kawil) 4-Longline (Palangre) 5- Bangus fry (sodsod) 6- Prawn juvenile (sigpaw)

Annex 9 Fisheries survey questionnaire (cont'd)

2. __________ (Gear). Months operated, Encircle (Specify months) (Panahon ng paggamit, Bilugan)	J F M A M J J A S O N D	
	Low (Pinaka-mababa)	High (PInaka-mataas)
FISHING EFFORT (DALAS/TAGAL NG PANGINGISDA)		
Approx Hours to fishing ground (travel time), range		
Aprox Hours of actual fishing/ trip, range		
Approx Number of fishing trips/ day, range		
Approx Fishing days/week, range		
No. of non-fishing days in a year due to bad weather, range		
PRODUCTION (HULIHAN)		
Approximate Total Catch per trip , kg/trip		
Major Species, percentage, and Price per kilo (*Klase ng isda na pinakamaraming nahuhuli, porsiyento at presyo), Php/kilo*		
_____________ %______		
_____________ %______		
_____________ %______		
_____________ %______		
_____________ %______		
_____________ %______		
Other species and Price per kilo (Iba pang *Klase ng isda at presyo), Php/kilo*		
______________________		
______________________		
______________________		
______________________		
______________________		

Fishing gears	1-Gill net (Lambat-lubog, Malaki) 2-Gill net (Lambat-lubog, Maliit) 3-Hook and Line (Kawil) 4-Longline (Palangre) 5- Bangus fry (sodsod) 6- Prawn juvenile (sigpaw)	
3. __________ (Gear). Months operated, Encircle (Specify months) (Panahon ng paggamit, Bilugan)	J F M A M J J A S O N D	
	Low (Pinaka-mababa)	High (PInaka-mataas)
FISHING EFFORT (DALAS/TAGAL NG PANGINGISDA)		

Annex 9 Fisheries survey questionnaire (cont'd)

Approx Hours to fishing ground (travel time), range		
Aprox Hours of actual fishing/ trip, range		
Approx Number of fishing trips/ day, range		
Approx Fishing days/week, range		
No. of non-fishing days in a year due to bad weather, range		
PRODUCTION (HULIHAN)		
Approximate Total Catch per trip , kg/trip		
Major Species, percentage, and Price per kilo (*Klase ng isda na pinakamaraming nahuhuli, porsiyento at presyo), Php/kilo*		
____________ %______		
____________ %______		
____________ %______		
____________ %______		
____________ %______		
____________ %______		
Other species and Price per kilo (Iba pang *Klase ng isda at presyo), Php/kilo*		
____________________		
____________________		
____________________		
____________________		
____________________		

Fishing gears	1-Gill net (Lambat-lubog, Malaki) 2-Gill net (Lambat-lubog, Maliit) 3-Hook and Line (Kawil) 4-Longline (Palangre) 5- Bangus fry (sodsod) 6- Prawn juvenile (sigpaw)											
4. __________ (Gear). Months operated, Encircle (Specify months) (Panahon ng paggamit, Bilugan)	J	F	M	A	M	J	J	A	S	O	N	D

	Low (Pinaka-mababa)	High (PInaka-mataas)
FISHING EFFORT (DALAS/TAGAL NG PANGINGISDA)		
Approx Hours to fishing ground (travel time), range		
Aprox Hours of actual fishing/trip, range		
Approx Number of fishing trips/day, range		

Annex 9 Fisheries survey questionnaire (cont'd)

Approx Fishing days/week, range		
No. of non-fishing days in a year due to bad weather, range		
PRODUCTION (HULIHAN)		
Approximate Total Catch per trip , kg/trip		
Major Species, percentage, and Price per kilo (*Klase ng isda na pinakamaraming nahuhuli, porsiyento at presyo*), Php/kilo		
_____________ %______		
______________ %______		
_____________ %______		
_____________ %______		
______________ %______		
_____________ %______		
Other species and Price per kilo (Iba pang *Klase ng isda at presyo*), Php/kilo		
________________________		
________________________		
________________________		
________________________		
________________________		

Annex 9 Fisheries survey questionnaire (cont'd)

Kind of Gear[1/]	Aproximate total catch per trip, High range, kg	Bait *(Pain)* *(Kg)*	Qty consumed at sea (Kg)	Qty shared with laborers (Kg)	Qty given away (Kg)	Qty consumed at home (Kg)	Qty sold as fresh/ processed (kg)

1/Gear Type
1. Gill net (Lambat-lubog, Malaki) 2-Gill net (Lambat-lubog, Maliit) 3-Hook and Line (Kawil) 4-Longline (Palangre)
5- Bangus fry (sodsod) 6- Prawn juvenile (sigpaw)

19. How and where are the fish catch sold *(Paano at saan itinitinda/ibinebenta ang mga nahuling isda?) REFER TO QUESTION 19, Quantity Sold*

Place of market	Please check, Multiple answer
1-Within the Bgy	
2-Outside barangay, within municipality	
3-Outside municipality	

20. Fishing equipment*(Mga gamit sa pangingisda)*

Items *(Uri ng gamit)*	Ownership *(Pag-aari)* 1/	Equipment or material *(Gamit o materyales)*	Quantity *(Bilang)*	Acquisition Cost, PhP *(Presyo ng pagkabili)*	Useful life of the equipment/material *(Bilang ng araw/buwan/taon na puwedeng magamit)*
1. Gear *(Panghuli)*1 ______________		Hook, #__________			
		Hook, #__________			
		Nylon, #__________			
		Nylon, #__________			
		Pabigat			
		Swivel			
2. Gear *(Panghuli)* 2 ______________					
3. Gear *(Panghuli)* 3 ______________					

Annex 9 Fisheries survey questionnaire (cont'd)

Items *(Uri ng gamit)*	Ownership *(Pag-aari)* 1/	Equipment or material *(Gamit o materyales)*	Quantity *(Bilang)*	Acquisition Cost, PhP *(Presyo ng pagkabili)*	Useful life of the equipment/material *(Bilang ng araw/buwan/taon na puwedeng magamit)*
4. Gear *(Panghuli)* ____________					
5. Boat *(Bangka)*-( ) *Motorized (de-motor)*					
6. Boat *(Bangka)*- (*Non- motorized (de-sagwan)*					
7. Engine (*makina)*		Horsepower ____________			
		____________			
8. Paddle *(sagwan)*					
9. Fishfinder					
10. GPS					
11. Tiken					
12. Banyera					
13. Balde					
14. Ice-chest					

1/**1** = owned (sarili)
2 = rented (inupahan)
3 = borrowed (hiniram)
4 = others, specify ______________________________

21. Fishing Inputs per trip*(Mga karagdagang pangangailangan sa pangingisda)*

Items *(Mga bagay na kailangan)*	Quantity and unit of measure (Please specify if per trip, per month, or others) *(Bilang ng mga bagay na kailangan sa bawat labas, lingo, buwan, etc)*				Cost Per Unit, PhP/Unit *(Presyo bawat bagay na kailangan)*
	Gear1	Gear2	Gear3	Gear4	
1. Labor 1a-. Unpaid (family labor,including the fisherman respondent), Man-day/trip					
1b. Paid labor/or in kind*(Upahang-tauhan), Regular, occasional)* Man-day/trip					

Annex 9 Fisheries survey questionnaire (cont'd)

Items *(Mga bagay na kailangan)*	Quantity and unit of measure (Please specify if per trip, per month, or others) *(Bilang ng mga bagay na kailangan sa bawat labas, lingo, buwan, etc)*				Cost Per Unit, PhP/Unit *(Presyo bawat bagay na kailangan)*
	Gear1	Gear2	Gear3	Gear4	
2. Fuel *(Gasolina/krudo)*, Liters/trip					
3. Oil *(Langis)*					
4. Flashlight Battery *(Baterya)*, Charging time/battery					
5. Crushed Ice *(Yelo)*, pcs or kg/trip					
6. Hooks					
7. Tingga					
8. Swivel					
9. Bait*(Pain)*, kg/trip					
10.Rentals *(Upa), eg gear, boat, etc.*					
11.Meal expense of the operator (if separate from labor pay), Php/trip					
12.Other fishing accessories ____________					

Annex 9 Fisheries survey questionnaire (cont'd)

ng "permits", atbp., na binabayaran sa pangingisda at kung magkano bawat buwan o taon)

Item *(Kailangangbayaran)*	Amount *(Presyo o halaga)*	Frequency of Payment, i.e daily, weekly, monthly, annually)*(Dalasngpagbayad, halimbawaaraw-araw, lingguhan, buwanan, taunan)*
a. Municipal/Mayor's Permit (note the nature of Mayor's permit)		
a.1 Residence Certificate (Cedula)		
a.2 Barangay Clearance		
b. Others? Please specify *(Iba pa? Tukuyin)* ___________		

23. Repair, Cleaning and Maintenance of fishing paraphernalia/equipment*(Gastusin sa pagkukumpuni at pag-papanatili ng kaayusan ng mga gamit sa pangingisda)*

Items *(Mga kailangan sa pangingisda)*	Frequency, please specify if per trip, daily, weekly, monthly, yearly *(Dalas, tukuyin kong bawat labas/ , lingguhan, buwanan, taunan)*	# of Hours allotted to the activity *(Oras na ginugol bawat gawain)*	Labor (prevailing)	Material	
			Cost/ Unit, Php	Item/ Quanti -ty	Cost /Unit, Php
a. Repair /Cleaning/Maintenance of fishing gears most frequently operated*(Pagkumpuni ng gamit sa panghuli)*					
Gear1 ________					
Gear2 ________					
Gear3 ________					
Gear4 ________					
b. Repainting of banca*(Pag-pintura ng bangka)*					
Motorized boat1					
Motorized boat2					
Non-motorized1					
Non-motorized 2					
c. Others? Please specify: ________					

Annex 9 Fisheries survey questionnaire (cont'd)

24. Are there existing fishermen's associations/peoples' organizations (PO), cooperative in your locality? If yes please specify, status of membership, fees, and assistance provided. *(Mayroon po bang asosasyon o koperatiba ng mangingisda sa inyong lugar? Kong oo, tukuyin ang nasabing mga asosasyon/kooperatiba, sabihin kung kasapi, mga kontribusyon, and mga natatanggap na tulong.)*

Fisheries association, cooperative	Membership 1/	Fees		Assistance provided
		Type of Fees	Amount, Php	

1/ 1- Yes 2- No

25. Ask interviewer to make a note of which questions are difficult or vague or unclear *(Tanungin ang kinakapanayam at isulat kung ano sa mga naitanong ang mahirap sagutin o di malinaw)*

Thank you, *(Marami pong salamat!)*

Surveyed by: ____________________/______________________ *Date:* ____________________

Print Name / Signature

Annex 10 Additional data on Fisheries in Sofronio Española

Table A10.1. Number of fishers in each barangay

Barangay of Sofronio Espanola	Total Number of Fishers	Distribution, Percent
Punang	29	11%
Pulot Shore	23	9%
Isumbo	27	10%
Aboabo	21	8%
Iraray	41	15%
Iraray	37	14%
Labog	31	12%
Panitian	57	21%
TOTAL	266	100%

Source: Record of members of Barangay Fisheries and Aquatic Resource Management Council (BFARMC).

Table A10.2. Summary of prices and fish species caught in the municipal waters of Sofronio Espanola

Fish Species	Average Price, Pesos	Number of times reported by fishers
abaan	76.7	2
alimasag	103.3	5
aloy	37.5	1
assorted	35.0	2
balarete		1
balila	60.0	1
bangus	0.9	1
bangus fry	0.2	3
bisugo	53.1	16
bulaw	59.2	4
dalagang bukid	40.0	1
daloso		1
danggit	55.0	1
dilawan	40.0	1
dilis		1
dugso	70.0	4
capada	43.3	1
galunggong	50.0	1
gapas gapas	50.0	1
gingaw	82.5	3
hinok	60.0	1
isdang bato	55.0	5
kalapato	64.4	4
karaho	23.8	2
kilawan	80.0	1
kuraho	27.5	1
lanibo	70.0	1
lapis	35.0	1

Annex 10 Additional data on fisheries in Sofronio Española (cont'd)

Fish Species	Average Price, Pesos	Number of times reported by fishers
lapu lapu	90.0	7
latab	37.5	1
lipte	65.0	1
lobster	1833.3	2
malaponte	82.5	1
mamsa	69.6	9
matambaka	41.0	4
mayamaya	92.9	2
pagi	44.0	1
palad	35.0	1
palaso	22.5	1
pitik	200.0	7
pugita	67.3	2
pulahan	80.0	9
pusit	77.1	2
rompe	55.8	1
rumpi/turcillo	35.0	19
salimburao	59.2	1
salmunete	50.0	13
sapsap	32.0	1
sugpo	0.7	2
suno	362.5	6
talakitok	72.0	5
tamban	30.0	4
tanigue	120.0	4
torsillo	40.0	11
tulingan	58.5	2

Table A10.3 Calculation of the fisheries resource rent per fishermen

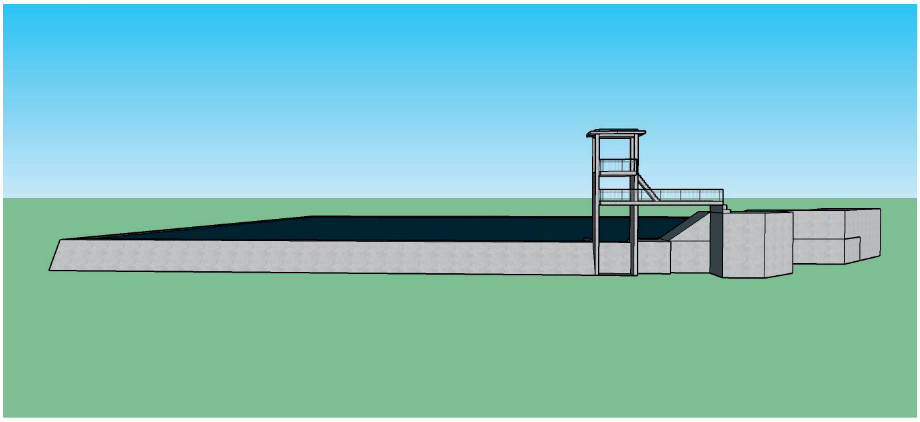
Respon-dent No.	Barangay	Average Price of Total Fish Catch per Fisher	Total Fishing Days	Total Catch, kg	Average Catch per day, kg	Gross Sales from Gear Catches	Total Compensation of Employees (CE)	Total Intermediate Consumption per year	Total Consumption of Fixed Capital	User Cost of Fixed Capital	Total Resource Rent of Sample	Resource Rent, pesos/Kg
1	Pulot Shore	38.33	319.00	11,650	350	3,349,500	281,700	11,870	1,600	320	3,117,010	27.92
2	Pulot Shore	66.67	364.00	14,014	39	674,925	345,800	1,560	9,630	3,098	314,837	22.47
3	Iraray	70.75	192.00	14,304	75	1,101,156	159,000	5,607	13,210	8,942	914,398	63.93
4	Iraray	61.04	220.00	8,800	40	435,896	172,800	2,172	5,595	1,705	253,624	28.82
5	Iraray	40.00	230.00	6,095	27	243,800	138,000	1,346	3,893	3,050	97,511	16.00
6	Punang	68.00	161.00	2,013	13	136,850	48,300	2,081	5,725	2,505	78,239	38.88
7	Punang	54.38	268.00	2,010	8	109,294	80,400	1,006	2,914	2,225	22,749	11.32
8	Pulot Shore	63.00	84.00	5,124	61	398,664	67,200	1,045	1,835	367	328,217	64.05
9	Iraray	90.00	115.00	3,048	27	274,275	34,500	3,214	6,621	4,735	225,205	73.90
10	Pulot Shore	95.42	48.00	3,360	70	453,240	50,400	2,812	825	165	399,038	118.76
11	Iraray	58.00	69.00	1,208	18	70,035	23,460	3,412	14,958	6,285	21,920	18.15
12	Iraray	56.50	54.00	2,700	50	76,500	21,600	2,870	6,797	4,418	40,815	15.12
13	Pulot Shore	58.75	154.00	13,321	87	1,020,963	75,600	1,365	4,750	2,450	936,798	70.32
14	Pulot Shore	67.50	16.00	640	40	43,200	4,900	906	2,333	1,948	33,113	51.74
15	Pulot Shore	25.02	216.00	325,296	1,506	210,720	78,000	7,893	583	810	123,434	0.38

Table A10.3 Calculation of the fisheries resource rent per fishermen (cont'd)

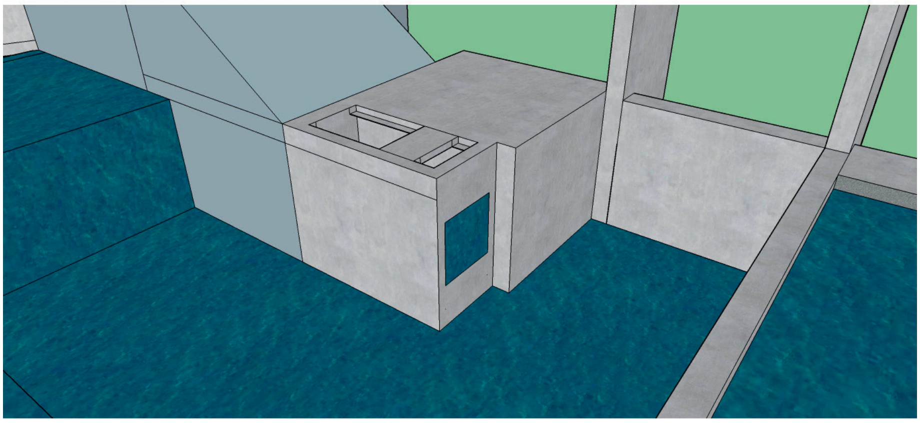
Respon-dent No.	Barangay	Average Price of Total Fish Catch per Fisher	Total Fishing Days	Total Catch, kg	Average Catch per day, kg	Gross Sales from Gear Catches	Total Compensation of Employees (CE)	Total Intermediate Consumption per year	Total Consumption of Fixed Capital	User Cost of Fixed Capital	Total Resource Rent of Sample	Resource Rent, pesos/Kg
16	Pulot Shore	50.00	252.00	4,410	18	220,500	75,600	435	1,050	510	142,905	32.4
17	Iraray	82.5	198.00	4,950	25	408,375	21,840	2,436	2,050	1,530	380,519	76.87
18	Iraray	76.67	252.00	3,780	15	289,800		2,299	3,286	2,300	281,915	74.58
19	Punang	66.67	216.00	2,808	13	187,200	450	965	6,592	5,436	173,757	61.88
20	Iraray	53.00	155.00	5,038	33	266,988	139,813	2,140	7,901	4,102	113,032	22.44
21	Punang	65.83	217.50	2,175	10	101,500	14,406	3,770	1,644	676	81,005	37.24
22	Punang	72.06	212.50	2,550	12	191,463	2,281	1,054	193	46	187,889	73.68
23	Iraray	42.50					570	92	295	68	-1,025	
24	Iraray	72.50	214.50	6,971	33	357,488	5,705	984	30	30	350,738	50.31
25	Pulot Shore	11.37	191.00	719,115	3,765	204,434	4,139	10,343	3,415	2,944	183,594	0.26
26	Pulot Shore	35.78	267.00	345,231	1,293	557,379	201,263	12,905	8,383	12,516	322,313	0.93
27	Pulot Shore	123.82	252.00	190,512	756	97,650	159,450	8,996	16,067	8,180	-95,042	
28	Pulot Shore	80.00	50.00	3,625	73	478,963	184,700	57,033	4,375	3,675	229,179	63.22
29	Punang	65.42	140.00	10,360	74	803,892	94,963	19,990	5,300	4,180	679,460	65.58
30	Iraray	69.90	331.00	75,634	229	4,421,510	105,025	23,592	4,215	6,315	4,282,363	56.62
31	Punang	82.36	329.00	29,775	91	1,255,841	213,600	2,191	275	55	1,039,720	34.92

ANNEX 11 Sketch of Pulot dam

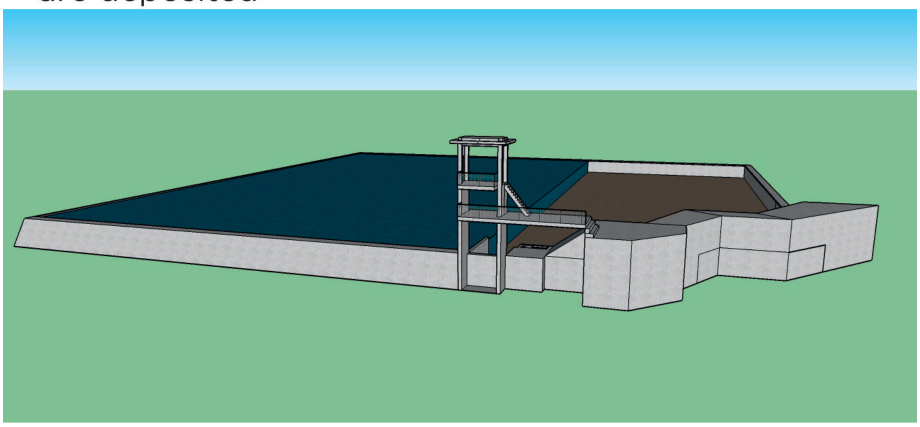
Pulot Communal Irrigation System Diversion Dam
Length - 80 meters
Width - 49;.36 meters
Depth - 2.7 meters



Dam intake gate to the irrigation canal (1m x 1m) and Vertical Lift Gate



Part of the Diversion dam where silt and sediments are deposited



ANNEX 12 Coastal ecosystem condition account and methodologies

Mangroves. For mangroves, the study monitoring survey used the Transect Line Plot Method (TLPM), a systematic sampling design for the conduct of mangrove resource assessment. The 15 sites assessed/monitored were located using a Global Positioning Satellite (GPS) System (Trimble Geo-explorer 3). For each site imaginary transect lines, with width ranging from 30 meters to 300 meters, were laid perpendicular to the shore starting at the seaward margin up to the landward edge of the mangrove forest. This width is measured from the perpendicular edge of the mangrove in the seaward or river bank side up to the landward edge. Along this line transect, 10m X 10m plots at 50-meter interval from the center of the plots were laid. All trees covered in each plot were identified and measured. All trees with diameter-at-breast height (dbh) greater than 4 cm were marked with permanent paint for monitoring purposes. Seedlings (mangroves with height less than 1 meter) and saplings (mangroves with height greater than 1 meter but having dbh less than 4 cm) of each species were identified and counted. The parameters used to characterize mangrove community structure included Relative Density, Relative Frequency, Relative Dominance, Species Diversity Index and Importance Value. However, for the ecosystem condition accounting only the following were used insofar as reported data were available (since they best reflect the health of the mangrove forest): Area (ha), Species diversity (H') and Number of species, Density (trees/ha), Total volume (m3), and Seedlings/saplings (individual/ha). The commonly used Shannon-Weiner Biodiversity Index was selected as measure of H'. The measure accounts for the species richness and evenness using the formula $H' = -\sum p_i \ln p_i$, where p_i is the proportion of individuals found in species estimated as $p_i = n_i/N$, where n_i is the number of individuals in species i and N is the total number of individuals in the community (Magurran, 2004, Molles, 1999). The minimum value of H' is 0, which is the value of H' for a community with a single species, and increases as species richness and species evenness increase with values normally

Seagrass. The Transect-Quadrat Sampling Method was used to assess the condition of the seagrass beds in the Municipality of Sofronio Espanola in 2011 and 2001 in six (6) survey sites. Caramay station in 2001 was replaced with Punang station in 2011 due to the absence of seagrass species in the site. The method involve the laying of a 100-meter transect line perpendicular to the shore starting at a point where the seagrass first appears. A transect can either be connected to a mangrove area or to a coral reef. Reading and recording of seagrasses and seaweed information commenced in its first appearance inside the quadrat along the transect line. A 50 cm x 50 cm stainless steel quadrat divided into 25 grids (1 grid=10 cm x 10 cm) was placed along the transect every 10 meters. For seagrass beds exceeding 100 meters in width, an interval of 20 meters was applied. Parameters used to describe the whole seagrass meadow included: species composition, percent cover, density and frequency.

ANNEX 12 Coastal ecosystem condition account and methodologies (cont'd)

Coral Reefs. The Line Intercept Transect (LIT) technique (English et al., 1997) was used for the surveys in 2011 and 2001. The method uses life form categories which provide a morphological (form and structure) description of the reef benthic community rather than species level data. At each sampling site, a 50-meter transect line was laid one meter from the reef crest if the reef is sloping or at the mid-section of the reef if it is a reef flat, at a depth of 5-10 meters.

Using SCUBA, the diver moved along the transect noting and recording each life form category and the corresponding start and end point on the transect line where such life form was observed. The percent cover for each category was then computed using the following equation:

$$\% \text{ Cover} = \frac{\text{Total length of category}}{\text{Total transect length}} \times 100$$

The percent cover describes the relative composition of the different benthic categories in the reef. The qualification of coral reef condition was done based on the DENR issued DENR Administrative Order No. 12, series of Guidelines for the Implementation of the Sustainable Coral Reef Ecosystems Management Program (SCREMP) as follows:

- Category 1 - Poor (coral reef with > 0 to 10% coral cover)
- Category 2 - Fair (coral reef with 11 - 30% coral cover)
- Category 3 - Good (coral reef with 31-50% cord cover)
- Category 4 - Very Good (coral reef with 51-75% cord cover)
- Category 5 - Excellent - (Coral reef with 76-100% coral reef cover)

Annex 13 Data quality assurance for ecosystem accounting

In principle, the data quality standards for Ecosystem Accounting are comparable to those of the National Accounts. However, it needs to be kept in mind that ecosystem accounting is still in an experimental phase, and that trial and error is needed to pinpoint the best approaches for the biophysical and monetary analysis of ecosystems and the services they supply.

In the WAVES Philippines Ecosystem Accounting pilot, the authors attempted to select the most accurate modelling and valuation approach for each account on the basis of the available data. However, data shortages were a significant concern, for instance in relation to the timing and duration of historical streamflow data for Pulot river. In view of data deficiencies, some datasets were collected by the TWG, such as these on fisheries and crop production.

Further work on enhancing the accuracy of the datasets would be needed if ecosystem accounting would be continued in the future. In addition, more work is needed to pinpoint the accuracy of the used data, and the sensitivity of the ecosystem services models for the underlying assumptions. Due to time constraints this was not possible in this first phase of the accounting project.

Based on the Eurostat Data Quality Framework[18], some guidance is provided below for handling data in the compilation of ecosystem accounts, specified for five key considerations in assessing data quality.

Relevance
The selection of ecosystem services and assets needs to be guided by user needs, usually in aide of informing specific policy questions, and with an eye to integration with wider information frameworks. Users include local, regional and national government, NGOs, academia and the general public.

Accuracy and reliability
Where possible, remote sensing datasets need to be field validated using sampling points, and the validation approach, number of sample points and measurement errors need to be published. Questionnaire surveys (for fishing, agricultural production) need to be assessed for sampling or non-sampling error, and standard deviations in the results should be published.

Timeliness and punctuality
The presented accounts need to be compiled with the most up-to-date information available and released within the timeframe requested.

Coherence and comparability
Where possible, data in the accounts needs to be (and has been) compiled using the System of Environmental-Economic Accounting Experimental Ecosystem Accounting framework and the associated Technical Recommendations for SEEA EEA. This framework ensures the concepts and measures are comparable between the accounts and other standardized macro-economic datasets such as the System of National Accounts.

Accessibility and clarity
All data to be compiled in the ecosystem accounts needs to be accessible and clear for the users. Interactions with users on a regular basis is important in order to update users on recent developments and to provide insights in how the accounts can be best made available to existing and potential users. Note that these pilot accounts are released in accordance with the World Bank policy on access to information, available at http://documents.worldbank.org/curated/en/2010/07/12368161/world-bank-policy-access-information

[18] See: http://ec.europa.eu/eurostat/quality

Annex 14 Phil WAVES Stakeholder Groups

IPMR

1. Artolin Edlap, Bataraza
2. Rolbing Sungit, Quezon
3. Silico Valdestamon, Rizal
4. Victoriano Colili, Brooke's Point

IP Leaders and representatives

1. Jother Duanan, Quezon
2. Sarilan Puntas, Rizal
3. Carlos Maludin, Brooke's Point
4. Nelson Sombra, Brooke's Point
5. Calib Tingdan, Quezon
6. Bernardo Barahim, Rizal
7. Donetor Cayag,
8. Joter Duanan, Quezon
9. Sarilan Puntas, Rizal
10. Pidrino Asuan,
11. Jonathan Ong, Sofronio Espanola
12. Pedro Sagad, Brooke's Point
13. Rolly Maludin, Brooke's Point

NCIP

1. Pablito Magbanua, NCIP-Palawan

Representatives of LGUs, DENR at PCSD

Wealth Accounting and the Valuation of Ecosystem Services

Wealth Accounting and the Valuation of Ecosystem Services (WAVES) is a global partnership led by the World Bank that aims to promote sustainable development by ensuring that natural resources are mainstreamed in development planning and national economic accounts.

www.wavespartnership.org

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