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Phil-WAVES

Guidebook on Ecosystem Accounting

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Guidebook on Ecosystem Accounting

WAVES
Wealth Accounting and the
Valuation of Ecosystem Services
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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, 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). Toward this end, WAVES (www.wavespartnership.org) brings together a broad coalition of governments, United Nations agencies, nongovernmental organizations and academics. Its core implementing countries include developing ones — Botswana, Colombia, Costa Rica, Guatemala, Indonesia, Madagascar, the Philippines and Rwanda — all working to establish natural capital accounts. WAVES' partner UN agencies, namely, UN Environment Programme, UN Development Programme, and the UN Statistical Commission, are helping to implement natural capital accounting. WAVES is funded by a multi-donor trust fund and is overseen by a steering committee. Donors include — Denmark, the European Commission, France, Germany, Japan, The Netherlands, Norway, Switzerland, and the United Kingdom.

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PREFACE

This **Guidebook on Ecosystem Accounting** is intended as a practical guide for the development of ecosystem accounts as part of efforts to mainstream and institutionalize Natural Capital Accounting (NCA) in the Philippines. Ultimately, it aims to aid government agencies in decision-making on matters relating to sustainable development, including the wise and efficient use of natural resources, by providing evidence-based, scientifically grounded information.

This Guidebook articulates the definitions, rationale, concepts, data sourcing methods, key steps, and policies needed to ensure the effective development of ecosystem accounts. It includes examples of ecosystem accounts that have been developed in pilot areas. As you read this guidebook and consider the examples, how to develop ecosystem accounts should become clearer.

This is primarily intended for the technical working groups (TWGs) of various government offices involved in protecting and preserving natural resources. Yet it is also targeted at a wider audience comprising different sectors of society who will benefit from getting a better understanding of the principles and significance of natural capital- and ecosystem accounting.

The guidebook is a product of the Philippines-Wealth Accounting and the Valuation of Ecosystem Services (Phil-WAVES) project which is jointly implemented by the National Economic and Development Authority, Philippine Statistics Authority, Department of Environment and Natural Resources, Palawan Council for Sustainable Development, and Laguna Lake Development Authority, with technical assistance from the World Bank. It applies the learning exercises comprising ecosystem accounting in the Philippines and is a supplement to the System of Environmental - Economic Accounting (SEEA) framework and the Phil-WAVES Technical Reports on Pilot Ecosystem Accounts.

This guidebook is in accordance with the SEEA-Experimental Ecosystem Accounting Technical Recommendations.

Overview of this Guidebook

The guidebook is organized into four parts. Part I introduces the concept of natural capital accounting in relation to ecosystem accounting and its significance. Part II explains some fundamental concepts relating to the development of ecosystem accounts. Part III expounds on ongoing efforts to develop pilot ecosystem accounts in the Philippines. Finally, Part IV tackles the uses and benefits of developing accounts in the country such as those involving policy making.

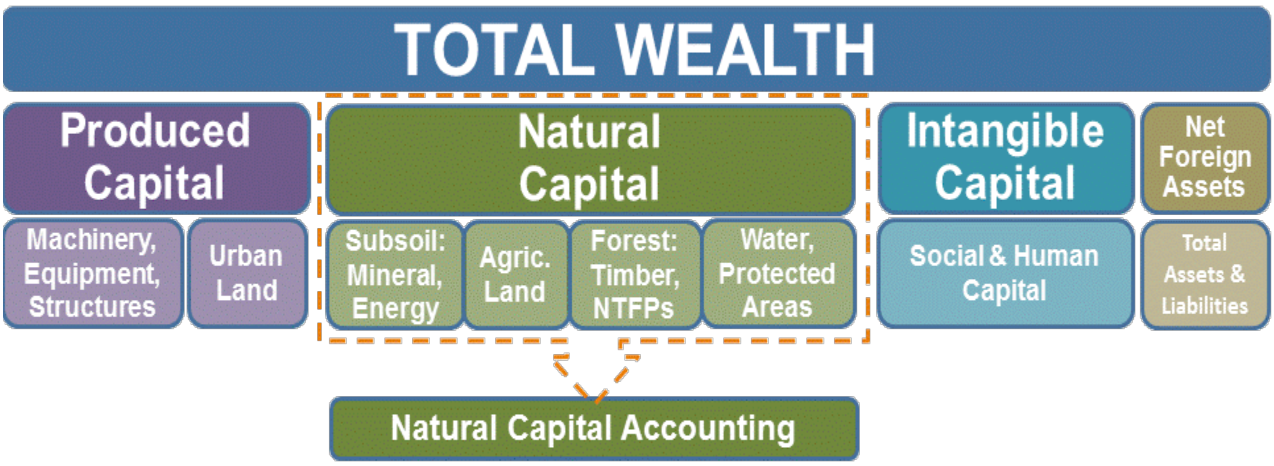
Part I Introduction to Natural Capital Accounting vis-à-vis Ecosystem Accounting

What is natural capital accounting (NCA)?

To define natural capital accounting, one must first know what natural capital is.

Natural capital includes all of the resources that we easily recognize and measure, like minerals, energy, timber, agricultural land, fisheries, and water. It also includes the ecosystem services that are often "invisible" to most people, such as air and water filtration, flood protection, carbon storage, pollination of crops, and habitats for wildlife. These values are not readily captured in markets, so we do not really know how much they contribute to the economy. We often take these services for granted and do not know what it would cost to lose them.

Natural capital accounting, therefore, is the process of taking stock of these resources.



Why does natural capital matter to economic growth?

Economic growth is currently measured in terms of Gross Domestic Product (GDP), which determines the value of the goods and services produced annually. This, however, is an incomplete assessment of a country's total economic well-being because GDP only looks at output but tells us nothing about income in the long term. Natural capital accounting goes beyond that. For example, when a country exploits its minerals, it is actually using up its finite mineral wealth.

A full picture of a country's wealth, which can be obtained through a methodology called wealth accounting, includes all assets that contribute to our economic well-being. These range from buildings and factory machines to infrastructure, human capital, social capital, and natural capital.

Natural Capital Accounting in the Philippines

The Philippines began using Natural Capital Accounting (NCA) in line with the implementation of the Environmental and Natural Resources Accounting Project (ENRAP) in the 1990s. The country's objective was to take stock of and appraise its natural resources. During this period, the Philippines was among the few countries that used NCA as an economic indicator.

(1991-2000) Environmental and Natural Resources Accounting Project (ENRAP)

(2000s) Philippine Economic-Environmental and Natural Resources Accounting (PEENRA)

(2014-Present) Philippines - Wealth Accounting and the Valuation of Ecosystem Services (Phil-WAVES)

To date the Philippines has been able to complete two NCA projects — ENRAP (1991-2000) and the Philippine Economic-Environmental and Natural Resources Accounting (PEENRA) in the 2000s.

Both globally and in the Philippines, past attempts to institutionalize the NCA had often failed due to lack of a clear policy link and clear mandate and coordination among concerned agencies, disagreements on methodology, and limited capacity and resources.

Nonetheless, the application of NCA principles was continued by various government and non-government organizations that conducted site-specific Total Economic Valuation (TEV) studies on natural resources and environment services. The Palawan Council for Sustainable Development (PCSD), for example, conducted TEV studies on the Mantalingahan mountain range in Southern Palawan. Learning from the past, the implementation of the Wealth Accounting and the Valuation of Ecosystem Services (WAVES) Project in the Philippines is grounded on building the technical capacity of government institutions involved in the protection and preservation of natural resources as well as policy and development planning.

What is an ecosystem?

An ecosystem is a dynamic complex of plant, animal and micro-organism communities that interact with their non-living environment as one functional unit[1].

What are ecosystem services?

In ecosystem accounting, ecosystem services are defined as contributions that ecosystems make to benefits used in economic and other human activity. It is therefore important to distinguish clearly between ecosystem services and benefits. Some ecosystem services are tangible, such as timber used for energy or for building houses. Others, on the other hand, are intangible, like water purification, water regulation, and flood control. Without these ecosystem services, our quality of life would be reduced.

Ecosystem services are classified into three types:

Provisioning services	Regulating services	Cultural services
Refer to material and energy contributions generated by or within an ecosystem. The associated benefits may be provided in agricultural systems, as well as within semi-natural and natural ecosystems.	Result from the capacity of ecosystems to regulate climate, hydrological and biochemical cycles, earth surface processes, and a variety of biological processes.	Relate to the intellectual and symbolic benefits that people obtain from ecosystems through recreation, knowledge development, relaxation, and spiritual reflection.

What then is ecosystem accounting?

Ecosystem accounting is a coherent and integrated approach to assessing the environment by measuring ecosystems and the flows of services from ecosystems into economic and human activity.

The scale of ecosystem accounting may vary according to land cover types such as forests, or based on larger integrated areas such as river basins. Ecosystem accounting also covers areas that may be considered relatively natural like those that may have been heavily influenced by human activity, such as agricultural sites.

Ecosystem accounting takes into account both concrete and intangible benefits derived from ecosystems. By accounting for the value nature provides for us, we can manage these resources more sustainably and leave a healthier planet for future generations.

[1] Convention on Biological Diversity (2003), Article 2, Use of Terms

Some of the key questions that may be answered using information obtained from ecosystem accounting include:

- ❖ Which ecosystems generate which ecosystem services?
- ❖ What is the extent of the contribution of ecosystem services to economic and other human activity?
- ❖ Which ecosystems are in the best condition and which are the most degraded?
- ❖ What changes have occurred over time and what have been their impact on the generation of ecosystem services?
- ❖ What monetary values might be attached to ecosystems?

Why apply ecosystem accounting?

Ecosystem accounting serves as a tool for compiling information on environmental changes, linked to economic and other human activities, and generating understanding of how these changes could lead to environmental degradation. Consequently, there is a reduced capacity for ecosystems to continue to provide the services on which economic and other human activity depends.

Part II Fundamental Concepts of Ecosystem Accounts

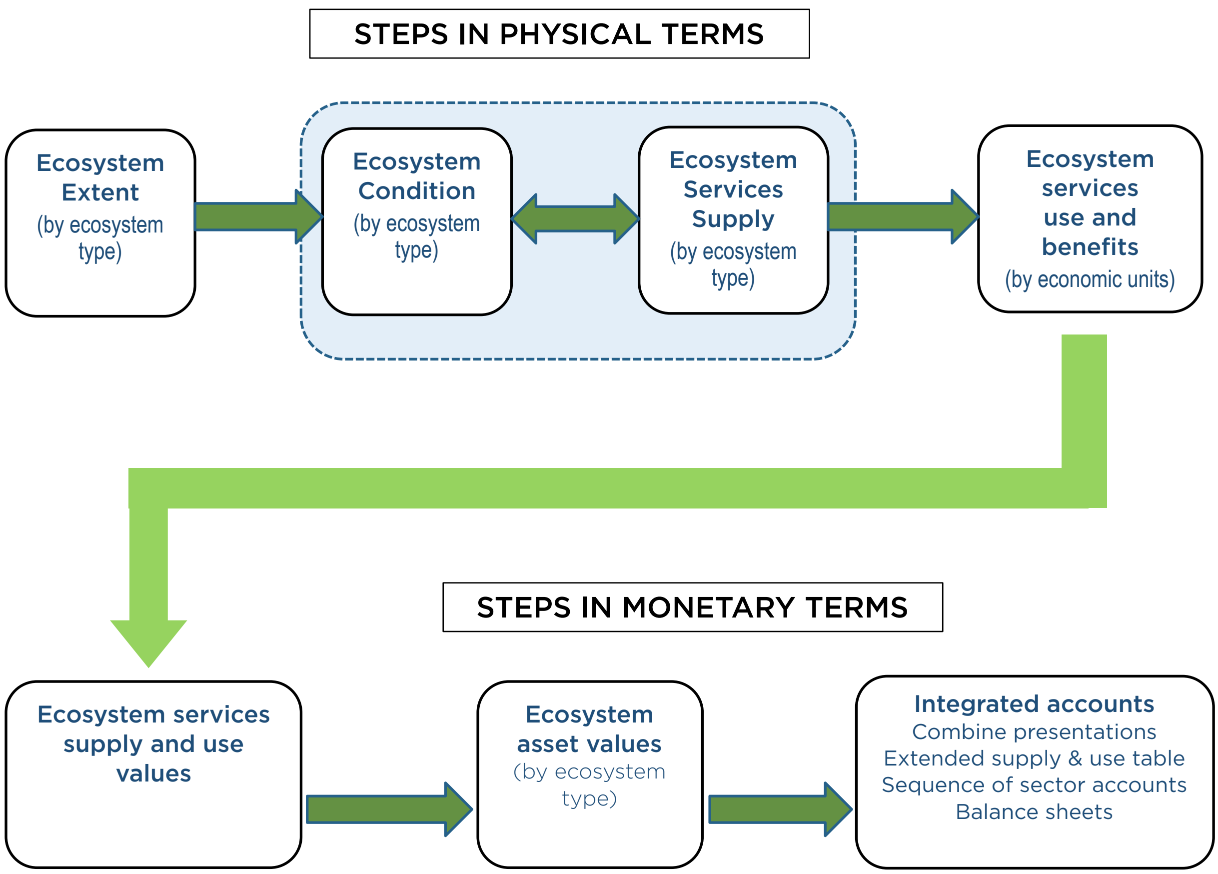
Key Concepts of Ecosystem Accounting

In the SEEA-EEA Technical Recommendations, ecosystem accounting complements, and builds on, the accounting for environmental assets as described in the SEEA Central Framework. In this framework, environmental assets are accounted for as individual resources such as minerals, timber, soil resources, and water resources. In ecosystem accounting based on the SEEA-EEA framework, the accounting approach recognizes the fact that these individual resources function together within a broader system.

The SEEA-EEA shows that a prime motivation underlying ecosystem accounting is that a separate analysis of ecosystems and the economy does not adequately reflect the fundamental relationship between humans and the environment. In this context, the SEEA-EEA provides a platform for the integration of relevant information on ecosystem extent, ecosystem condition, ecosystem services and ecosystem capacity, with information on the associated beneficiaries (households, businesses, and governments).

Broad Steps in Ecosystem Accounting

The SEEA-EEA Technical Recommendations identify the following main steps in accounting for ecosystems in physical and monetary terms:



1

Delineation of ecosystem assets is the first important step in ecosystem accounting. Information on the total area of different types of ecosystem assets, often measured in hectares, is presented in an ecosystem extent account. In principle, these areas should cover the entirety of a country's terrestrial area (including inland waters) and, as appropriate, relevant coastal and marine areas, possibly extending to a country's exclusive economic zone (EEZ). In the Philippines, classifying the coverage of ecosystem asset can be done following the land cover classification being used by the National Mapping and Resource Information Authority (NAMRIA).

2

Compilation of the ecosystem condition account is the next step. In this step, information on the various characteristics that reflect the condition or state of an ecosystem, including trends in ecosystem degradation or enhancement and over time, should be recorded. The set of relevant characteristics will depend both on the type of ecosystem (i.e., indicators for forests will likely be different compared to indicators for coastal ecosystems) and the use of the ecosystem, since how an ecosystem is used will usually have a direct effect on how its condition changes.

3

What follows is a measurement of ecosystem services in physical terms. This involves considering each ecosystem asset and determining the relevant ecosystem services and appropriate indicators. This task should be conducted using a system of classification of ecosystem services, such as the Common International Classification of Ecosystem Services (CICES) (Haines-Young and Potschin, 2013). A classification can provide a checklist to ensure appropriate coverage. This step also involves the estimation of both the supply of ecosystem services from each ecosystem asset and the use of those services by various beneficiaries. Together, the information on supply and use is used to compile an ecosystem services supply and use table.

4

Valuation of ecosystem services is a necessary step for certain types of integration with the standard national accounts and extended measures of net wealth. Valuation of ecosystem services can be done by applying relevant prices to the physical flows of ecosystem services measured in Step 3, and by estimating the net present value (NPV) of the future flow of all ecosystem services from each ecosystem asset. A particularly important one is estimating the future flow of ecosystem services and the extent to which current ecosystem services supply can be maintained. This requires an assessment of ecosystem capacity, which reflects the connection between ecosystem condition and ecosystem services. The value of ecosystem degradation will be related to the change in the NPV of ecosystem assets. Opening and closing values for ecosystem assets and changes in those values over an accounting period are presented in an ecosystem monetary asset account.

5

The final step involves the use of information on ecosystem services, ecosystem assets, and ecosystem degradation generated from the accounts described above, to integrate environmental and economic data and augment the current standard national accounts.

Key Consideration in Compiling Ecosystem Accounts

There are six considerations in ecosystem accounting (Technical Recommendations):

FIRST	It is a set of accounts, each of which contains specific information applicable to one part of the ecosystem accounting model. There is not one single "ecosystem account".
SECOND	The accounts are designed to link together such that information can be readily compared across accounts.
THIRD	A specific design feature of the ecosystem accounts is that ultimately the information should be integrated with the standard national accounts that record economic activity.
FOURTH	The accounting structures presented should not be considered unchangeable with regard to the level of detail they contain.
FIFTH	The accounts present information corresponding to one accounting period, usually one year. The length of the accounting period determines the points chosen to measure the opening and closing stocks. Flows are measured in terms of observed changes between the opening and closing of the accounting period.
SIXTH	The structure of accounts generally represents a level of detail suitable for presentation and analysis of outputs from accounting. It represents a level of detail at which accounting relationships (e.g., supply and use, balancing end of period stocks and changes in stocks) are applied. However, it will generally be necessary for underlying information to be compiled at different, usually lower, levels of aggregation before entry into the account.

Ecosystem Stocks and Flows: The Basic Foundation of Ecosystems Accounting

Ecosystem accounting is founded on the relationships between stocks and flows. **The stocks** are represented by spatial areas comprising an ecosystem asset. Each ecosystem asset has a range of ecosystem characteristics — such as land cover, biodiversity, soil type, altitude and slope, climate, etc. — which describe the location and functions of the ecosystem.

The flows in ecosystem accounting are of two types. First, there are flows within and between ecosystem assets that reflect ongoing ecosystem processes referred to as **intra-ecosystem flows** and **inter-ecosystem flows**. The recognition of inter-ecosystem flows highlights the dependencies between different **ecosystem assets**. For instance, wetlands are dependent on flows of water from the upland forest ecosystem. There are also flows — collectively called **ecosystem services** — indicating that people, through economic activities, take advantage of the multitude of resources and processes that are generated by ecosystem assets.

Ecosystem Accounting Units

Ecosystem accounting requires integration of spatial units within a country such that there are no gaps or overlaps in the scope and coverage of the accounts, thus delineating types of ecosystems that supply specific services. The delineation of spatial units will involve the use of a range of spatial information relating to:

- Land cover and land use
- Topography of the country (coastline, digital elevation model (DEM), slopes, river basins, and drainage areas)
- Vegetation, habitats, and species composition
- Soil resources
- Meteorological data
- Bathymetry (for coastal areas)
- Administrative boundaries
- Population, built-up areas and settlements
- Transport and communication (roads, railways, power lines, pipelines)

Three types of ecosystem accounting spatial areas are as follows:

Ecosystem Asset (EA)	Ecosystem Type (ET)	Ecosystem Accounting Area (EAA)
• EA are individual, contiguous ecosystems (e.g., a specific forest ecosystem) that are considered assets for the purpose of accounting • EAs are delineated based on various characteristics including vegetation structure and type, species composition, ecological processes, climate, hydrology, soil and topography. • Land cover based delineation of EAs can also be used as a starting point which raises the practical question of which land cover classes should be considered and at what level of detail.	• ETs are aggregations of ecosystem assets. ETs are areas with a comparable ecology and ecosystem use, located within the area for which the account is produced. • An ET may be a type of forest or grassland. • Generally, across a country, there will be a number of different areas of the same ET. For example, there may be different areas of mangrove forest in different parts of a country. Each individual mangrove forest is considered a separate EA but is classified to the same ET.	• EAAs are larger areas (geographical aggregation) that correspond to the area for which an ecosystem account is constructed and EAAs comprise a range of ecosystem types. • Within EAA, for a given sub-national administrative area, an ecosystem extent account would show the changing total area of each ET (e.g., forest, cropland). It would not show the changing area of each individual EA.

Overview of Constructing Ecosystem Accounts Using SEEA EEA Framework

There are three main types of ecosystem accounts (SEEA-EEA Technical Recommendation):

a) Accounts for ecosystem assets

b) Accounts for ecosystem services

c) Integrated accounts, which present ecosystem accounting information alongside standard economic and national accounts data

Thematic accounts on themes such as land, biodiversity, carbon, and water provide important context and supporting information for ecosystem accounts, which follow the structure described in the SEEA Central Framework or have a similar asset account-based structure. Other potential thematic accounts include those for soil, nutrients, air, timber, and fish resources.

A. Accounting for Ecosystem Asset

In accounting for ecosystem assets, spatial areas containing a combination of biotic and abiotic components and other characteristics that function together are mainly considered. Ecosystem assets are measured from two perspectives, that is, ecosystem assets are considered in terms of:

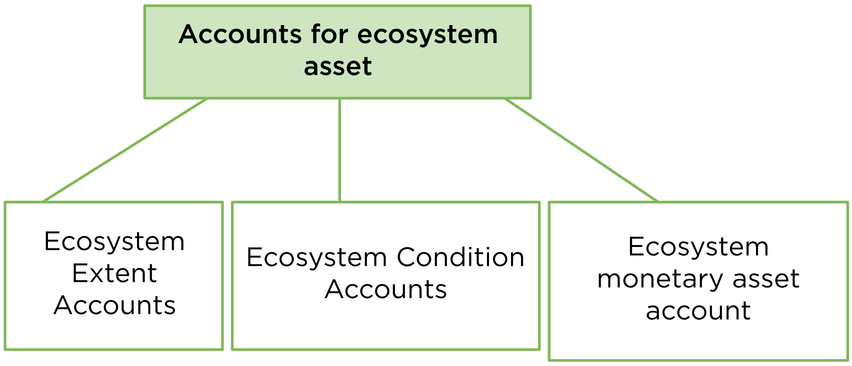
- Ecosystem condition and ecosystem extent
- Expected ecosystem service flows

Ecosystem assets also focus on an assessment of the capacity of an ecosystem asset to generate an anticipated combination of provisioning, regulating, and cultural services generated by an ecosystem asset. The capacity of an ecosystem asset to generate such services can be understood as a function of the condition and extent of that ecosystem.

General approaches to assessing ecosystem assets

The assessment of ecosystem assets is covers three key concepts:

1. ecosystem condition
2. ecosystem extent
3. ecosystem monetary asset



Ecosystem asset accounts are intended to organize information on the extent and condition of ecosystems, and ecosystem asset. The number of related concepts requires that a large amount of information be integrated while the suggestions made in this section for accounting tables are intended to provide a starting point for experimentation in compiling information rather than providing a definitive methodological guidance.

Key considerations on ecosystem assets accounting:

Accounting for ecosystem extent	• Defining the ecosystems of interest for accounting purposes is by no means straightforward and a balance between scale of analysis, available data, and policy questions is needed. It is appropriate to start this discussion by examining the most conceptually straightforward issue relating to the definition of ecosystem assets and the delineation of their extent. • Organization of information required to establish an **ecosystem extent account** is likely to be a good entry point for establishing a national spatial data infrastructure. • The structure of the **ecosystem extent account**, as shown below, gives a clear indication of the nature of accounting for assets in a SEEA context. • An **ecosystem extent account** provides a clear basis for the development of other ecosystem accounts. It yields important information such an assessment of ecosystem diversity at a national level. Commonly, higher-level extent accounts are based primarily on land cover information. Ideally, all countries should report in detail changes in ecosystem extent on a regular basis. • Information making up an ecosystem extent account is usefully presented in maps using different colors for different types of EU. This is to readily highlight issues of fragmentation of ecosystem types and possible connections between ecosystem types that are not apparent when the information is presented in a traditional table format

Accounting for ecosystem condition	• Ecosystem condition is the overall quality of an ecosystem asset. The assessment of ecosystem condition involves distinct measurement of both quantitative and qualitative aspects of characteristics of the ecosystem assets. An ecosystem condition account is compiled in physical terms using a variety of indicators for selected characteristics • Measures of ecosystem condition are generally compiled in relation to key ecosystem characteristics (e.g., water, soil, carbon, vegetation, biodiversity) and the choice of characteristics generally varies depending on the type of ecosystem asset. • The selection of ecosystem characteristics should take into account current and expected future uses of the ecosystem, (e.g., for agriculture, forestry, carbon sequestration, recreation, etc.), since these uses are likely to have the most impact on certain characteristics and the overall condition and capacity of the ecosystem asset to generate alternative baskets of ecosystem services. • Generally, it is useful to compile these accounts by type of EU within a relevant geographical aggregation. Each type of EU (e.g., tree-covered areas, grasslands, mangroves, etc.) has distinct characteristics that should be taken into account in assessing ecosystem condition. • There is a range of measurement issues and challenges in the compilation of ecosystem condition accounts. Indeed, it is reasonable to conclude that there is still much to learn about the structure and compilation of these accounts. • Such issues include the selection of specific characteristics of different ecosystem types, the relevant indicators of different characteristics, the potential to aggregate data across different characteristics to derive an overall measure of the condition of a single EU, the aggregation of condition measures for multiple EUs of the same type, and the approach to recording changes in ecosystem condition over time.

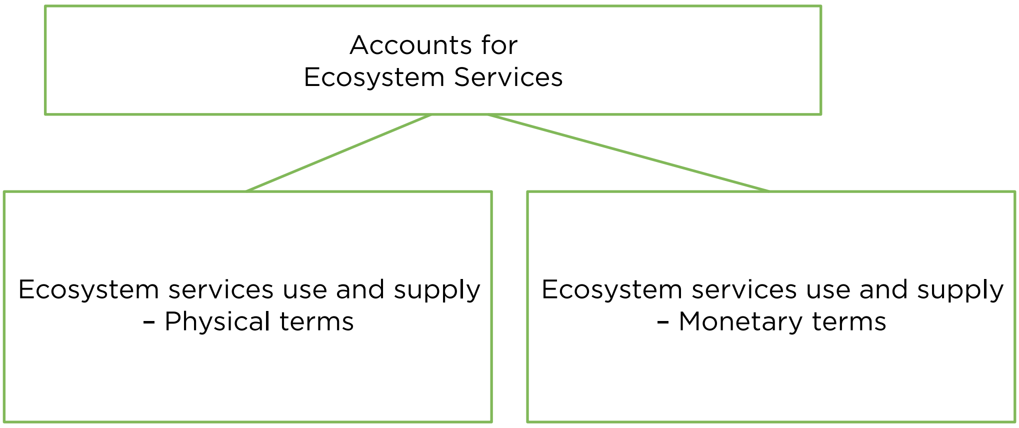
Ecosystem asset accounts	• Ecosystem assets require integration of data on a range of characteristics with different units of measure. • In the ecosystem monetary asset account, the opening and closing stocks of ecosystem assets are estimated using the net present value of the future stream of each ecosystem service – covering provisioning, regulating, and cultural services. It is assumed that the individual services are mutually exclusive and can be aggregated • Accounting for ecosystem assets in monetary terms may appear more tractable, since a single unit of currency is used. However, the complexities in accounting for the changes in assets remain. • Ecosystem asset tables are designed to give a broad picture of the potential of ecosystem accounting to organize information across a range of areas and from multiple perspectives. It may be useful to consider that these tables show a summary of information coming from a broader database containing more detailed data on ecosystem condition, changes in condition and extent, and expected ecosystem service flows. As a matter of compilation practice, it is recommended that focus be placed first on the description and measurement of the relevant characteristics before consideration of aggregation.

In national accounting terms, the concept of ecosystem degradation has a specific role. It represents the capital cost that should be attributed to a user of an ecosystem asset in generating an income stream. Thus, degradation should not include changes in the value of the asset that arise for other reasons. In particular, reductions in asset value due to unforeseen events, which are not part of the use of the asset in production (e.g., due to natural disasters), are not considered part of degradation for accounting purposes. Further, it is possible that the value of an asset changes solely due to changes in prices. These are considered revaluations for accounting purposes and are separately recorded.

Note: For the purposes of SEEA EEA, it is not necessary to build complete ecosystem models and measure every possible stock and flow. Rather, what is needed is to identify the most relevant aspects of ecosystem assets from the perspective of providing aggregated information for measuring trends and comparing ecosystem assets for policy and analytical purposes.

B. Accounting for Ecosystem Services

The aim of accounting for ecosystem services is to organize information on the flows of ecosystem services by type of service, by ecosystem asset, and by economic units involved in generating and using such services. This section describes the supply of ecosystem services by ecosystem assets and the use of these services by economic units, including households as one of the most important aspects of ecosystem accounting. These are the flows that reflect the link between ecosystems and economic and human activity. The supply and use table records the actual flows of ecosystem services provided by ecosystem assets and used by economic units during an accounting period. The data relate to a given geographical aggregation and should be structured by type of ecosystem service. The table may be compiled in both physical and monetary terms.



To interpret the supply and use table, it is important to distinguish between economic units and ecosystem assets in relation to the supply and use of ecosystem services. Following the ecosystem accounting model, only ecosystem assets can supply ecosystem services that are then received by economic units.

An important difference between the supply and the use tables lies in the focus of the use table, which is on the link between ecosystem services and different types of beneficiaries, while the supply table focuses on the supply from types of EU.

Ecosystem services supply table. A likely challenge in compiling the supply table is attributing the supply of ecosystem services to a specific EU. This may be an issue with provisioning services, but it may be so with regulating services and some cultural services in cases where the service is provided through a combination of ecosystem types. Therefore, it is recommended that, as a first step in accounting for ecosystem services, compilers create a table showing which ecosystem services are likely to be supplied from different EU types for their country or target geographical area. For this task, it is relevant to use a classification of ecosystem services such as CICES as a type of checklist. It is to be expected that some services, particularly regulating ones such as carbon sequestration, are supplied by more than one EU type. The supply of other ecosystem services may be a result of the combined production of neighboring EU types such as cultural services supplied in a mixed landscape setting. In these cases, some allocation between EU types are required.

The ecosystem services supply table can be compiled in monetary terms, usually by applying appropriate prices to the physical flows of each ecosystem service. Direct measurement of values may be possible for some provisioning services.

Ecosystem services use table. The use table may be compiled in both physical and monetary terms. In physical terms, entries will be limited to measures of indicators for each ecosystem service. Note that since supply must equal use, the unit of measurement applied for each ecosystem service must be the same in both the supply and use table in order so a balance can be obtained.

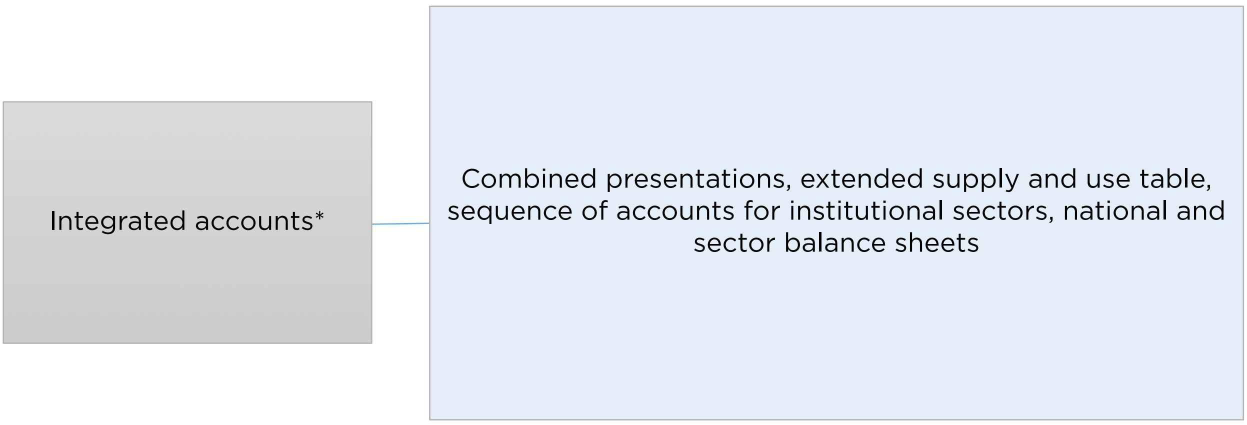
An important difference between the supply and the use tables is that the focus of the latter is on the link between ecosystem services and different types of beneficiaries, while the former focuses on the supply from certain types of EU.

While the supply of ecosystem services can be directly linked to a spatial area (e.g., to an EU), there is no requirement that the location of the beneficiary be the same as the location of the area from which the ecosystem service is supplied. This is especially the case for regulating services, but also applies to some cultural services.

C. Integrated accounts

These accounts integrate ecosystem accounting information with standard economic and national accounts data.

The discussion on the ecosystem services supply and use account highlights the potential for information on ecosystem services to be integrated with information presented in standard supply and use or input-output tables. However, the accounts described in the previous sections do not involve integration of information on ecosystem assets or services with the standard national accounts. Since one of the motivations for the development of ecosystem accounting is integration with the standard national accounts, this section shows how this step might be achieved.



The integration of ecosystem asset values is a complex process with the following major challenges:

1. First, in a full System of National Accounts (SNA) and SEEA Central Framework balance sheet, there are values recorded for natural resources, such as timber and fish. Since the value of these resources is embedded in the value of ecosystem assets, it is necessary to appropriately ensure the removal of double counting of these resources. This also applies to various cultivated biological resources such as orchards and vineyards.

2. Second, in many countries, the value of land is recorded in the SNA balance sheet, which is based on its market price. Since there is a generally well-established land market value, balance sheet values may be obtained more directly than by using NPV techniques as applied in resource accounting. The market values of land, particularly agricultural land, may capture the value of some ecosystem services to some extent. However, they may not capture a full basket of ecosystem services, particularly those that have clear public good characteristics and longer-term benefits. Also, the land value may well reflect aspects that are not ecosystem services in nature such as location and the value of alternative uses.

Basic Concepts in Constructing Monetary Ecosystem Accounts and Valuation in Ecosystem Accounting

Accounting for ecosystems in monetary terms is critical in ecosystem accounting as it integrates information on ecosystems with measures of economic activity. This considers alignment of the spatial coverage of ecosystem data and measures of economic activity, possibly using information on land use or land ownership, such that flows of ecosystem services and changes in ecosystem assets can be linked directly to measures of output, employment, and value added in the same spatial areas.

A number of motivations exist for the valuation of ecosystem services and ecosystem assets depending on the purpose of analysis and the context underlying the use of valuations in monetary terms. Different motivations point to different requirements in terms of concepts, methods, and assumptions. Often, valuation is dismissed or utilized without a more careful consideration of the relationship between the purpose of analysis and the choice of valuation concepts and methods.

Key considerations:

❖ In ecosystem accounting, the primary purpose of valuation is the integration of ecosystem accounting information with information in the standard national accounts. For this purpose the valuation used in ecosystem accounting must be consistent with the valuation concept used in the national accounts

❖ SEEA-EEA recognizes that the term valuation can mean different things. Among accountants and economists, valuation is almost always used in the context of placing a monetary price (dollar value) on assets, goods, or services. In other contexts, valuation may refer to a more general notion of recognizing significance or importance. In SEEA-EEA, the focus is on valuation in monetary terms without discounting the role or importance of other concepts of value.

❖ Monetary valuation in the SEEA-EEA is applied to the valuation of ecosystem services and the valuation of ecosystem assets. There is a direct connection made between these two distinct targets of valuation, whereby the value of ecosystem assets at any given time, usually the date to which the balance sheet relates, is equal to the NPV of the future flows of ecosystem services that are expected to occur.

- ❖ The application of the NPV technique is required since there are no markets for the buying and selling of ecosystem assets, where the value of all ecosystem services is captured.

- ❖ From a practical perspective, the need to apply NPV techniques to value ecosystem assets implies that the valuation of ecosystem assets cannot be determined directly. Instead, the asset value relies on the estimation of the value of ecosystem services. Thus, in an accounting context, the valuation of ecosystem services and the valuation of ecosystem assets are distinct but related tasks.

- ❖ It is important to note that the monetary value in the accounts is not equal to the welfare-based economic value. For example:

    - The value concept in accounting is based on exchange values, i.e. the price at which informed buyers and sellers are willing to exchange a good or service. Where ecosystem services or benefits derived from these services are not traded in a market, non-market valuation methods have to be applied that provide comparable value metrics. In particular, the consumer surplus element of value, which is excluded in an accounting approach to valuation, should be excluded from the value estimates for the ecosystem accounts. Consequently, the value recorded in the ecosystem account does not represent the full societal (economic) value of ecosystem services supply or an ecosystem asset. To analyze the societal value of (change in) ecosystem assets or services supply, (change in) consumer surplus needs to be included. The accounts can provide the basis for such valuation (for instance based on the TEV principles) by providing the required physical information and part of the monetary information. Generally, it should be noted that it is only practically feasible to analyze changes in the societal value using a TEV approach, for instance as a consequence of the implementation (or not) of a policy option. The accounts, on the other hand, aim to record overall levels of and changes in natural capital, using accounting-conform monetary values.

SUMMARY OF VALUATION METHODS AND THEIR USE IN ECOSYSTEM ACCOUNTING (Technical Recommendations)

To design a valuation approach for a specific ecosystem service, it is necessary to understand how the service leads to the generation of benefits, and the relation between these benefits and the recording of the related economic activity in SNA.

Valuation method	Description	Comments	Suitability for ecosystem accounting
Unit Resource Rent	Prices determined by deducting costs of labor, produced assets and intermediate inputs from the market price of outputs (benefits)	Estimates are affected by the property rights and market structures surrounding production. For example, open access fisheries and markets for water supply often generate low or zero rents	In principle this method is **appropriate** but requires a consideration of market structures.
Production function, cost function, and profit function methods	Prices obtained by determining the contribution of the ecosystem to a market based price using an assumed production, cost or profit function.	In principle these are analogous to resource rent but generally focused on the valuation of regulating services. It may be difficult to estimate the functions.	These are **appropriate** provided the market-based price being decomposed refers to a product rather than an asset – e.g., value of housing services rather than the value of a house.
Payment for Ecosystem Services (PES) schemes	Prices are obtained from markets for specific regulating services (e.g., in relation to carbon sequestration)	Estimates are affected by the type of market structures put in place for each PES (see SEEA EEA 5.88-94)	This is **potentially adequate** depending on the nature of the market structures.
Hedonic pricing	Prices are estimated by decomposing the value of an asset (e.g., a house block including the dwelling and the land) into its characteristics and pricing each characteristic through regression analysis	This is a data-intensive approach and separating the effects of different characteristics may be difficult, unless there are large sample sizes.	This is **appropriate** and heavily used in the pricing of computers in the national accounts.
Replacement cost	Prices reflect the estimated cost of replacing a specific ecosystem services using produced assets and associated inputs.	This method requires an understanding of the ecosystem function underpinning the supply of the service and an ability to find a comparable "produced" method of supplying the same service.	This is **appropriate** under the assumptions (i) that the estimation of the costs reflects the ecosystem services being lost; (ii) that it is a least-cost treatment; and (iii) that society would replace the service if it was removed. (Assumption (iii) may be tested using stated preference methods.)
Damage cost avoided	Prices are estimated in terms of the value of production losses or damages that would occur if the ecosystem services were reduced or lost due to ecosystem changes (e.g., as a result of pollution of waterways).	It may be challenging to determine the value of the contribution/impact of an individual ecosystem service.	This is **appropriate** under the assumptions (i) that the estimation of the damage costs reflects the specific ecosystem services being lost; (ii) that the services continue to be demanded; and (iii) that the estimated damage costs are lower than potential costs of abatement or replacement.

Averting behavior	Prices are estimated based on individuals' willingness to pay for improved or avoided health outcomes.	Requires an understanding of individual preferences and may be difficult to link the activity of the individual to a specific ecosystem service.	This is likely **inappropriate** since it relies on individuals being aware of the impacts arising from environmental changes.
Restoration cost	This refers to the estimated cost to restore an ecosystem asset to an earlier, benchmark condition. It should be clearly distinguished from the replacement cost method.	The main issue here is that the costs relate to a basket of ecosystem services rather than a specific one. This is often used as a means to estimate ecosystem degradation, but there are issues in its application in this regard.	This is inappropriate since it does not determine a price for an individual ecosystem service.
Travel cost	Estimates reflect the price that consumers are willing to pay in relation to visits to recreational sites.	The key challenge here is determining the actual contribution of the ecosystem to the total estimated willingness to pay. There are also many applications of this method with varying assumptions and techniques being used with a common objective of estimating consumer surplus. Finally, some travel cost methods include determining the value of time taken by the household, which is beyond the scope of the production boundary used for accounting purposes.	This is **potentially appropriate** depending on the actual estimation techniques and whether the approach provides an exchange value, i.e., excludes consumer surplus.
Stated preference	Prices reflect willingness to pay based on contingent valuation studies or choice modelling.	This approach is generally used to estimate consumer surplus and welfare effects. These are within the range of techniques used there can be potential biases that should be taken into account.	This is **inappropriate** since it does not measure exchange values
Marginal values from revealed demand functions	Prices are estimated by utilizing an appropriate demand function and setting the price as a point on that function using (i) observed behavior to reflect supply (e.g., visits to parks) or (ii) modelling a supply function.	This method can use demand functions estimated based on travel cost, state preference, or averting behavior methods. The use of supply functions has been termed the simulation exchange method (Campos and Caparros, 2011)	This is **appropriate** since this method aims to directly measure exchange values. However, the creation of meaningful demand functions and estimating hypothetical markets may be challenging.

Tools and methodologies that can be used in ecosystem accounting

There are several ways to account for ecosystems, ranging from the use of mapping and remote sensing data to modelling and the conduct of survey/focus group discussions. This section cites some of the applicable tools in the construction of physical ecosystem accounts that could later serve estimating monetary accounts.

Geographic Information System and Remote Sensing

- The delineation of units should be undertaken in concert with the development of spatial databases in Geographic Information Systems (GIS).
- These databases could contain information such as soil type and status, water tables, rainfall amount and pattern, temperatures, vegetation, biodiversity, slopes, altitude, etc., as well as, potentially, information on land management and use, population, and social and economic variables. Such information may also be used to assess flows of ecosystem services from given spatial areas to relevant beneficiaries.
- Given the spatial diversity and heterogeneity of ecosystems, ecosystem asset accounts generally needs to be developed in a GIS context. Although the specific datasets should be determined on a country basis, a number of basic resource accounts are fundamental to ecosystem accounting and typically need to be developed in each country. Among others, these include:
    - land accounts (land cover change, Sedimentation)
    - water accounts (Water Balance, Fishery Zoning)
    - carbon accounts
    - soil and nutrient accounts
    - forest accounts
    - biodiversity accounts
- Ecosystem services generally have a high spatial variability. For instance, both marine flood risk and the mitigation of flood risk by a protective ecosystem vary as a function of local topography and distance from the sea. The spatial aspect of regulating services means that the generation of regulation services is best measured in a GIS context. It should be noted that the lack of spatial overlap on how the services are provided and used (i.e., where are the beneficiaries) is a significant reason for using GIS.

- In a GIS, the processes and/or components of the ecosystem that support the supply of ecosystem services need to be recorded, alongside the relevant features of the physical or socio-economic environment in which the service is generated. The required resolution depends on the specific ecosystem service.

Spatial inputs may include:
1. Historical Remote Sensing/Satellite Imagery;
2. Topographic map;
3. Digital Elevation Model (DEM);
4. Landcover/Landuse/Vegetation Map
5. Soil type
6. River network map

Survey / Primary data gathering / Focus Group Discussion (FGD)

- In instances where data are not available or not sufficient to undertake the valuation, actual field survey or primary data gathering may be conducted instead. Survey questionnaires can be generated for specific information needed.
- FGD is a form of qualitative research in which a group of people are asked about their beliefs or opinions on certain issues or topics.
  - Questions are asked in an interactive group setting where participants are free to talk with other group members.
  - During this process, the researcher either takes notes or records the vital points raised during the FGD. Participants should be carefully selected to ensure effective and authoritative responses.

Table analysis using MS Excel Pivot Table

- To further analyze the generated table, use the Pivot Table tool incorporated in MS Excel.
- For the land accounts, information on land cover can support environmental policy by providing information on the status of and trends in the land cover in a watershed.

Bathymetric survey

- Bathymetry is the study of underwater depth of lakes or ocean floors. It is the underwater equivalent of topography.
- Use the bathymetry of the water body to support the Delft3D model

Equipment needed:

1. Echo sounder
2. Boat
3. Geographic Positioning System (GPS)

Sednet- Sediment Network Modelling

- The SedNet model is used to quantify the sediment inputs and outputs (source and deposition) of the watershed in kilotons per year. It provides a summary budget containing all parameters generated from the model. Results are exportable and are then post-processed in GIS software.

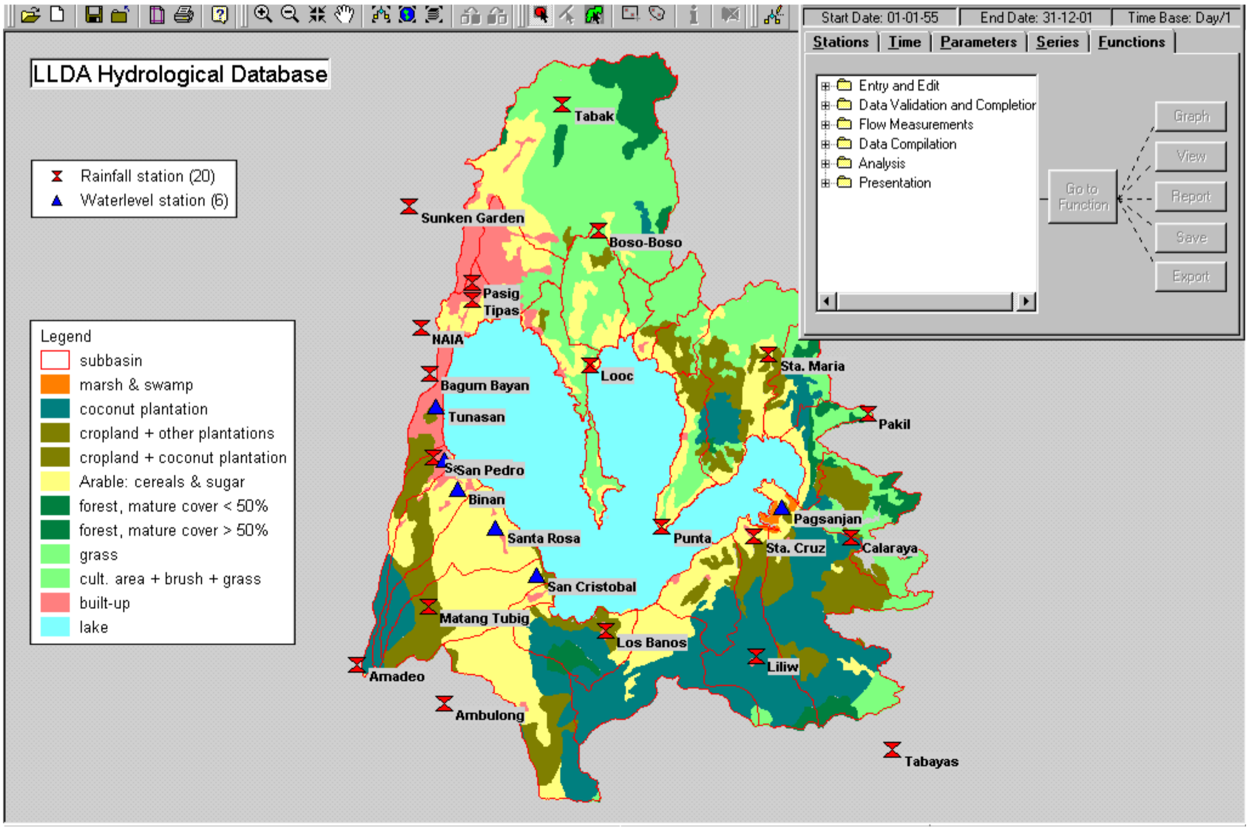
Spatial inputs include:

1. **Digital Elevation Mode**l (DEM) to define the stream and create sub-catchments
2. **Soil Loss** based on **Rainfall Erosivity** (R) **Soil Erodibility** (K) **Slope Length** (L), and **Slope Steepness** (S) factors based on the Revised Universal Soil Loss Equation (RUSLE)
3. Annual Average **Rainfall**, PET/Rainfall ratio
4. **Streamflow** for flow regionalization

Note: Refer to the training booklet on SedNet prepared for WAVES

<u>**HYMOS- Hydrological Modelling System**</u>

- HYMOS is an information system for storage, processing, and presentation of hydrological and environmental data. HYMOS combines an efficient database structure with powerful tools for data entry, validation, completion, analysis, retrieval, and reporting.
- Currently, this model is being used for Laguna de Bay account only.

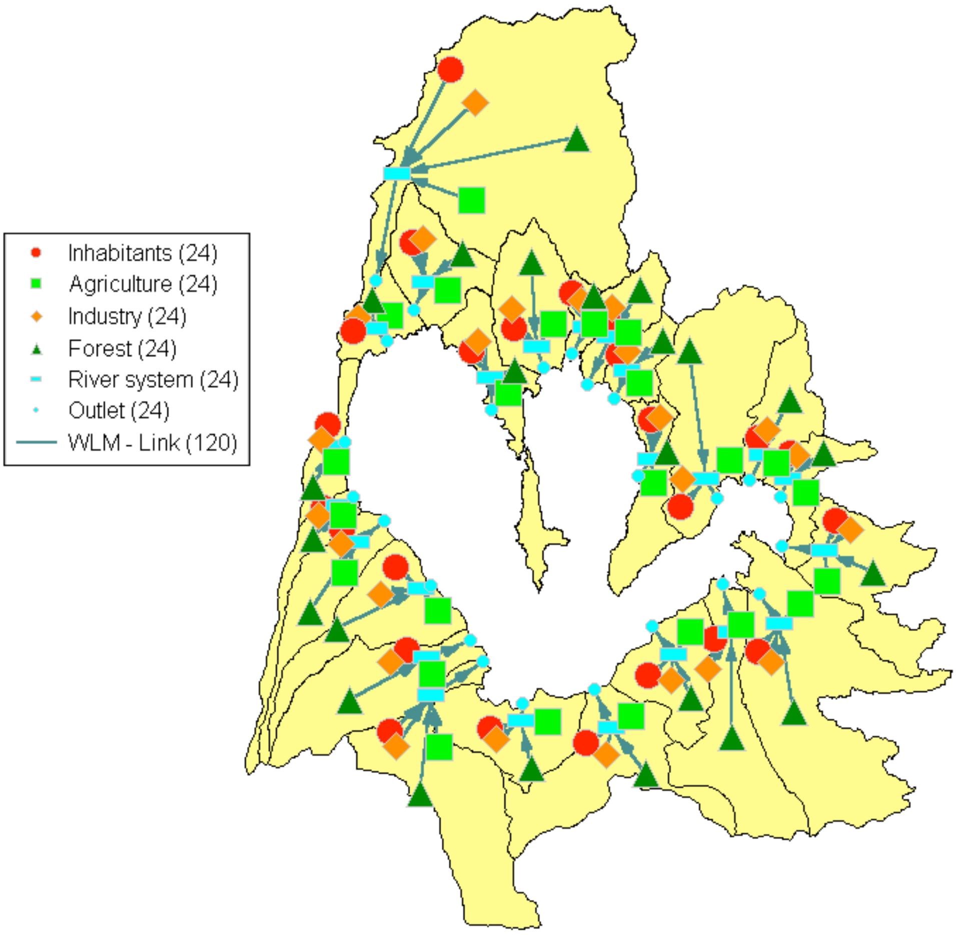


Spatial inputs include the following GIS datasets (shapefile):
1. River network
2. Road network
3. Inland water
4. Water Quality Monitoring station
5. Hydro-meteorological Monitoring station
6. Landcover/Landuse/vegetation
7. Watershed delineation
8. Elevation

Other inputs includes:
1. Historical Water Quality data
2. Historical Hydro- meteorological data (Rainfall, wind speed, wind direction, temperature)
3. Streamflow

Waste Load Model (WLM)

- To estimate the actual and future discharge of waste loads to surface water and the effects of managerial strategies on the future discharges
- The Waste Load Model WLM can be used in stand-alone applications, but most often it is integrated within the Decision Support System (DSS) for water quality analysis.

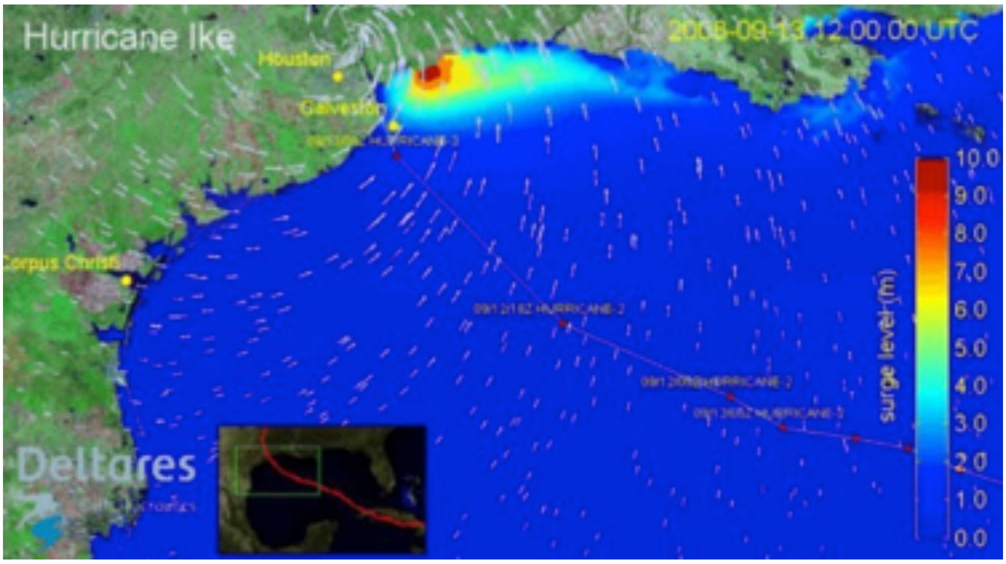


Spatial inputs include the following GIS datasets (shapefile):
1. River network
2. Inland water
3. Landcover/Landuse/vegetation
4. Watershed delineation
5. Elevation

Inputs include:
1. Historical data on industrial discharge;
2. Historical data on domestic discharge;
3. Historical data on agricultural discharge
4. Historical data on streamflow
5. Population/Inhabitants data

Delft3D (Hydrodynamics and Water Quality Modeling suite)

- Delft3D (by DELTARES) is a powerful modelling suite that focuses primarily on application in the free surface water environment.
- Delft3D simulates two-dimensional (in either the horizontal or a vertical plane) and three-dimensional flow, sediment transport and morphology, waves, water quality and ecology, and is capable of handling the interactions between these processes.
- Delft3D is used to calculate the lake/water volume at different levels.



Inputs include:

1. Bathymetry
2. Meteorological data
    a. (rainfall, wind speed/direction, evaporation)
3. Rainfall run-off
4. Historical lake/water level
5. Flow velocity

Spatial inputs include the following GIS datasets:

1. Groundwater Resource
2. Shoreline delineation
3. Use/s of the water body

Part III Pilot Ecosystem Accounts in the Philippines

How to construct Land Accounts

Land accounts include information on land cover, land use and/or land titles. Land accounts are important to support strategic environmental policy by providing information on the status of and trends in the land cover and use watersheds, influencing both the quantity and quality of water and other ecosystem services within watersheds. Moreover, it can inform the debate on population settlement, agricultural productivity, health of environment, cost and benefits of economic activities, investment on environmental protection (e.g., biodiversity conservation, assessment of flood risk and erosion in watersheds). It is important to note that the land account differs from the ecosystem extent account. The former is less detailed and focuses on land cover whereas the latter also considers ecosystem/land uses.

An understanding of the implications of changes in land cover and land use is a fundamental part of planning for sustainable development. On the one hand, the transformation of land cover and land use by human action can affect the integrity of natural resource systems and the output of ecosystem goods and services. On the other, by careful planning, the development of new patterns of land cover and use can enhance the well-being of communities (Millennium Ecosystem Assessment, 2005).

Land accounts aim to present the implications of changes in land cover and land use and ecosystems of a particular watershed or focus area as a fundamental part of planning for sustainable development. The accounts can provide guidance on efforts at land conversion that may not be aligned with development plans or planning laws, enabling better enforcement of such regulations.

There are four basic guidelines to follow in producing a Land Account:

1. Integrate existing environmental and economic information at the finest level possible.
2. Use GIS technology to integrate data and information.
3. Present results at various geographic levels (e.g., watershed, region, municipality, community, and other basic spatial unit) depending on the expected decision outcomes.
4. Present results for at least two time periods for comparison and preparation of land accounting matrices.

To develop a land account, four major steps are followed:

Step 1.
Data Scoping

1. **Identification of objectives and end goal of land accounting.** The concerned agency/or institution tasked to develop a land account shall identify the objectives of land accounting, delineate watershed or basic spatial unit/s to be analyzed or assessed, identify the sources of information (maps, GIS datasets, etc.) and the level of information to be included in land accounting.

2. **Selection of parameters and aggregation level of information to be included in the account**

   A. Parameters
   - Land cover classification derived from NAMRIA

     Land Cover (AGG12)
     Annual Crop
     Perennial Crop
     Built-up
     Open/Barren
     Shrubs
     Grassland
     Fishpond
     Marshland/Swamp
     Open Forest
     Closed Forest
     Mangrove Forest
     Inland Water

   - Extent of each land cover
   - Changes in land cover (i.e., addition and reduction)

   B. Disaggregation - national, regional, provincial, watershed, etc. The extent of accounts can be determined depending on the uses. Land cover accounts can be disaggregated/aggregated to national, regional, provincial, watershed, etc.

3. **Conduct of data assessment to identify gaps**

Geospatial Data	Metadata Summary					
	Source	*Processing From source*	*Date Released*	*Type of file/ format*	*Processing by GIS user*	*Issues*
Land Cover 2003 2010	NAMRIA	Rectification by NAMRIA based on coastlines	2003; 2010	Vector, shapefiles	Overlay Mapping of potential mis-classifications	Not ground validated With possible mis-classifications Different resolution for two comparing years

Data quality. The spatio-temporal resolution and accuracy are vital for data and information assessment of a particular spatial unit. Consistent land cover classification and spatial resolution of land cover data in future years will maximize the comparability of the data over time, resulting in more accurate accounts that take less time to compile.

4. **Consolidation of outputs on data assessment addressing the data gap.** After finalizing the scope, selection of parameters, and conducting data assessment, there should be metadata (in Excel form), which consolidates all the outputs before the start of data collection.

Step 2. Data Collection	
Step 2. **Data Collection**	The next step is collecting data identified in the previous step. **GIS Datasets**. Data sources for land accounts can be generated using secondary data from various sources, including government agencies, international organizations (e.g., NAMRIA, DENR-FMB, ESA, among others). Such data corresponds to these institutions' mandates and may be acquired in close coordination with the said agencies. Data on land cover and land classifications including GIS datasets may be provided by NAMRIA, the mapping agency of the Philippines. On the GIS datasets under data collection, the pilot accounts basically rely on data provided by NAMRIA. Under this step there are three major activities conducted by NAMRIA a) Pre-processing and interpretation activities; b) field validation activities, and c) post-processing and final processing activities. For more details on data and map preparation the agency preparer/account preparer can coordinate with NAMRIA. The data requested from NAMRIA should cover at least two time periods to facilitate comparison. The following are the sub-activities in collecting the data needed for land accounting: 1. Identify the possible agency or organization that can provide the needed data based on the objectives of land accounting. 2. Coordinate with the concerned agency on how to secure the data needed for land accounting (e.g., this may be through a formal written request) 3. Schedule the collection of data. Disclaimer: It is understood that land cover classification can be compared with other thematic maps showing slope type, soil type, elevation category, other forms of land classification, among others. The methodology being used for this land accounting, however, focuses only on land cover classification per land cover units/basic spatial unit.

Step 3. Development of maps and tables of land cover units	This succeeding step includes the preparation and development of maps and tables for the identified land cover units. Land Cover Classification and other units for comparison can be prepared using the applicable maps and GIS datasets from NAMRIA. The ensuing assessment or analysis covers two years.

Step 3.
Development of maps and tables of land cover units

This succeeding step includes the preparation and development of maps and tables for the identified land cover units. Land Cover Classification and other units for comparison can be prepared using the applicable maps and GIS datasets from NAMRIA. The ensuing assessment or analysis covers two years.

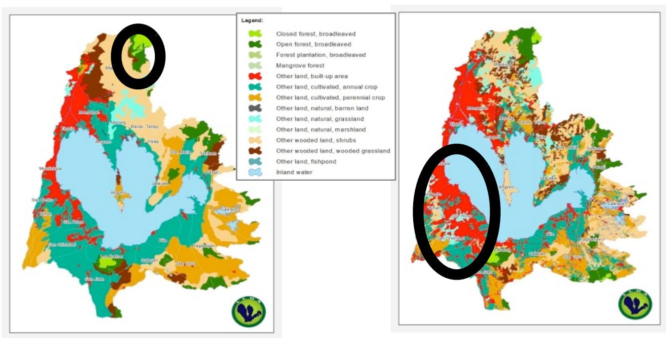
However, it is assumed that the concerned government agency/land account preparer has a GIS specialist to further reclassify, edit, process, and validate the data provided by NAMRIA using the GIS software.

Preparation of maps using datasets provided by NAMRIA. Delineation of land cover classifications on the identified land cover units (watershed, region, forest zones, among others). The Land Classification provided by NAMRIA is based on the 21 categories patterned from FAO-Forest Resources Assessment standard classification. The coverage of land classification depends on the basic spatial unit being analyzed.

Analysis of the generated maps per land classification category

- Overlay of two periods in a GIS interface like ArcGIS, QGIS, Manifold or programming language like R and NetLogo.
- Presentation of map outputs
- Adjustments or refinement of map outputs based on the comments and recommendations

Preparation of final maps



Creation of tables of land cover classification per land cover units

- Using MS Excel operation, specifically the use of Pivot Table, the tables on land cover types will be prepared for the target land cover units.
- Analysis of the information generated from the tables will be prepared
- Report writing/output preparation

Preparation of Final Tables

Presentation of outputs
Final processing and editing of generated tables
Preparation of land accounting table
Report writing

	Example: Land Cover Accounts matrix
	(table below)

Example: Land Cover Accounts matrix

Land Cover 2003	Area in Hectares	Area Percentage	Land Cover 2010	Area in Hectares	Area Percentage
Annual Crop					
Perennial Crop					
Built-up					
Open/Barren					
Grassland					
Shrubs					
Wooded grassland					
Open Forest					
Closed Forest					
Mangrove Forest					
Inland Water					
Marshland/Swamp					
Fishpond					
Grand Total					

Note: Do not use decimals when presenting figures unless the values are very certain. Usually the figures in the land account are converted into hectares or square kilometers.

Step 4.
Calculation of land cover change over time

After constructing land accounting table and data, land cover change over time will be calculated by following this procedure:

Preparation of opening stock and closing stock relative to two years. The land cover matrix and physical accounts are prepared with the corresponding tables using pivot table in MS Excel.

Example: Land cover change matrix - Laguna de Bay Region

Land Cover Change Matrix of Laguna de Bay Region (in hectares)

LAND COVER	Opening Area 2003	Change in Land Cover Types of Laguna de Bay Region (2003 to 2010)															Closing Area 2010
		Closed forest, broadleaved	Forest plantation, broadleaved	Inland water	Mangrove forest	Open forest, broadleaved	Other land, built-up area	Other land, cultivated, annual crop	Other land, cultivated, perennial crop	Other land, fishpond	Other land, natural, barren land	Other land, natural, grassland	Other land, natural, marshland	Other wooded land, shrubs	Other wooded land, wooded grassland	Net Change	
Closed forest, broadleaved	7,843.86	3,942.30	0.00	7.19	0.00	3,837.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	57.20	0.00	2,580.60	5,263.26
Forest plantation, broadleaved	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	59.80	59.80
Inland water	90,115.53	0.00	0.56	89,458.21	0.00	0.45	229.70	54.67	44.53	0.00	0.34	2.43	0.18	301.27	23.22	6,381.03	96,496.56
Mangrove forest	93.90	0.00	0.00	59.06	0.00	0.00	4.94	0.00	0.00	0.00	0.00	0.01	0.00	29.88	0.00	92.43	1.47
Open forest, broadleaved	41,769.65	1,274.50	18.72	419.69	0.00	26,205.24	228.73	188.06	2,526.16	0.00	1.18	124.43	0.00	8,057.37	2,725.57	1,125.03	40,644.63
Other land, built-up area	52,056.74	0.00	0.00	558.71	0.00	49.64	49,784.52	524.27	151.12	0.34	56.90	531.36	0.00	190.98	208.92	40,842.64	92,899.39
Other land, cultivated, annual crop	96,956.82	40.45	0.00	3,342.44	1.47	1,048.86	28,466.41	39,517.60	10,291.00	75.75	270.71	5,581.30	4.17	4,462.36	3,854.32	39,599.71	57,357.11
Other land, cultivated, perennial crop	84,673.87	0.00	9.29	942.30	0.00	704.14	7,483.47	11,978.36	37,096.94	0.00	2.75	561.47	0.00	21,340.78	4,554.38	17,618.49	67,055.38
Other land, fishpond	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	76.09	76.09
Other land, natural, barren land	1,151.91	0.00	0.00	358.36	0.00	0.00	378.41	389.46	8.31	0.00	0.00	4.58	0.00	5.25	7.55	449.79	702.12
Other land, natural, grassland	9,661.86	0.00	0.00	63.29	0.00	94.53	2,748.91	2,432.10	566.57	0.00	115.31	2,249.73	0.00	467.19	924.24	10,269.60	19,931.46
Other wooded land, fallow	26.28	0.00	0.00	0.00	0.00	10.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	15.93	0.00	21.93	4.35
Other wooded land, shrubs	89,621.49	6.02	31.23	1,092.59	0.00	7,174.38	1,549.70	1,532.74	12,289.07	0.00	79.55	9,202.57	0.00	36,147.05	20,516.58	11,724.84	77,896.65
Other wooded land, wooded grassland	21,764.20	0.00	0.00	194.74	0.00	1,519.87	2,024.61	739.85	4,081.69	0.00	175.39	1,673.59	0.00	6,821.38	4,533.08	15,583.65	37,347.85

Finalization of summary land cover change matrix
The land cover change matrix is summarized to show the changes in hectares and rate of land cover change. Below is a sample summary.

Example: Land Cover Change, Laguna de Bay Watershed

Land Cover	Land Cover 2003		Land Cover 2010		Change in Land Cover		
	Hectares	Share of Land Cover	Hectares	Share of Land Cover	Change in Hectares	% Change Land Cover	% Change in Share of Land Cover
Annual Crop							
Perennial Crop							
Built-up							
Open/Barren /fallow							
Shrubs							
Grassland							
Wooded grassland							
Marshland/Swamp							
Open Forest							
Closed Forest							
Mangrove Forest							
Inland Water							
Total							

Step 5. Analysis of land cover change	This includes analysis of the changes indicated in the land cover accounts for the accounting period, valuation of the derived figures, and finalization of the matrix for reporting purposes. Analysis should focus on the critical figures and trends. Refer to Annex A for the detailed process of developing land accounts

How to construct Water Accounts

The Water Account records the physical stocks and flows of water bodies in a given area. Its overall objective is to assess the water resources of a defined hydrologic boundary for a specific period of time. Data and information must be collected relative to a specified time period and spatial reference. Water balance shows the water volume during a certain period of time and the difference between total inflow and outflow changes of water storage within a defined area. It involves the hydrologic application of techniques denoting measurements of both stocks and flows of water. The quantification of water is an important issue in social and economic development, wherein water balance can indicate the distribution of water within a hydrologic regime such as a watershed area.

Accounting for water balance is used to determine the availability of water and general condition of the quantity of water resources in a hydrological system of a water body (i.e., lake). The equation considers the entire amount of water inflows and outflows of the basin. Hence, the distribution water into the hydrologic component is distinguished from its various hydrologic components.

The SEEA Water (https://unstats.un.org/unsd/envaccounting/seeaw/seeawaterwebversion.pdf) provides a detailed guideline in the development of water accounts.

In developing the water balance account, the following steps must be undertaken:

Step 1.
Data Collection

This covers the collection of maps with attributes of watershed delineation, land cover, topography and soil characteristics, and records of the meteorological data and station location coordinates. The maps serve as inputs to the computer mapping software to generate layers of thematic maps showing watershed boundaries, land cover extents, soil type and locations of weather monitoring stations. Data on precipitation and evaporation are used as inputs to the hydrological model.

Data Needs	Concerned Agency	Source of information	File type	unit
		Spatial data		
Watershed boundaries	LLDA	Watershed map	Vector file	hectares
Land Cover	NAMRIA	land cover map	Vector file	hectares
Elevation	NAMRIA	Digital Elevation Map	Raster file	meters
Soil Characteristics	BSWM	Soil Type Map	Vector file	hectares
Weather Monitoring Station Location	PAGASA, ASTI	Records	coordinates	UTM
		Weather data		
Precipitation	PAGASA, ASTI	rainfall depth	historical records (time-series)	millimeters
Evaporation	PAGASA, ASTI	evaporation depth	historical records (time-series)	millimeters
		Water flow		
River discharge	DPWH	flow rate	historical records (time-series)	cu.m/sec
Groundwater flow	NWRB	flow rate	historical records (time-series)	cu.m/sec

Step 2. Data Processing through Computer Mapping Software	The data collected is normally processed using a GIS program to delineate the watershed boundaries from the available watershed boundary shapefile. It is overlaid over the land cover map to produce a thematic watershed-delineated land cover map. The same procedure applies to the production of watershed-delineated soil map. The weather stations is plotted through the location coordinates into the watershed-delineated land cover map using a GIS program. This should yield a thiessen polygons[2] for the distribution of rainfall and evaporation over the watershed.
Step 3. Hydrological Computer Modelling	Data generated from GIS such as watershed boundary, land cover types and soil characteristics serve as inputs to generate watershed-related information and characterization using a hydrology software. The rainfall and evaporation data together with the setting of desired time period will be processed and simulation activities will be conducted using the software to determine the amount of streamflow generated by the watershed.
Step 4. Application of a Water Balance Equation	The flow of water in and out of a hydrologic system is described through a water balance equation. It shows the hydrologic cycle and renewal and loss of water quantity of an area. The general equation of the balance is described below: $P + Q_I + G = Q_O + E + \text{Abstraction} + \Delta S$ where: P is precipitation, Q_I is inflow from surface run-off, G is the groundwater flow, Q_O is the outflow of water, E is the release of water through evaporation, and ΔS is storage changes. Hence, the balance of inflow and outflow of water is described in the formula.
Step 5. Preparation of Water Account Tables	The simplest general form, water balance is expressed as inflow = outflow ± change in volume. This is an important method to construct accurate estimates of water movement and distribution of water in a lake. As **inflow of water into the lake**, the origin of water is from weather-driven precipitation (P), surface run-off (Q) from the catchment, and gradual release of groundwater flow (GW). These inflows constitute the total quantitative water condition of the lake. Based on the hydrologic system of the lake, the process of lake water stock, infiltration (I) and water uptake of vegetation make up the storage (S) in the lake's hydrology. The **outflow of the water** into the hydrologic regime is in the form of evaporation (E) and river discharge (Q). Evaporation is a form of hydrologic loss and influenced by weather conditions. River discharge is the outflow of lake water into elevations lower than the lake's topography. Human consumption of water should be factored into the computation of the quantity of water.

A summary of water balance is shown in the following table:

Summary of parameter determined for every year and representation of water balance of a lake

	Year 1	Year 2	Year n
Inflow			
Precipitation			
Surface Run-Off from the watersheds			
Groundwater Flow			
Outflow			
Evaporation			
River Discharge			
Water Usage			
Lake water Change			

To standardize data generated from the computer models, use a SEEA-based framework to align the information from the simulation and data collection. SEEA provides internationally accepted standard concepts, definitions, classifications, accounting rules and tables for producing water asset account of the lake and its connection with the economy. Based on SEEA standards, the following table can be used to obtain consistent indicators and descriptive statistics to identify the relationship of the economy and the environment and the state of the environment. In the end, the information provided by the table can be used to improve the management of the lake.

Here is an example of a summary table of various information arranged to SEEA standards.

Year	Surface Water		Groundwater	Soil water	Total
	Lakes	**Rivers**			
1. Opening Stocks					
Increases in stocks					
2. Returns					
3. Precipitation					
4. Inflows					
4.a. from upstream territories					
4.b. from other resources in the territory					
Decreases in stocks					
5. Abstraction					
6. Evaporation/Actual evapotranspiration					
7. Outflows					
7.a. to downstream territories					
7.b. to the sea					
7.c. to other resources in the territory					
8. Other changes in volume					
Net changes					
9. Closing Stocks					

The values of the parameters can be arranged depending on the requirement of the table of SEEA. There are four hydrological regimes which are lakes, rivers, ground water and soil water. Each of the hydrological regimes is taken from the parameters of water balance. For example lake regime inflows from other resources in the territory are the combination of surface run-off from the watersheds and groundwater flow. On the other hand, outflow to other resources in the territory of the lake is the discharge of a river from the water balance. River inflow from other resources in the territory comprises surface run-off from the watersheds and river discharge while outflow to other resources in the territory show the amount of surface run-off from the watersheds. Based on the amount of water released from the ground, the decrease of stock is the result of groundwater flow from the land into the lake and rivers. Both soil water inflow and outflow are from the surface run-off from the watersheds. The net change is the difference between the increase and decrease of stock.

How to construct Ecosystem Condition Accounts

In the SEEA-EEA framework, accounting for ecosystem condition can be done through an assessment of predetermined characteristics for which indicators have been carefully selected. The development of an Ecosystem Condition Account entails evaluation and assessment of terrestrial and aquatic ecosystems (i.e., upland, lowland, coastal, lake) using different parameters and indicators. Essentially, the ecosystem (ES) conditions are inputs in generating ES models.

Here is a sample ecosystem condition account table showing variety of indicators for the selected characteristics.

Type of ecosystem unit			**Ecosystem characteristics**			
	Vegetation	Water	Soil	Biodiversity	Air	!

Note: NAMRIA land cover classification can be used as the type of ecosystem unit

Terrestrial Ecosystem Condition Accounts

Step 1. Identification of the scope	Identify the boundary of the ecosystem, scope and coverage, and level of aggregation/disaggregation (i.e., national, regional, local). Each level has its own set of ecosystem units.
Step 2. Selection of parameters	See parameter table and note below

Data Parameters	***Source***
Climatic Data (rainfall)	DOST
Evapotranspiration Rates	DOST
Soil Texture	BSWM
Slopes	NAMRIA
Elevation	NAMRIA
Water Quality	NWRB, BMB
Land Cover Types and Hectarage	NAMRIA
Risk of flooding and landslides	Susceptibility Models from DENR
Soil Loss	BSWM
Vegetation biomass	FMB
Key biodiversity areas	BMB

Note: Soil loss under current land cover conditions can also be derived using the Revised Universal Soil Loss Equation (RUSLE). It is expressed in tons/hectare/year. Soil loss is also a primary input in modelling sedimentation for the watershed.

Step 3. Assessment of the ecosystem condition	To reflect the ecosystem components and functioning throughout the national, regional, and local scope, the terrestrial condition account intends to register a number of key variables from these two condition indicator groups: ***Geomorphological indicators*** *express the physical parameters that define the landscape which are exogenous to the system. These shall include:* • *Elevation* • *Precipitation* • *Evapotranspiration* • *Slope* ***Environmental State indicators*** *reflect abiotic environmental conditions that are relevant particularly in analyzing regulating services. These shall include:* • *Hazards* • *Soil loss* These should be selected, in addition to land cover, as they are important in understanding the services provided by the uplands to terrestrial areas. 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.
Step 4. Processing of data and reporting	Processing of data on ecosystem condition accounts for the different types of ecosystem assets is done once and does not record changes in condition over time. It should be noted that issues and challenges in the compilation of ecosystem condition accounts are still evident, making it necessary to improve the structure and compilation of these accounts.

Aquatic Ecosystem Condition Accounts

Step 1. Identification, collection, and consolidation of data	Identify the type (e.g., river, lake, coastal, and marine) and scope (i.e., national, regional, or local) of the ecosystem to be assessed.
Step 2. Selection of indicators and parameters	The indicators and parameters should be significant in the evaluation of the ecosystem. This guidebook focuses only on the following aquatic condition indicators: • Bathymetry • Water pollution loading • Water quality • Subsystem condition: coral reefs, mangroves and seagrasses Collect data from different government agencies or institutions, depending on the coverage of the ecosystem.

Data	Sources
• **Water quality data**	Secondary data from LLDA, DENR and other concerned Agencies
• **Water Depth**	Secondary Data from NAMRIA, LLDA
• **Population Data**	Secondary data from PSA
• **Stream Flow**	Secondary data from LLDA, DENR and other concerned Agencies
• **Industrial Effluents (parameter concentrations and volumetric flowrate of wastewater)**	Secondary Data from LLDA, DENR, other concerned Agencies and Industries located in the area of coverage
• **Domestic Effluents (BOD generated per person)**	Secondary data from research journals on BOD loading
• **Agricultural Land Waste (land cover data to determine the total area of agricultural land and unit BOD generated per area)**	Secondary data from NAMRIA and Secondary data from research journals on BOD loading
• **Forest Land Waste (land cover data to determine the total area of forest land and unit BOD generated per area)**	Secondary data from research journals on BOD loading
• **Solid Waste (population data, solid waste generation data per person)**	Secondary data from PSA and from research journals

Step 3.
Processing of data and assessment of the ecosystem condition

Data and all other relevant information are processed for each aquatic condition indicator.

Bathymetry

- Identify an inland body of water within the target site to conduct a bathymetrical survey.
- Conduct a reconnaissance survey prior to the actual bathymetrical survey to determine the condition of the target site.
- Mount the eco-sounder/transducer on the outrigger of the boat and connect it to the monitor/data logger. Record the water depth and the corresponding GPS coordinates.
- Form an imaginary grid across the surface of the lake and select arbitrary locations for recording of the water depth and GPS coordinates in order to establish the lake's bottom configuration and depths.
- Conduct photo documentation to provide digital visualization of the actual bathymetrical survey being undertaken.
- Take note of the recorded lake water level on the day of the actual survey to facilitate adjustments during the mapping of the lake's bottom configuration and depths.

Water Pollution Loading

To assess water pollution loading, calculate the biochemical oxygen demand (BOD) loadings per source. Different sources include:

❖ Industrial effluents
❖ Domestic effluents

Industrial effluents. For the BOD generation from industrial effluents, compute the BOD concentration in effluent and the effluent discharge rate.

BOD loading = BOD conc. x Q x D X 0.001

where:
BOD loading = pollution (BOD) loading in kilograms
BOD conc. = average concentration of BOD in the effluent or wastewater discharged, mg/l or g/m^3
Q = average daily volumetric flow rate of the final effluent of wastewater discharged, m^3/day
D = number of discharge days per year, days/yr
0.001 = conversion factor (ml to m3 and mg to kg)

Note: For industries with more than one outfall, summation of BOD loading per outfall is obtained.

Then get the average BOD loadings per industry category. Apply average BOD loadings per industry category to the industries without data and calculate the total annual BOD loadings in metric tons.

Sample table:

	Name of Firm	Address	Business Activity	BOD loadings (MT/yr)			
				Year 1	Year 2	Year 3	Year 4
1							
2							
3							
4							

Domestic effluents. Calculate the BOD loadings from domestic effluents using the mass of BOD generated per individual multiplied by the given population. The population data from the Philippine Statistics Authority and the annual growth rate are used in the estimation of the population per year.

	Province	Municipality	Population			
			Year 1	Year 2	Year 3	Year 4
1						
2						
3						

Assume the waste load model report that grey water and use of toilets generate BOD at rates of 15 and 35 g/person/day, respectively.

The equation from that potential scenario is:

BOD1 = P (F1 + F2) [365 days/year/1,000,000 g/MT]

where:
BOD 1 = Generated from domestic activities
P = Population
F1 = BOD generation rate from grey water = 15 g/person/day
F2 = BOD generation rate form toilets = 35 g/person/day

Septic tanks are assumed to remove 50% of BOD (LLDA waste load model report, 2004) while the local drains are believed to remove 20% of BOD from both gray water and toilet discharges (Capalungan with LLDA study team, 2009). It can be further assumed that about 90% of the population maintains septic tanks (PSA data as of May 2000). The BOD generated now represents BOD loading into sub-basins, computed using the following formula:

BOD2 = P [F1 (1-D1/100) + F2 (1-(D2/100)(S/100))(1-D1/100)) [365 days/year/1000000 g/MT]

where:
BOD2 = BOD discharged to sub-basin
D1 = BOD loss in local drains = 20%
D2 = BOD loass in septic tanks = 50%
S = percent of population with septic tanks = 90%

As domestic effluent travels along the watercourses of the sub-basin, further BOD loss is assumed. Factors associated with BOD loss are BOD decay rate constant, distance of source from the bay water, and mean speed of stream water. The fraction of BOD remaining is computed as exp(-Kx/u). The equation is expressed as follows:

BOD 3 = BOD2 * exp (-Kx/u)

where:
BOD3 = BOD loading in Laguna Lake
K = decay rate constant by waste type
K = K2 ϴ (T-20); K2 = 0.7/day; ϴ = 1.047; T=27 oC
K = 0.97
x = average of the nearest and farthest stream distance of the municipality from the shoreline
u = mean stream flowrate within distance x.
x/u = mean travel time (in days) of effluent from discharge point to distance x.

Generically, BOD loss, % = (1 - exp(=Kx/u)) x 100. On the average the BOD loss is computed at 48%.

- Calculate the total BOD loadings and determine the % contribution of each source of pollution.

- Analyze the results and compare them with the pollution loading rate of river/s within the concerned area (stream flow multiplied by the average BOD concentration of the river/s).

Agricultural and forest lands. BOD generation from agriculture is computed as the product of the agricultural land and unit BOD generated per area of the agricultural land, expressed as follows:

BOD1 = A F1[1 MT/1000 kg]

where:
BOD1 = BOD generated, MT
A = area of the agricultural land, ha
F1 = BOD generation factor = 0.75 kg/ha/year for rice farming and 0.25 kg/ha/year (based on LLDA Waste Load Model)

BOD loading in rivers and streams from agricultural land is calculated as follows:

BOD2 = BOD1 [exp (-Kx/u)]

where:
BOD2 = BOD loading in rivers and streams
K = decay rate constant at 27oC = 0.166/day
x = average distance of the agricultural land from the shoreline = 1,000 m
u = mean stream flowrate within distance x = 0.1 m/s
x/u = mean travel time (in days) of effluent from discharge point to distance x.

BOD loss, % = (1 - exp (-Kx/u)) x 100

	Land Area, ha			**Annual BOD Generation, MT**			**Annual BOD Loading in rivers and streams, MT**		
Land Use	**Year 1**	**Year 2**	**Year 3**	**Year 1**	**Year 2**	**Year 3**	**Year 1**	**Year 2**	**Year 3**
Rice Farming									
Other Crops									
Total									
BOD Loading Factor, kg/ha/year									
Rice Farming									
Other Crops									
BOD Decay in stream water									
K, 1/day									
x, m									
u, m/s									
x/u, day									
Kx/u									
exp(-Kx/u)									
BOD loss, %									

BOD generation from forest land should be computed as the product of the forest land and unit BOD generated per area per year of the forestland, expressed as follows:

BOD1 = A F1 [1 MT/1000 kg]

where:
BOD1 = BOD generated, MT
A = area of the agricultural land, ha
F1 = 50 kg/ha/year for forest land (based on LLDA Waste Load Model)

BOD loading in rivers and streams from forest land is calculated in the same way as agricultural land.

Solid Wastes.

The BOD generation from solid wastes should be computed using the following formula:

BOD1 = P F1 F2 F3 [365 days/year x 1 MT/1000kg]

where:
BOD1 = BOD generated at source
P = municipal population
F1 = solid waste generation rate = 0.5 kg/person/day in urban areas or 0.3 kg/person/day in rural areas (World Bank, 2004)
F2 = fraction of kitchen waste in solid waste = 45% (World Bank, 2004; MMDA, 2003)
F3 = biodegradable to BOD conversion factor from field tests = 0.00285 BOD/wet waste; (based on Visvanathan, C, et al., 2002; Chiemchaisri, C. et al., 200)

In estimating water pollution loading, compute the total BOD loadings and determine the % contribution of each source of pollution. Assemble the results into an accounting table based on the International Standard Industrial Classification (ISIC) of all economic activities

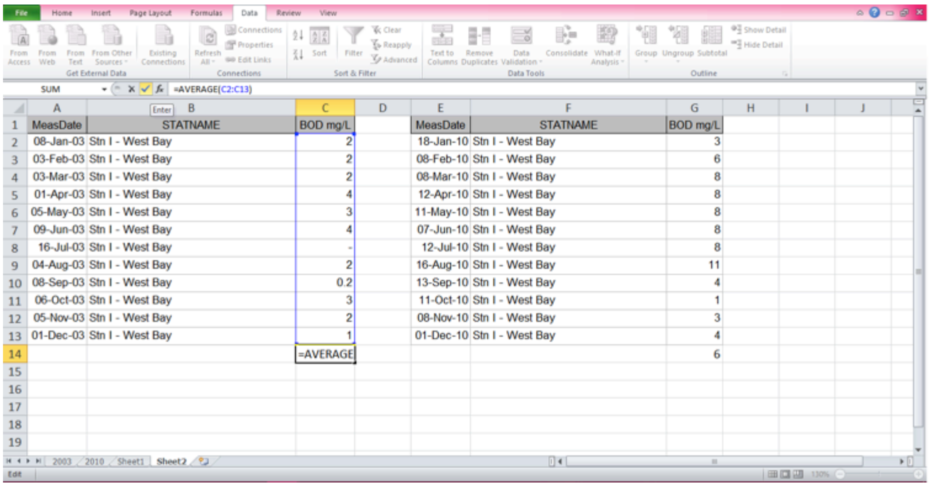
Sample water account table:

2010	Industries (P SIC Code)				House holds	Agricul tural Lands	Forest Lands	Solid Waste s	Rest of Philippin es	TOTAL
	Agriculture Industry	Manufacturi ng & Others	Sewage Treatme nt	Accommo dation, Food services, etc.						
1. Gross emissions (BOD, metric tonnes)										
1a. Direct emissions to water										
1a.1 Without treatment										
1a.2 After onsite treatment										
1a.i to inland water resources										
1a. Ii to the sea										
1b. To Sewerage										
2. Reallocation of emissions										
3. Net Emissions (1a+2)										

Water Quality

In assessing water quality, undertake the following:

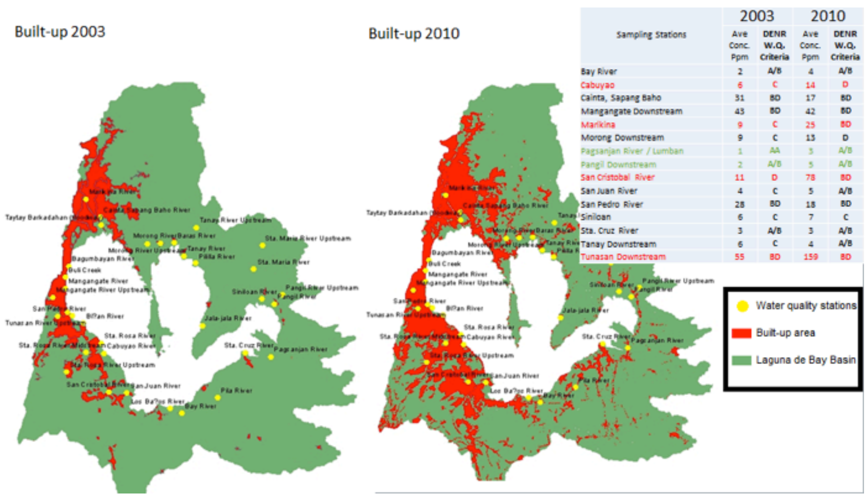
1. Identify a year to be used for the analysis of the ecosystem condition accounting (e.g., 2003 and 2010)
2. Identify water quality parameter to be used for the water condition accounting (e.g., BOD)
3. Collect secondary GIS dataset from NAMRIA
4. Collect monthly water quality data within a specific year and coverage area (e.g., rivers, lakes, ground water). Water quality data can be obtained from relevant agencies like LLDA and DENR.
5. Process data using a spreadsheet, then calculate the average values for the assigned water quality parameter.



	A	B	C	D	E	F	G
1	MeasDate	STATNAME	BOD mg/L		MeasDate	STATNAME	BOD mg/L
2	08-Jan-03	Stn I - West Bay	2		18-Jan-10	Stn I - West Bay	3
3	03-Feb-03	Stn I - West Bay	2		08-Feb-10	Stn I - West Bay	6
4	03-Mar-03	Stn I - West Bay	2		08-Mar-10	Stn I - West Bay	8
5	01-Apr-03	Stn I - West Bay	4		12-Apr-10	Stn I - West Bay	8
6	05-May-03	Stn I - West Bay	3		11-May-10	Stn I - West Bay	8
7	09-Jun-03	Stn I - West Bay	4		07-Jun-10	Stn I - West Bay	8
8	16-Jul-03	Stn I - West Bay	-		12-Jul-10	Stn I - West Bay	8
9	04-Aug-03	Stn I - West Bay	2		16-Aug-10	Stn I - West Bay	11
10	08-Sep-03	Stn I - West Bay	0.2		13-Sep-10	Stn I - West Bay	4
11	06-Oct-03	Stn I - West Bay	3		11-Oct-10	Stn I - West Bay	1
12	05-Nov-03	Stn I - West Bay	2		08-Nov-10	Stn I - West Bay	3
13	01-Dec-03	Stn I - West Bay	1		01-Dec-10	Stn I - West Bay	4
14			=AVERAGE				6

6. Assign water quality classification for the generated annual average values, based on the DENR Administrative Order 34.

Note: To determine the effects of land cover change on water quality, use the GIS software with corresponding datasets and plot the GPS coordinates of corresponding to each water quality station and overlay the area on the same map/coverage area corresponding to the same year (e.g., change in built-up area vs BOD concentration, change in agricultural area vs nutrient concentration).

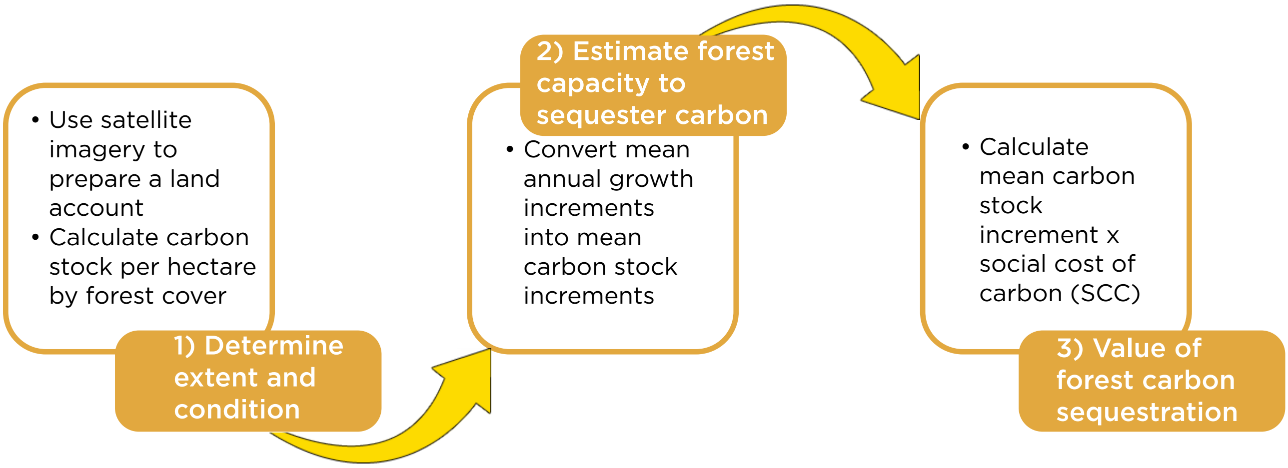


Sampling Stations	2003 Ave Conc. Ppm	2003 DENR W.Q. Criteria	2010 Ave Conc. Ppm	2010 DENR W.Q. Criteria
Bay River	2	A/B	4	A/B
Cabuyao	6	C	14	D
Cainta, Sapang Baho	31	BD	17	BD
Mangangate Downstream	43	BD	42	BD
Marikina	9	C	25	BD
Morong Downstream	9	C	13	D
Pagsanjan River / Lumban	1	AA	3	A/B
Pangil Downstream	2	A/B	5	A/B
San Cristobal River	11	D	78	BD
San Juan River	4	C	5	A/B
San Pedro River	28	BD	18	BD
Siniloan	6	C	7	C
Sta. Cruz River	3	A/B	3	A/B
Tanay Downstream	6	C	4	A/B
Tunasan Downstream	55	BD	159	BD

How to construct Ecosystem Service Use and Supply Accounts

Carbon Accounts

Carbon accounting and valuation is done to determine carbon stock, carbon sequestration, and the carbon value of a given ecosystem accounting unit in a given accounting period. It aims to measure in physical and monetary terms the changes that occur in a given year in a specified forest area using these variables. It shows the stocks and flows of carbon as an ecosystem service using the following framework:



Carbon accounting and valuation is conducted through the following steps:

Step 1. Data Scoping	The first step in the compilation of carbon account is to identify the area and the extent (type of forest-open, closed and mangrove). This includes determination of the accounting period for the opening and closing years and the methods applicable (e.g., Stem Volume Approach, Use of Allometric Equations).
Step 2. Data Collection	Once the ecosystem accounting unit is already determined, find out if there are available data that can support carbon accounting and valuation in the area. Relevant data include: ***Land cover maps*** corresponding to at least two time periods in the accounting period being considered, and ***Forest cover change data*** showing land cover transition from one land cover to another. Sources of data include NAMRIA. Global forest data that may contain information that may be calibrated at the country level may also be used. The next important data that carbon accounts developers should be looking for are forest inventory data that can serve as basis for computing carbon stocks in the various land cover classes present in the accounting unit. National, regional, provincial or project-level forest inventory data may also be useful.

Depending on the carbon quantification approach that will be used, carbon stock estimates can be generated through allometric equations or direct conversion from timber stock volume to tree carbon content. In this regard, biomass expansion factor, wood density, root-to-shoot ratio at various growth periods, and carbon fraction should also be collected. To determine the land cover's capacity to sequester carbon, applicable timber growth rate data or mean annual growth increment should also be generated. A template for such data requirement is shown in this table:

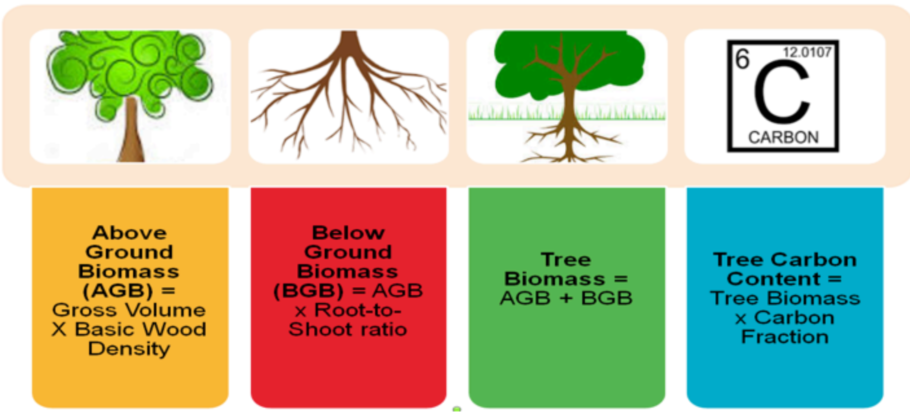
Assumptions and data for the development of the Carbon Account:

Ecosystem unit	Gross timber volume (m^3/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)
Closed forest				
Open forest				
Mangrove forest				

Step 3.
Accounting for Carbon in Physical Terms

Carbon Stock

The first step in carbon stock accounting is to impute a specific carbon stock to a specific land cover type, and multiply it by the extent of the various land cover in the accounting periods being observed. For the former, the tree carbon content per hectare of the land cover classes of interest can be done using the approach depicted below:



Biomass and carbon accounting data can be derived from the established volume account of timber, divided into five parameters: Stem Biomass, Above Ground Biomass, Ground Biomass (BGB), Tree Biomass, and Tree Carbon Content. First, stem biomass is derived by multiplying the stem volume by the basic wood density. Second, ABG is obtained by multiplying the stem biomass with a factor that reflects the stem biomass-total biomass ratio (total biomass also includes biomass in branches and leaves). Third, the BGB is derived by multiplying the computed ABG by the root-to-shoot ratio constant. The tree biomass could then be computed by summing up the AGB and BGB, expressed in tons of dry matter per hectare. To obtain the tree carbon content, multiply estimated tree biomass by the carbon fraction constant of 0.47 ton of carbon per ton of dry matter. Finally, the Carbon Dioxide 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.

Carbon Sequestration

Forest carbon sequestration capacity can be derived from established timber volume growth rates per hectare of specific forest types, e.g., closed forest, open forest, mangrove forest, plantation forest in terms of mean annual volume increment. A straightforward approach is to convert these volume increments into carbon as depicted in the diagram on page 53 to arrive at the carbon sequestration rate for each of the forest or land cover type.

Step 4.
Accounting for Carbon in Monetary Terms

Valuation of carbon can make use as basis Market Price of carbon of the Social Cost of Carbon (SCC) and multiplying this by the sequestration capacity of the land cover types of interest and multiplying the product by the area extent of land cover types. The market price of carbon can be based on current prices in existing markets while the social cost of carbon is based on yearly estimates published by the US Environmental Protection Agency. 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. Its is assumed to be US$32 or Php1,344 per ton CO_2 at 3% discount rate while the SCC at 5% is estimated to be US$11 or PhP462 per ton CO_2t based on EPA estimates.

Step 5.
Presentation of Carbon Account

Carbon Stock

The carbon account can be presented in a table or graphical form as shown below:

Ecosystem type	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									
Open Forest									
Mangrove Forest									
Total:									

The table should show physical and monetary estimates of carbon stock and carbon sequestration per forest ecosystem.

Carbon Sequestration and Carbon Sequestration Value

The table below shows the physical and monetary estimates of carbon sequestration and carbon sequestration value per forest ecosystem.

Ecosystem type	2003				2010			
	Area (ha)	Carbon Sequestration (in ton	Carbon Sequestration (in million ton CO_2)	Carbon Sequestration Value (in million	Area (ha)	Carbon Sequestration (in ton CO_2 per ha)	Carbon Sequestration (in million ton CO_2)	Carbon Sequestration Value (in million pesos)
Closed Forest								
Open Forest								
Mangrove Forest								
Total:								

Accounting for Soil Erosion Control Service

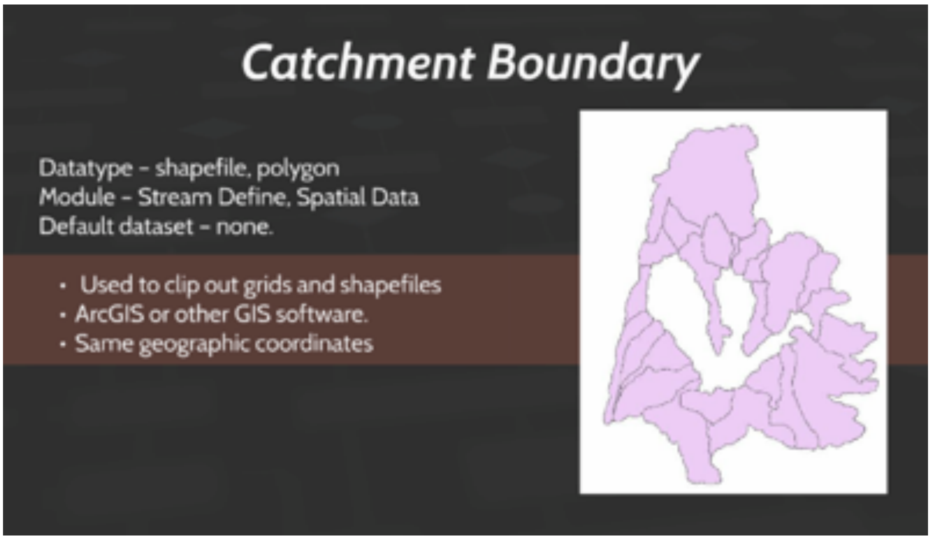
The ecosystem service 'erosion control' is defined as the amount of sedimentation avoided because of vegetation cover. This is calculated by comparing the erosion and sedimentation rates in the lake that would have taken place without vegetation cover with the actual erosion and sedimentation rates. Erosion control is important in maintaining the water retention capacity of the lake and reduce flood risks. Modelling facilitates identification of zones that are particularly important as a source of sediments and that are priority areas for ecosystem restoration.

Erosion control is one of ecosystem's contributions to the well-being of society. The volume of erosion avoided is based on the soil loss estimates under actual and bare (no-forest) scenarios. As expressed in kilograms per year, the generation of information on the rate of erosion on both scenarios is determined using GIS programs and computer software models such as SedNet.

Soil erosion control service is conducted through the following steps:

Step 1.
Data Scoping

This covers identifying the area, extent, and time frame of the account to be developed. Data scoping is a critical and initial stage in accounting for erosion control as an ecosystem service. In this regard, identification of the spatial and temporal coverage is a vital component of accounting for ecosystem services. Data scoping is the initial step in identifying and analyzing the area and period covered. Such information shall be the basis for choosing the appropriate software such as SedNet and ArcGIS.



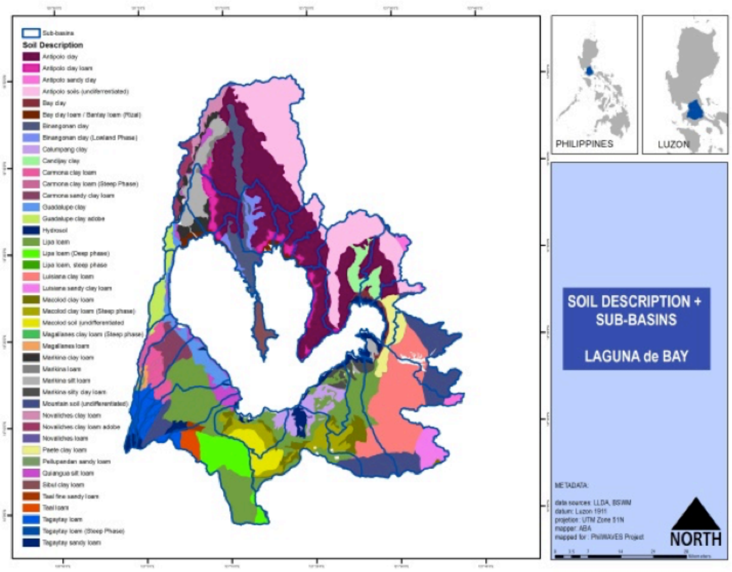
This step also includes determination of the modelling software to be used if the following basic data are not readily available:

Data Needs	unit	File type	Source of information	Concerned Agency
Spatial Data				
Flood plain extent	hectares	Vector file	Watershed map	LLDA, DOST
Land Cover	hectares	Vector file	land cover map	NAMRIA
Catchment boundary	meters	Raster file	Digital Elevation Map	NAMRIA
Rainfall Erosivity (R) Soil Erodibility (K) Slope Length (L), and Slope Steepness (S)	hectares	Vector file	Soil Type Map	BSWM
Weather Data				
Precipitation	millimeters	historical records (time-series)	rainfall depth	PAGASA, ASTI
Evaporation	millimeters	historical records (time-series)	evaporation depth	PAGASA, ASTI
Temperature	Celcius	historical records (time-series)		PAGASA, ASTI
Water flow				
River discharge	cu.m/sec	historical records (time-series)	flow rate	DPWH

Step 2.
Data Collection

The identification of data requirement and choice of appropriate computer program should lead to the identification of the types of data needed for simulation. Since the use of the right computer program facilitates the simulation of data, records of specific information are needed as inputs in the software to develop scenarios that portray the condition of the soil on the landscape. For example, soil characteristics and coverage of soil types pertaining to a specific landscape are inputs for the software in which the information shall be integrated and processed with other information such as slope and land cover area.

Sample map: Extent of soil types is available on the website of Bureau of Soil and Water Management (www.bswm.da.gov.ph/).



Sample map: Slope of the lake can be determined through the Digital Elevation Model of NAMRIA.

Land cover characteristics and corresponding hectares can be derived from the shapefile of NAMRIA.

Step 3. Pre-processing of data for modelling	There are parameters and corresponding measurements prior to the simulation of erosion control ecosystem service. Such data are relevant to the characteristics of the location such as weather and physical attributes. In the event of missing precipitation, Inverse Weighted Distance (IWD) is used to complete the entire period of rainfall events. On the other hand, potential evaporation is determined by using Kriging method. Furthermore, streamflow and erodibility information are known by means of GIS. Eventually, such information is used for the modelling stage.
Step 4. Modeling of soil erosion control	The last stage in accounting for the soil erosion control ecosystem service is the modelling of the data inputs. Software such as GIS and SedNet is used to process the data and yield information on the amount of sedimentation. This stage requires the simulation of two scenarios, namely, actual land cover area and bareland condition of the target location. Such scenarios show the importance of vegetation. Moreover, validation of the results is important to generate realistic values. This information can be achieved by comparing actual measurement to the simulation results. To determine the value substituting erosion control ecosystem service, the cost of erosion control material such as coco matt is used to value this service. The ability of this material to reduce soil loss as a useful substitute for the value of land cover to control soil erosion. The price of coco matting is based on market price. To obtain the value of erosion control ecosystem service, compute the following: 1. Quantity of erosion blankets required (sq m/year) = Erosion avoided (kg/year) / Trapping capacity of coco matting (kg/sqm) 2. Replacement cost of erosion control ES (Php/year) Note that the use of replacement cost method is only appropriate if it can be inferred that society would choose to replace the service if it was lost. In this case, the cocomats would be placed if the erosion control service of the vegetation was indeed lost. Otherwise an alternative method, e.g. avoided damage costs, has to be used. Logically, a practical question can be raised: if the damage costs are lower than the replacement costs, why replace the service?

Step 5. Presentation or results (accounting tables)	The following table is used to achieve the presentation of results of the SedNet model based on the existing land cover and a bare land scenario. The sediment generation is the result of SedNet modelling from the data inputs shown in Step 1. The unit of the sediment generation is kilotons in a year. On the other hand, sediment yield under bare land cover (KT/Yr) is achieved based on the assumption that all land covers such as closed and open forests, shrub areas, grasslands, and wooded grasslands would be converted to bare land. The results of the bare land scenario should be placed in the fourth column. In the end, the difference between the sediments generated under land cover and under bare land cover represents the avoided erosion. The avoided erosion is the amount of soil remaining intact through the existing land cover.

Watershed	Area (Km^2)	Sediment generated under land cover (KT/Yr)	Sediment that would be generated under bare land cover (KT/Yr)	Ecosystem service (avoided erosion)

Step 6. Soil Erosion Control Ecosystem Service Value	Finally, the results of the model is further analyzed using the formula given below on valuing the service through the substitute of prices such as the cost of coco mat. Note that different valuation methods can be used (as described in the previous sections). For the purpose of this guidebook, the value of erosion control service is computed as follows: • To determine the value of substituting erosion control ecosystem service for certain variables, the cost of erosion control material such as coco matt is used for the valuation of this service. The ability of this material to arrest soil loss is a useful substitute for the value of land cover to control soil erosion. The price of coco matting is based on market price. • To obtain the value of erosion control ecosystem service, the following are computed: 1. Quantity of erosion blankets require (sq m/year) = Erosion avoided (kg/year) / trapping capacity of coco matting (kg/sq m) 2. Replacement cost of erosion control ES (Php/year) = Quantity of erosion blankets (sq m/year) * Price of coco matting (Php/sq m)

Accounting for Flood Control Service

Flooding of houses and infrastructure is a significant economic issue. This guidebook will cover only accounting for the flood retention service of a lake ecosystem, or the capacity of the lake to store water that would otherwise lead to flooding of houses and infrastructure. The capacity to store water is defined as the water that can be stored in the zone between (a) the average water level in the beginning of the rainy season (July); and (b) the water level at which the first houses along the lake are flooded. In between these two levels, water can be stored without causing economic losses due to flooding. Note that the flood retention capacity is not related to the overall volume of water stored in the lake. The water level below the average beginning of the rainy season level is, on average, filled throughout the year and therefore not available as retention basin.

<table>
<tr>
<td>Step 1.
Consolidation of data</td>
<td>The following basic date are needed:

<table>
<tr><th>Data</th><th>Sources</th></tr>
<tr><td>Inundation depth</td><td>DOST</td></tr>
<tr><td>Flood duration</td><td>DOST</td></tr>
<tr><td>Population density (i.e.,average number of people per household</td><td>PSA</td></tr>
<tr><td>Number of building per meter of flood height (note: flood height varies depending on the sites)</td><td>PSA, DOST</td></tr>
<tr><td>Flood prone areas using spatial data</td><td>DOST, LGUs</td></tr>
<tr><td>Average house price of a basic house in the flood zone</td><td>PSA</td></tr>
</table>
</td>
</tr>
<tr>
<td>Step 2.
Assessment of affected areas</td>
<td>Based on a given level of flood occurrence in an area, the extent of flood shall be determined (i.e., flood zone). This step involves determining the number of houses per flood zone, the number of people per household, and the average house price of a basic house in the flood zone.</td>
</tr>
</table>

Step 3. Preparation of simple spreadsheet model to estimate cost of flood damages	To relate the annual flood level to damage costs, a simple spreadsheet model should be prepared with the following sample calculations: ***Estimation of the amount of damage*** Based on inundation depth, flood duration, the construction type and materials used (wood, concrete, bricks, etc), and the flood control measures in place, the account preparer shall assess the amount of damage in the area. The analysis should consider damages to houses, infrastructure, crops, and other properties.

1. Calculating number of houses flooded

		Houses flooded per flood zone			
Year	Flood Level	13.5-14.5m flood zone	14.5-15.5m flood zone	15.5-16.5m flood zone	13.5-14.5m flood zone
1997	Insert flood level	=MAX(0,MIN(1,(flood level-12.5))*#houses)	=MAX(0,MIN(1,(flood level-13.5))*#houses)	=MAX(0,MIN(1,(flood level-14.5))*#houses)	=MAX(0,MIN(1,(flood level-15.5))*#houses)
...	"	"	"	"	"
2014	Insert flood level	"	"	"	"

The number ofhouses is calculated per year and per flood zone

Model calculations of damage cost which allow predicting flood damages as a consequence of flood levels in the future. Run spatial analysis to calculate damage cost/predict flood damages.

2. Calculating damage costs

	Damage costs per flood zone				Damage costs houses all flood zones	Total Damage costs
Year	12.5-13.5m flood zone	13.5-14.5m flood zone	14.5-15.5m flood zone	15.5-16.5m flood zone		
1997	=MAX(0,0.0614*(inundation depth * #houses flooded* house price)	=MAX(0,0.0614*(inundation depth * #houses flooded* house price)	=MAX(0,0.0614*(inundation depth * #houses flooded* house price)	=MAX(0,0.0614*(inundation depth * #houses flooded* house price)	=sum(all damage costs)	=damage costs houses * 1.2
...		"	"	"	"	"
2014		"	"	"	"	"

Step 4. Presentation of results	**Maps and tables.** A flood risk map can also be presented to show the flood prone areas. Make an approximation of ecosystem service "water retention" by comparing flood levels with and without the water storage volume of the catch basin.

Provisioning Crops Production Account

The ecosystem services supply account records the flow of ecosystem services in physical and monetary terms. It shows the ecosystem's contribution to crop production. The choice of specific accounts to develop is based on the importance of specific ecosystem services to crop production to the local economy and data availability.

Considering the difficulty of quantifying the contribution of water infiltration, sediment retention, nutrient cycling, and water holding capacity of the ecosystem unit, the amount of crops produced or harvested in physical terms and monetary terms serves as proxy data for the provisioning service.

Below are the procedures in development of the account on provisioning service for crop production:

Step 1.
Data Collection

- Gather secondary data from concerned government offices like the Department of Agriculture and its attached agencies, PSA, among others, that provide relevant information for the development of the account. Table 1 shows the list of the data that need to be gathered. If the area or spatial unit has been identified, major crops could be determined from the PSA statistical reports posted on the agency's website (www. psa.gov.ph), which covers regional or provincial data on crops.
- Assessment and review of data to determine gaps. Prepare metadata that could serve as guide in supplementing data collection.
- Collect the data based on the identified gaps
- If necessary, conduct focus group discussions and/or key informant interviews to acquire primary data such as crop yields and cost of production.

Following is a list of data needed in developing provisioning services for crop production.

Data requirements	Unit of Measure	Source	Mode of data acquisition
Crops produced		PSA Reports, LGU agriculture office or Provincial/Municipal Planning Office	Online, Document review
Area planted per crop	Hectares	PSA reports, LGU-Agriculture Office	Online, Document review
Quantity produced per crop Sold Consumed and/or given away	(kg/hectare/year)	LGU-Agriculture office, farmers	Online, Document review, KII, FGD
price per unit (FOB)	Pesos	PSA Reports, LGU agriculture office, farmers	Online, Document review, KII, FGD
Production cycle per crop Number of cycle/yr (annual) Number of harvest/yr (perennial)		Literature, farmers	Online, document review, FGD, KII
Establishment and operating costs (per cycle or per year, whichever is applicable) Material inputs Labor inputs (including local wage rate) Other expenses Utilities (water or irrigation fees, electricity, communication, etc) Government taxes, permits Post harvest, transport Marketing	Pesos	PSA Costs and Return data, Farmers	Online, Document review, KII, FGD
Number of standing trees (perennial crops)		Farmers	Survey
Age of trees	Years	Farmers	Survey
Economic rotation of plantation crops	Years	Literature, farmers	Online, document review, KII

Step 2. Mapping

Acquire the latest land cover map from NAMRIA and use it as a base map and to come up with look-up tables. The modelling of provisioning services requires four steps:

- delineation of the study area
- the extraction of the land-use of interest
- conversion of data formats
- assigning EUs the average production (yields/ha)

Step 3. Ecosystem Service Analysis

- Calculate the number of hectares grown and harvest in terms of kg products per hectare per crop (and per year) for all crops.
- Map the study area showing the delineation of crops selected for the ecosystem account to present findings

Here is an example of an ecosystem services supply account for crop production

Ecosystem Units	Area (ha)	Yield (ton/ha/ year)	Yield (ton/year)	Area (ha)	Yield (ton/ha/ year)	Yield (ton/year)
	YEAR			YEAR		

Step 4. Valuation

- Based on the data gathered, compute the cost and return of producing the crops identified in the area on a per hectare basis.
- Compute the resource rent to be used as an indicator for the value provided by the ecosystem and present this in tabular form. The formula for the resource rent is as follows:

RR = GS - CFC - UCFC - LC - II

where:
RR = Resource Rent
GS = Gross Sales (Price x Catch)
CFC = Consumption of Fixed Capital
UCFC = User Cost of Fixed Capital (assumed to be 10% of Total Fixed Capital)
CE = Labor Cost or compensation of employees
II = Intermediate Input

The table below shows sample monetary values of the provisioning services of crops.

Ecosystem Units	Area	Production Costs per hectare				Yield	Farm -Gate Price	Resource Rent/ha	Resource Rent, of the Ecosystem
		Intermediate Consumption	Compensation to Employees	Taxes and Subsidies	User Costs of Produced Assets				
	(ha)	(Php)	(Php)	(Php)	(Php)	(ton/ha)	(Php/ kg)	(Php)	(Php)

Fisheries Account

The fisheries account helps to ensure the equitable distribution of fisheries resources and to provide an assessment of an ecosystem both on physical and monetary terms. The societal benefits were expressed as the resource rent generated by the ecosystem in terms of supporting capture and aquaculture fisheries.

Step 1.
Preparation of data requirements

Consolidate the following data needed to account for fisheries:

Data	Unit of measure	Source
Stocking density	No. of fish/hectare	Primary data from operators
Total harvest	Kilogram of fish/hectare	Primary data from fishermen and operators
Total Harvest per fish species	Kilogram of fish species/hectare	Primary data from fishermen and operators
Species composition	Fish species/hectare	Primary data from fishermen and operators
Labor Costs	Pesos/hectare	Primary data from fishermen and operators
Price	Pesos/kilogram/hectare	Primary data from fishermen and operators

Step 2.
Data collection

If the fisheries data/information are not readily available, conduct a fisheries survey to get primary data from fishermen and operators.

Harmonization of survey instrument for fisheries evaluation. Seek clearance from the PSA and coordinate with Bureau of Fisheries and Aquatic Resources on the survey instrument and other documents required.

Information covered by the survey questionnaires. The survey seeks to generate information needed in the development of the fisheries account, including the following:

(a) stocking density per aquaculture structure
(b) total harvest from aquaculture/capture fisheries
(c) total harvest per fish species from aquaculture/capture fisheries
(d) species composition of cultured/captured fishery
(e) labor costs/expenditures incurred during the culture/capture period
(f) price of fish harvest/capture (gross sale) fishermen/operators
(g) cultured period/time consumed for cultured/capture fishery

Survey Approach

- Orient the enumerators on the survey questionnaires and the protocol to be observed in dealing with the respondents.
- Execute the survey with the aid of enumerators who are not identified with the regulating agency so as not to intimidate respondents in answering the questionnaire.
- Review and ensure the completeness of the survey questionnaire and determine if validation is needed.
- Compile all filled-up survey questionnaires and encode the gathered data in tabular format using Excel.
- The sampling design should cover:
  - Distribution of the targeted respondents for capture fishery
  - Proportion method or random sampling for aquaculture operators
  - Number of respondents and replicates for the survey

Step 3. Evaluation of area	The information on the area for fishery activity should show which is more productive between aquaculture and capture fisheries.

Data	Unit of measurement	Source
Total surface area	hectares	Secondary data from LLDA, SEAFDEC, BFAR
Area of open water	hectares	Primary from survey
Area of aquaculture structure	hectares	Secondary data from LLDA, BFAR
Total number of fishermen/operators	person	Secondary data from BFAR and LLDA

- Determine the total surface area of the water body.
- Determine the total area occupied by the open water/ capture fisheries.
- Determine the total area occupied by aquaculture structure.
- Determine the total number of fishermen/operators benefitting in the ecosystem.

Step 4. Calculation of resource rent

- Analyze and determine the data necessary for the computation of the resource rent.
- Compute the resource rent using the formula:

$$RR = GS - CFC - UCFC - LC - II$$

where:
RR = Resource Rent
GS = Gross Sales (Price x Catch)
CFC = Consumption of Fixed Capital
UCFC = User Cost of Fixed Capital (assumed to be 10% of Total Fixed Capital)
CE = Labor Cost or compensation of employees
II = Intermediate Input

Note: If there are available data on fish production, the resource rent can be computed right away.

Step 5. Presentation of results and reporting

Tables and maps highlight the findings of the accounts and analyze the state of fisheries production in a certain area.

How to construct Ecosystem Asset Accounts

Ecosystem Asset: Crop Production

An Ecosystem Asset account for crop measures the ability of ecosystems to generate ecosystem services under current ecosystem conditions and uses at the maximum level without causing degradation of the ecosystem

The asset for crop production is expressed in physical terms as the hectares of crop land (from the Land Account) and the asset in monetary terms as the Net Present Value of the expected flow of ecosystem services, in this case the NPV of the resource rent generated from crop production.

Here is an example of biophysical asset account for crops by year and spatial unit:

		Land Cover (area of crops in hectares)			
ACCOUNT TYPE					
Opening (_year___)					
	Area (in hectares)				
Addition to stock					
	Regeneration, natural(net of normal natural losses)				
	Regeneration, through human activity				
	Reclassification				
Total addition to stocks					
Reduction in stock					
	Reductions due to ongoing human activity				
	Catastrophic losses due to human activity				
	Catastrophic losses due to natural events				
	Reclassifications				
Total reductions in stocks					
Revaluations					
Closing stocks (__year____)					
	Area				
	Productive				
	Non-Productive				

In monetary terms, the asset account is calculated in terms of NPV of the expected flow of ecosystem services per hectare (Table 2). Consistent with the UN definition (2015), the resource rent is used to indicate the value of the ecosystem service. In computing the NPV of each crop system, much consideration is given to determining the appropriate discount rate to be applied.

Here is a sample monetary account for ecosystem asset for crops per year and spatial unit:

Ecosystem units	Area	Resource Rent, Pulot Watershed	Net Present Value at Discount Rates		
			10%	12%	15%
	(ha)	(million Php)	(million Php)	(million Php)	(million Php)
Year					
Year					

Part IV Interpretation and Use of the Accounts

Use of the Accounts

Both ecosystem accounting and economic and environmental assessment hold special relevance. The accounts are useful in the formulation of appropriate policy responses around economic activity and ecosystems. Here are some of the ways the accounts can support policy formulation and implementation:

- **Policy planning and programming.** Inform policymakers of the status, uses and monetary values of ecosystems at the time a specific policy is being formulated. For instance, the account can indicate sensitive areas or areas that are particularly important in supplying ecosystem services.
- **Decision-making.** The accounts can alert policymakers to trends in ecosystems and the services they supply. In some cases, these may already have affected the livelihood of the communities that depend on these ecosystems.
- **Forecasting.** Information may be useful in forecasting potential future impacts. By monitoring trends in ecosystems over time, the accounts can also provide information on the effectiveness of specific policies.
- **Knowledge management and information dissemination.** A particular feature of the accounts is that these make information available in an aggregated and coherent way. The accounts consolidate information that is usually dispersed in different agencies, hence leading to easier access to an integrated dataset and new insights resulting from bringing together these data.

Below is an enumeration of potential accounts and their relevance to natural resource management and development:

Land Account	As part of planning for sustainable development, it is important to understand the implications of changes in land cover and land use. Land cover is extracted through the latest remote-sensing data that will be used as a reference to a more detailed and updated land accounts such as land cover, land use and/or land titles. Land accounts can help determine trends and the status of land cover, thus supporting strategic environmental policy and monitoring of land assets and efforts to assess their contribution to economic activities. Land accounts yield data on land cover, land use, and land divisions. Ecosystem services accounting helps harmonize these data. It must be noted that land cover can provide data on ecological functions while land divisions data are used to assess ecosystem assets and services. The accounts can guide efforts around land conversion to make sure they are aligned with, and could facilitate more efficient implementation of, development plans and appropriate laws.

Water Account	Water accounting is the process of communicating water resource-related information and the services generated from consumptive use in a geographical domain of, among others, river basin, lake, and other water bodies. A water account shows the existing status of and potential trends in water availability in a lake over a specified period of time. In terms of beneficial use, the computation of water balance provides a comprehensive interpretation of the water flow system and water resources in the lake. Since water inflow is heavily influenced by the seasonal weather patterns throughout the year, water balance can show the differences between inflow and outflow of water in the basin, thus generating knowledge on the quantity of water that serves as natural asset for users of the water resources. This should lead to improve management of water resources. The investigation of water balance structure of a lake lays down the basis for the development and implementation of water-related projects utilization, regulation, and distribution of water resources over time. For a multiple-use water resource, such as a lake, the water account can be used by policymakers in determining allocation of water for various uses in terms of quantity and quality. For instance, they can set usage limits on account of water quality issues. Thus, even if a lake may contain a huge volume of water, it cannot be used for domestic purposes if it has e high level of toxic substances. On the other hand, a water resource with poor water quality can still be used for domestic purposes but this will require a costly treatment process that will affect the price of water for such use. The water account can guide resource managers and policy makers in deciding if a dominant use policy is necessary for a particular water resource. The output of other accounts such as on fisheries is a useful input in determining if the economic and social benefits far outweigh those of the other uses such as water supply, irrigation, transportation, etc. The water account can guide policymakers in determining how much water can be abstracted for various uses such as irrigation and water supply, and can provide the necessary input for water pricing. Assessment of the ecosystem conditions such as flooding is necessary in the formulation of policies on the use of shoreland, choice of locations for specific housing projects and relocation sites for displaced settlers, and identification of necessary infrastructure to mitigate flooding. Information on sedimentation is essential in land use planning as well as a necessary input in the assessment of the land account. **Water account vis-a-vis Ecosystem Service** Key question: • How much water should be retained in a lake at a given time to support ecosystem functions?

Ecosystem Service Supply and Use Account	This account records the flow of ecosystem services in both physical and monetary terms. It interlinks the values derived from different services being provided by the environment such as carbon sequestration, water regulation, and the ecosystem's contribution, for example, to crops and fisheries. The output derived from this account gives a clear picture, for instance, of how the ongoing conversion of forests in the uplands affects water regulation service and how forest degradation affects the agricultural potential of a specific area. It is therefore a useful guide in crafting or revising relevant policies. This takes into consideration ecosystem units and calculation of resource generation. <u>Ecosystem Services Supply Account</u> <u>Carbon Sequestration.</u> One of the data that can be generated through carbon accounting is the rate of carbon sequestration. This is the capture of carbon from the atmosphere by vegetation, in particular by different types of forests. It is acceptable to include carbon sequestration both in carbon account and ecosystem services accounts. <u>Crop Production.</u> Resource rent per hectare is used in assessing the monetary value derived from the crop production from the ecosystem. <u>Water Regulation.</u> Water supplied to irrigated rice paddies in the watershed can be accounted for through water regulation. Hydrological modelling is used to simulate inflow and outflow accounting parameters of water loss from rainfall to amount of water discharged from a dam. <u>Fisheries</u>. It is the assessment of fish capture from aquaculture with fish pens and fish cages. The account monitors the economic value of fisheries, seeks to improve fisheries management, and may estimate the costs and benefits of fisheries. The data gathered is used as reference for policy makers to address issues arising from the uses of lakes for fisheries, fish pens, and fish cages.

References:

System of Environmental-Economic Accounting 2012— Experimental Ecosystem Accounting. 2014. https://unstats.un.org/unsd/envaccounting/seeaRev/eea_final_en.pdf

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Technical Report on Pilot Ecosystem Accounts for Laguna de Bay. December 2016. https://www.wavespartnership.org/sites/waves/files/kc/LdeBay%20FINAL%20LowRes%20Dec15%202016.pdf

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Wealth Accounting and the Valuation of Ecosystem Services. https://www.wavespartnership.org/

ANNEX A

Topic: Developing Physical Land Asset Accounts from GIS-Analysis of Land Cover Change Matrix

Data Needs and Sources: GIS layers used cover two periods.

Objective: In this exercise, the shapefiles of classified land cover for 2010 and 2014 were interpreted and produced by NAMRIA from acquired satellite imagery.

Description of the Data: Attributes data of shapefiles of land cover for at least two periods. In this exercise are land covers of 2010 and 2014 for the Pulot Watershed of Sofronio Espanola in Southern Palawan. The data can be generated from any GIS software. The pre-processed data is generated by intersecting the two shapefiles in GIS software. The resulting attribute table is exported as excel spreadsheet file with single column headers.

Link to the Sample MS Excel Worksheet:

https://drive.google.com/open?id=0B6ryv7mIA46WQklyUW9mczl0Xzg

Tools for this Exercise: MS Office Excel spreadsheet software for transforming an attribute table into a land cover change matrix

Objectives of the Exercise:

(1) To learn and experience developing land accounts

(2) To familiarize onseself with the steps in developing ecosystem accounts using primary or secondary data

(3) To learn how to develop a physical land asset account derived from spatial information

Steps in Developing the Physical Land Asset Accounts:

(1) Process the layers in GIS software to generate the intersect of a two-period land cover:

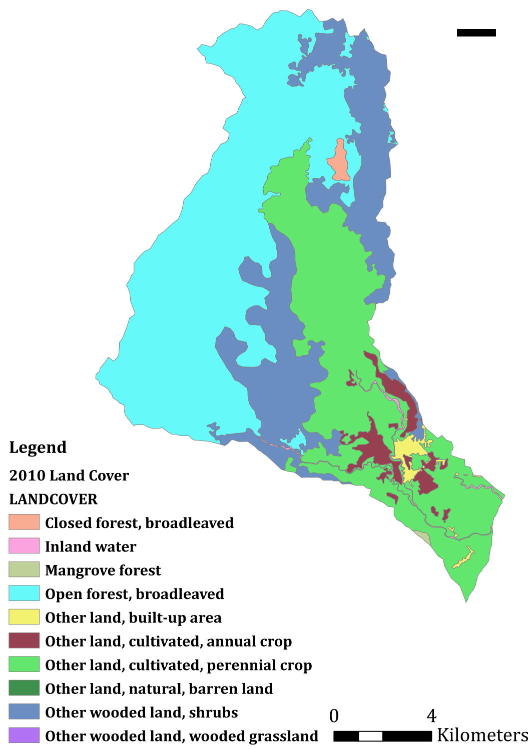


Figure 1a. Land cover of 2010 generated by NAMRIA

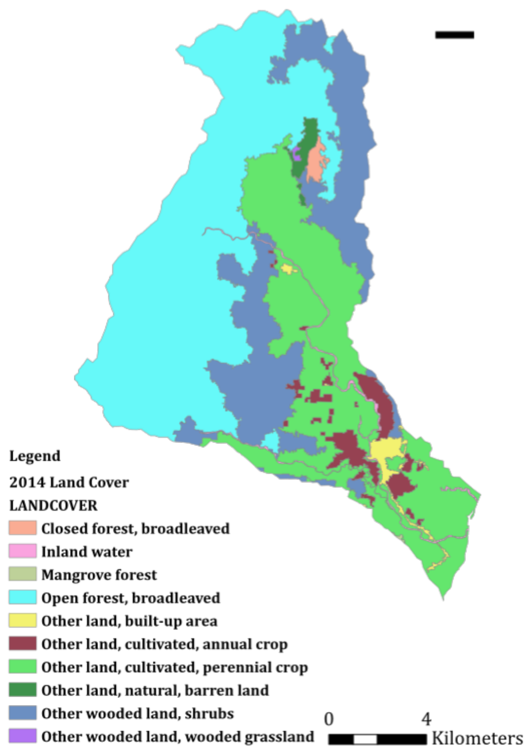
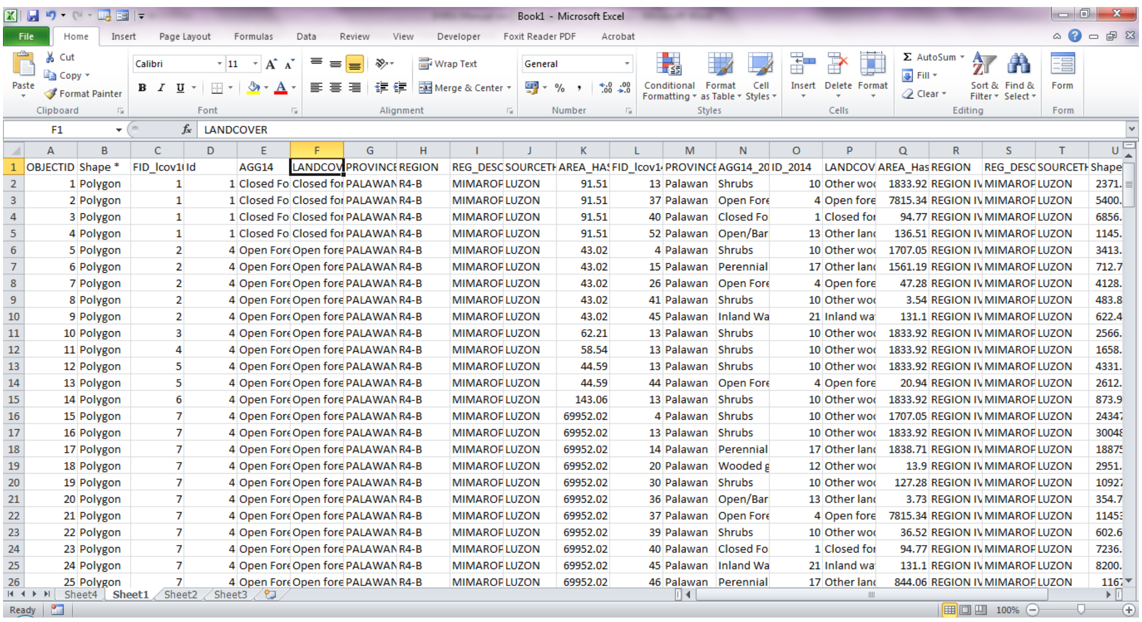


Figure 1b. Land cover of 2014 generated by NAMRIA

(2) Export the attribute tables of the shapefile produced from intersecting 2010 and 2014 land cover data to MS Excel. Then review the output to ensure that no data was missed;

Here is an example of an exported attribute table will appear as below:



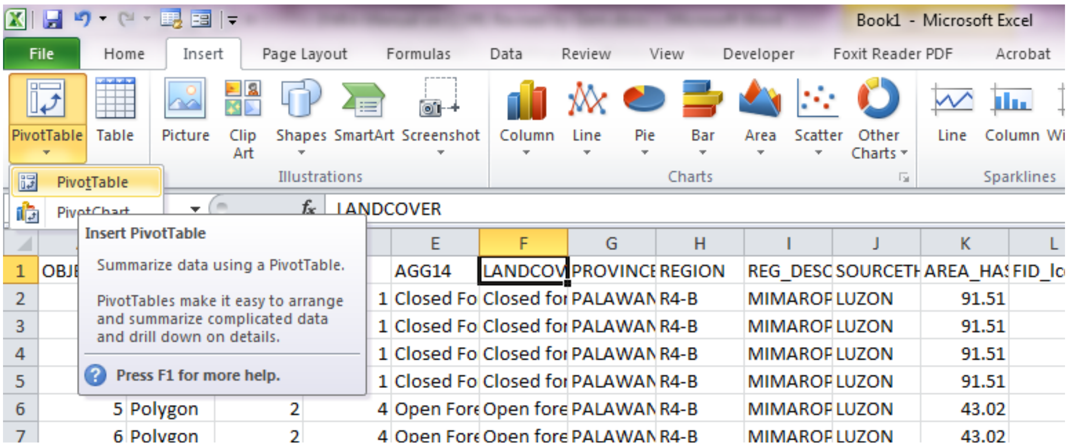
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U
1	OBJECTID	Shape *	FID_lcov1(	Id	AGG14	LANDCOV	PROVINCE	REGION	REG_DESC	SOURCETH	AREA_HA	FID_lcov1	PROVINCE	AGG14_20	ID_2014	LANDCOV	AREA_Has	REGION	REG_DESC	SOURCETH	Shape
2	1	Polygon	1	1	Closed Fo	Closed for	PALAWAN	R4-B	MIMAROF	LUZON	91.51	13	Palawan	Shrubs	10	Other woo	1833.92	REGION IV	MIMAROF	LUZON	2371.
3	2	Polygon	1	1	Closed Fo	Closed for	PALAWAN	R4-B	MIMAROF	LUZON	91.51	37	Palawan	Open Fore	4	Open fore	7815.34	REGION IV	MIMAROF	LUZON	5400.
4	3	Polygon	1	1	Closed Fo	Closed for	PALAWAN	R4-B	MIMAROF	LUZON	91.51	40	Palawan	Closed Fo	1	Closed for	94.77	REGION IV	MIMAROF	LUZON	6856.
5	4	Polygon	1	1	Closed Fo	Closed for	PALAWAN	R4-B	MIMAROF	LUZON	91.51	52	Palawan	Open/Bar	13	Other land	136.51	REGION IV	MIMAROF	LUZON	1145.
6	5	Polygon	2	4	Open Fore	Open fore	PALAWAN	R4-B	MIMAROF	LUZON	43.02	4	Palawan	Shrubs	10	Other woo	1707.05	REGION IV	MIMAROF	LUZON	3413.
7	6	Polygon	2	4	Open Fore	Open fore	PALAWAN	R4-B	MIMAROF	LUZON	43.02	15	Palawan	Perennial	17	Other land	1561.19	REGION IV	MIMAROF	LUZON	712.7
8	7	Polygon	2	4	Open Fore	Open fore	PALAWAN	R4-B	MIMAROF	LUZON	43.02	26	Palawan	Open Fore	4	Open fore	47.28	REGION IV	MIMAROF	LUZON	4128.
9	8	Polygon	2	4	Open Fore	Open fore	PALAWAN	R4-B	MIMAROF	LUZON	43.02	41	Palawan	Shrubs	10	Other woo	3.54	REGION IV	MIMAROF	LUZON	483.8
10	9	Polygon	2	4	Open Fore	Open fore	PALAWAN	R4-B	MIMAROF	LUZON	43.02	45	Palawan	Inland Wa	21	Inland wa	131.1	REGION IV	MIMAROF	LUZON	622.4
11	10	Polygon	3	4	Open Fore	Open fore	PALAWAN	R4-B	MIMAROF	LUZON	62.21	13	Palawan	Shrubs	10	Other woo	1833.92	REGION IV	MIMAROF	LUZON	2566.
12	11	Polygon	4	4	Open Fore	Open fore	PALAWAN	R4-B	MIMAROF	LUZON	58.54	13	Palawan	Shrubs	10	Other woo	1833.92	REGION IV	MIMAROF	LUZON	1658.
13	12	Polygon	5	4	Open Fore	Open fore	PALAWAN	R4-B	MIMAROF	LUZON	44.59	13	Palawan	Shrubs	10	Other woo	1833.92	REGION IV	MIMAROF	LUZON	4331.
14	13	Polygon	5	4	Open Fore	Open fore	PALAWAN	R4-B	MIMAROF	LUZON	44.59	44	Palawan	Open Fore	4	Open fore	20.94	REGION IV	MIMAROF	LUZON	2612.
15	14	Polygon	6	4	Open Fore	Open fore	PALAWAN	R4-B	MIMAROF	LUZON	143.06	13	Palawan	Shrubs	10	Other woo	1833.92	REGION IV	MIMAROF	LUZON	873.9
16	15	Polygon	7	4	Open Fore	Open fore	PALAWAN	R4-B	MIMAROF	LUZON	69952.02	4	Palawan	Shrubs	10	Other woo	1707.05	REGION IV	MIMAROF	LUZON	24347
17	16	Polygon	7	4	Open Fore	Open fore	PALAWAN	R4-B	MIMAROF	LUZON	69952.02	13	Palawan	Shrubs	10	Other woo	1833.92	REGION IV	MIMAROF	LUZON	30048
18	17	Polygon	7	4	Open Fore	Open fore	PALAWAN	R4-B	MIMAROF	LUZON	69952.02	14	Palawan	Perennial	17	Other land	1838.71	REGION IV	MIMAROF	LUZON	18875
19	18	Polygon	7	4	Open Fore	Open fore	PALAWAN	R4-B	MIMAROF	LUZON	69952.02	20	Palawan	Wooded g	12	Other woo	13.9	REGION IV	MIMAROF	LUZON	2951.
20	19	Polygon	7	4	Open Fore	Open fore	PALAWAN	R4-B	MIMAROF	LUZON	69952.02	30	Palawan	Shrubs	10	Other woo	127.28	REGION IV	MIMAROF	LUZON	10927
21	20	Polygon	7	4	Open Fore	Open fore	PALAWAN	R4-B	MIMAROF	LUZON	69952.02	36	Palawan	Open/Bar	13	Other land	3.73	REGION IV	MIMAROF	LUZON	354.7
22	21	Polygon	7	4	Open Fore	Open fore	PALAWAN	R4-B	MIMAROF	LUZON	69952.02	37	Palawan	Open Fore	4	Open fore	7815.34	REGION IV	MIMAROF	LUZON	11453
23	22	Polygon	7	4	Open Fore	Open fore	PALAWAN	R4-B	MIMAROF	LUZON	69952.02	39	Palawan	Shrubs	10	Other woo	36.52	REGION IV	MIMAROF	LUZON	602.6
24	23	Polygon	7	4	Open Fore	Open fore	PALAWAN	R4-B	MIMAROF	LUZON	69952.02	40	Palawan	Closed Fo	1	Closed for	94.77	REGION IV	MIMAROF	LUZON	7236.
25	24	Polygon	7	4	Open Fore	Open fore	PALAWAN	R4-B	MIMAROF	LUZON	69952.02	45	Palawan	Inland Wa	21	Inland wa	131.1	REGION IV	MIMAROF	LUZON	8200.
26	25	Polygon	7	4	Open Fore	Open fore	PALAWAN	R4-B	MIMAROF	LUZON	69952.02	46	Palawan	Perennial	17	Other land	844.06	REGION IV	MIMAROF	LUZON	1167

Figure 2. GIS-generated intersect layer attributes table exported to MS Excel

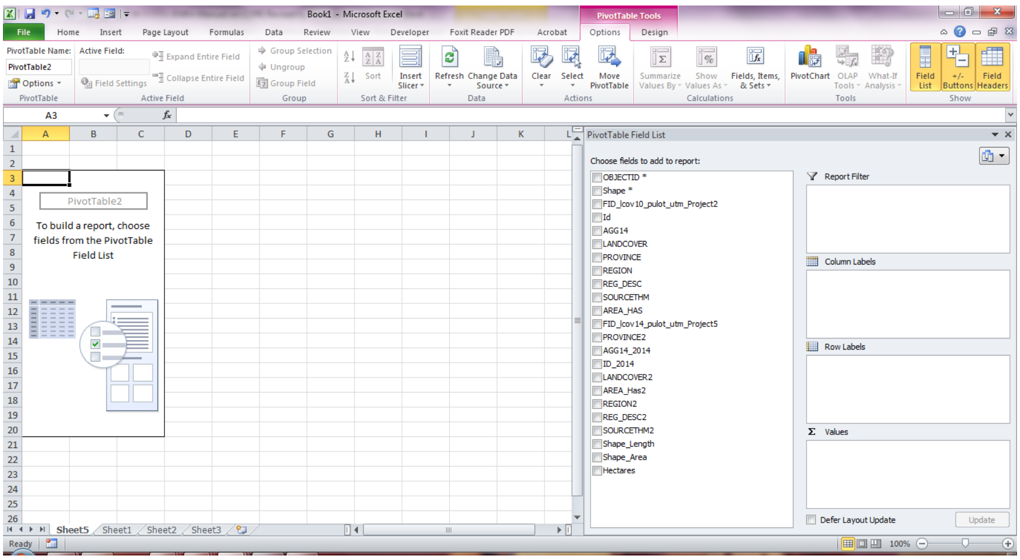
(3) Generate a land cover change matrix of 2010 and 2014 data by creating a pivot table in MS Excel as shown below:

a. Create a Pivot Table: (Click INSERT, PIVOT TABLE, Pivot Table)

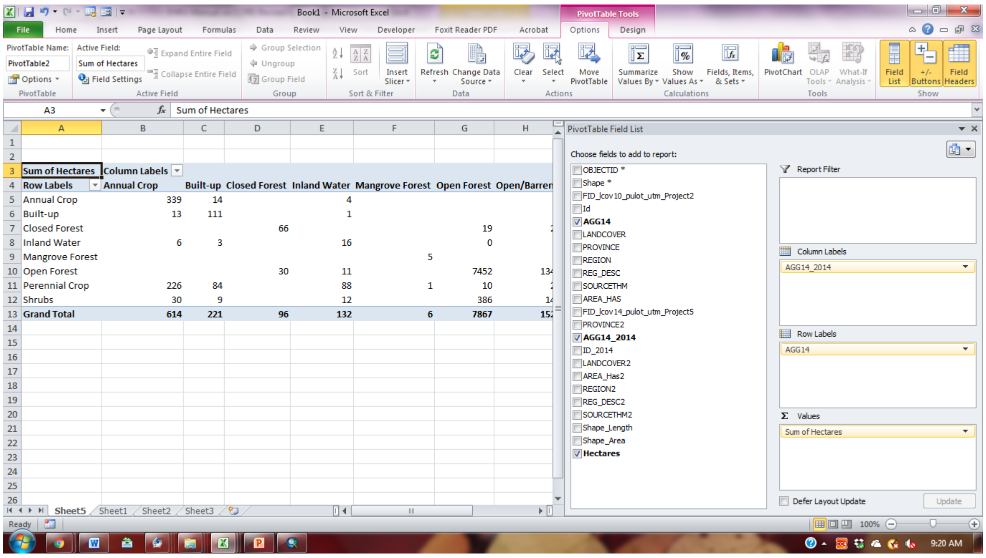
Make sure that your cursor is inside the data table to ensure that Excel automatically selects all data in the spreadsheet.



The output is a blank pivot table template with corresponding column headers for a database for which to select and place in the Column Labels, Row Labels, and Values boxes.



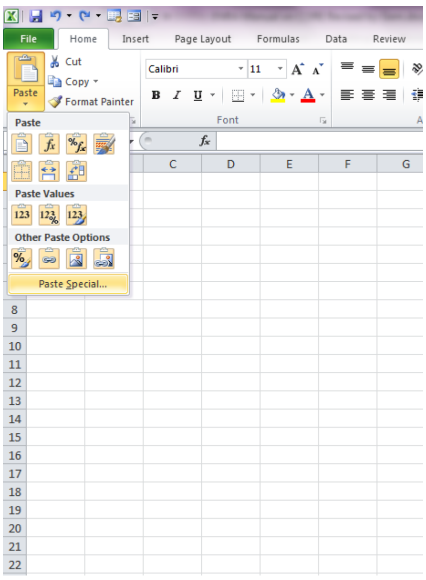
b. Drag the AGG14 (2010 Land Cover Classification) from the Field List to the Row Labels Box, then onto the AGG14_2014 (2014 Land Cover Classification) Column Labels box. Drag Hectares (area per land cover by land cover class) toward the Values box. The resulting output is a matrix of land cover change from 2010 to 2014:



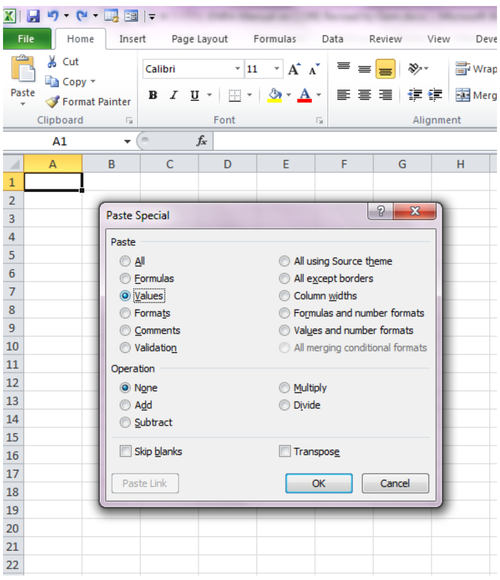
c. Move the slider of excel to view the whole table or click X to remove the field list. You can restore the Field List by clicking on the Field List icon at the top menu.

(4) Prepare a Land Cover Change Matrix to facilitate the creation of Physical Land Asset Accounts, the steps of which are as follows:

a. Copy the entire matrix (pivot table output) to another worksheet. Under the Paste menu, be sure to set the cursor to A1 in the new worksheet. Click on Paste, Paste Special, then Values as shown below:



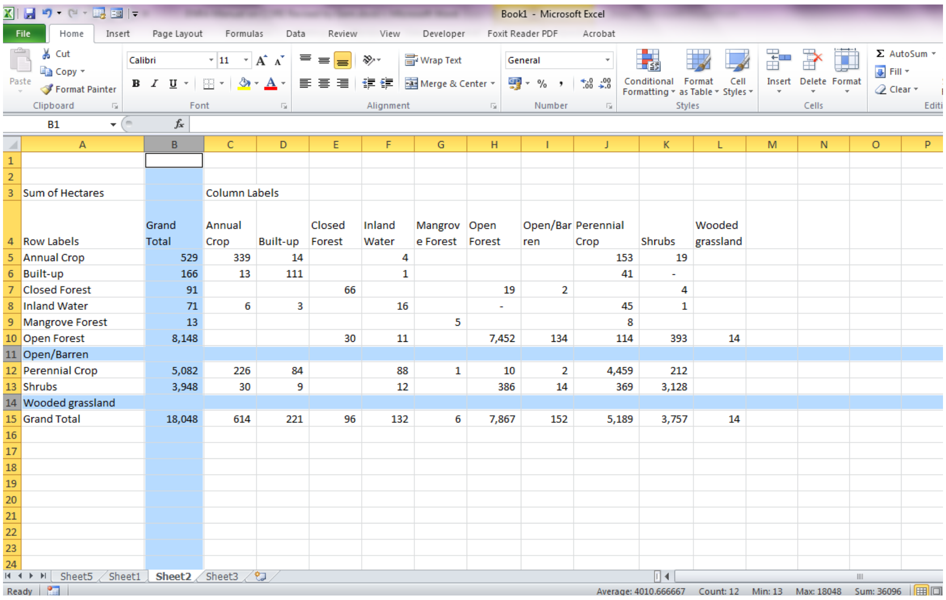
First, Click Paste, Paste Special



Second, Click Values

The resulting spreadsheet should comprise plain numbers and text with no special formatting and filter marks. However, the matrix needs bit of restructuring to create an asset account structure.

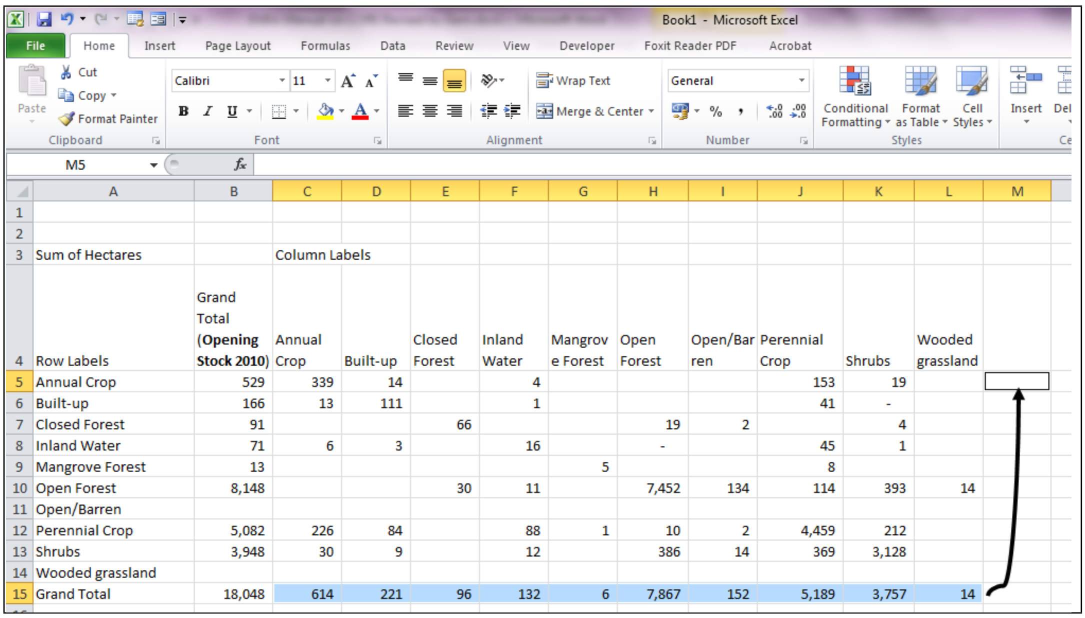
b. Restructure the matrix. Note that the column header labels do not have the same number as the row labels. This means that it is not a square matrix (with the same number of rows and columns). In the row column insert a row after Open Forest and type "Open/Barren," then insert a row after Shrubs and type "Wooded Grassland." Finally, Cut the Grand Total column (right-click on the L header on top and click Cut). Right-click on B header on top. Finally, click Insert Cut Cells. Here is how the final matrix looks.



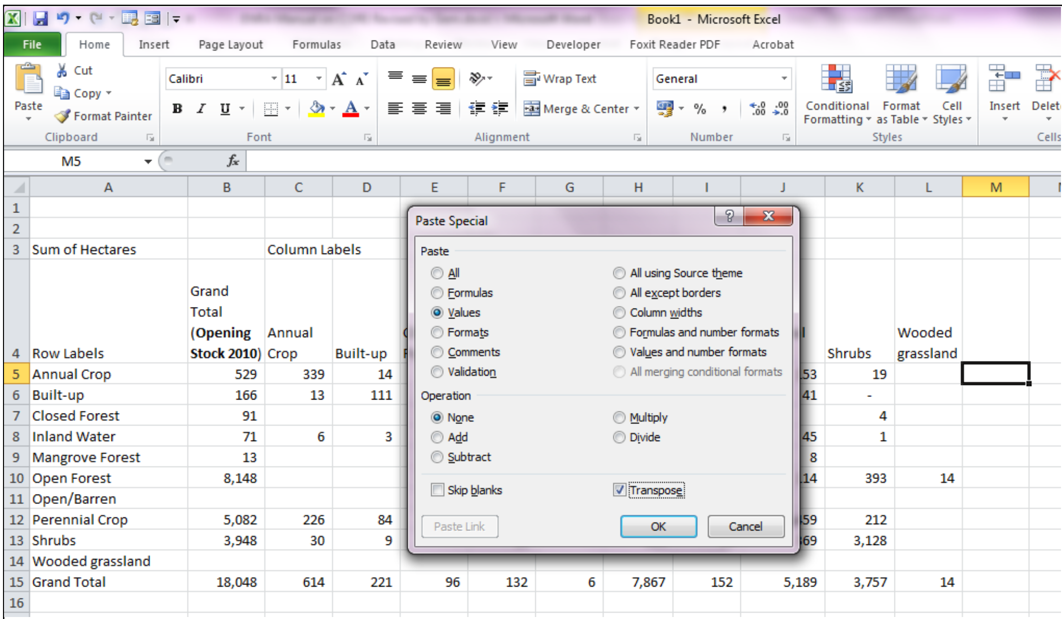
Sum of Hectares		Column Labels									
Row Labels	Grand Total	Annual Crop	Built-up	Closed Forest	Inland Water	Mangrove Forest	Open Forest	Open/Barren	Perennial Crop	Shrubs	Wooded grassland
Annual Crop	529	339	14		4				153	19	
Built-up	166	13	111		1				41	-	
Closed Forest	91			66			19	2		4	
Inland Water	71	6	3		16		-		45	1	
Mangrove Forest	13					5			8		
Open Forest	8,148			30	11		7,452	134	114	393	14
Open/Barren											
Perennial Crop	5,082	226	84		88	1	10	2	4,459	212	
Shrubs	3,948	30	9		12		386	14	369	3,128	
Wooded grassland											
Grand Total	18,048	614	221	96	132	6	7,867	152	5,189	3,757	14

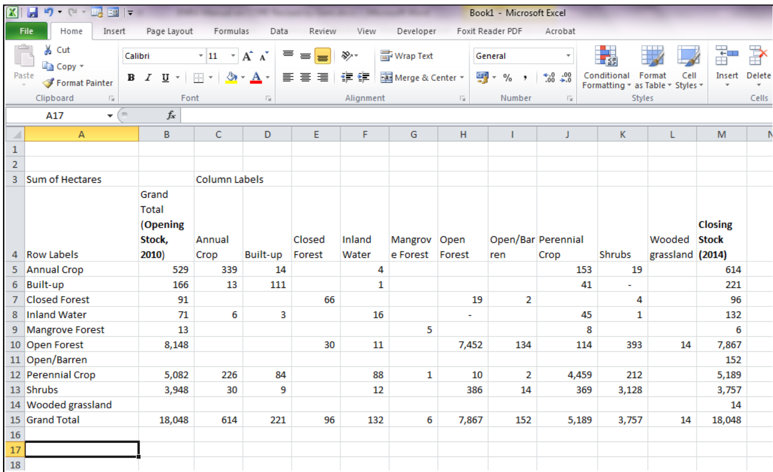
Note: The gray highlight shows where the changes are made.

c. In the Grand Total row, highlight columns starting with Annual Crop to Wooded Grassland Column. Then click Copy and move the cursor to M2 (or the Annual Crop row and after Wooded Grassland column). Finally, click Paste, Paste Special, Value and Transpose. Note sample matrices below.



Sum of Hectares		Column Labels									
Row Labels	Grand Total (Opening Stock 2010)	Annual Crop	Built-up	Closed Forest	Inland Water	Mangrove Forest	Open Forest	Open/Barren	Perennial Crop	Shrubs	Wooded grassland
Annual Crop	529	339	14		4				153	19	
Built-up	166	13	111		1				41	-	
Closed Forest	91			66			19	2		4	
Inland Water	71	6	3		16		-		45	1	
Mangrove Forest	13					5			8		
Open Forest	8,148			30	11		7,452	134	114	393	14
Open/Barren											
Perennial Crop	5,082	226	84		88	1	10	2	4,459	212	
Shrubs	3,948	30	9		12		386	14	369	3,128	
Wooded grassland											
Grand Total	18,048	614	221	96	132	6	7,867	152	5,189	3,757	14


Book1 - Microsoft Excel
File Home Insert Page Layout Formulas Data Review View Developer Foxit Reader PDF Acrobat
Cut
Copy
Format Painter
Paste
Clipboard
Calibri 11
Font
Wrap Text
Merge & Center
Alignment
General
Number
Conditional Formatting
Format as Table
Cell Styles
Styles
Insert
Delet
Cells
M5
Sum of Hectares
Column Labels
Row Labels
Grand Total (Opening Stock 2010)
Annual Crop
Built-up
Shrubs
Wooded grassland
Annual Crop 529 339 14 19
Built-up 166 13 111 -
Closed Forest 91 4
Inland Water 71 6 3 1
Mangrove Forest 13
Open Forest 8,148 393 14
Open/Barren
Perennial Crop 5,082 226 84 212
Shrubs 3,948 30 9 3,128
Wooded grassland
Grand Total 18,048 614 221 96 132 6 7,867 152 5,189 3,757 14
Paste Special
Paste
All
Formulas
Values
Formats
Comments
Validation
All using Source theme
All except borders
Column widths
Formulas and number formats
Values and number formats
All merging conditional formats
Operation
None
Add
Subtract
Multiply
Divide
Skip blanks
Transpose
Paste Link
OK
Cancel


Book1 - Microsoft Excel
A17
Sum of Hectares
Column Labels
Row Labels
Grand Total (Opening Stock, 2010)
Annual Crop
Built-up
Closed Forest
Inland Water
Mangrove Forest
Open Forest
Open/Barren
Perennial Crop
Shrubs
Wooded grassland
Closing Stock (2014)
Annual Crop 529 339 14 4 153 19 614
Built-up 166 13 111 1 41 - 221
Closed Forest 91 66 19 2 4 96
Inland Water 71 6 3 16 - 45 1 132
Mangrove Forest 13 5 8 6
Open Forest 8,148 30 11 7,452 134 114 393 14 7,867
Open/Barren 152
Perennial Crop 5,082 226 84 88 1 10 2 4,459 212 5,189
Shrubs 3,948 30 9 12 386 14 369 3,128 3,757
Wooded grassland 14
Grand Total 18,048 614 221 96 132 6 7,867 152 5,189 3,757 14 18,048

Here is an explanation of what the data in the matrix represent. (Refer to the succeeding table.)

- The BLUE shaded cells are areas retained as existing land cover from Year 2010.
- The rest of the data in each row corresponding to the land cover are REDUCTIONS to the existing stock, in hectares.
- The rest of the data, corresponding to the land cover in each column are ADDITIONS to existing stock, also expressed in hectares.
- Opening Stock (or Land Cover in 2010, in hectares) Plus Additions Minus Reductions equals Closing Stock (or Land Cover in 2014, in hectares.

Land Cover	Grand Total (Opening Stock, 2010)	Annual Crop	Built-up	Closed Forest	Inland Water	Mangrove Forest	Open Forest	Open/ Barren	Perennial Crop	Shrubs	Wooded grassland	Closing Stock (2014)
Annual Crop	529	339	14		4				153	19		**614**
Built-up	166	13	111		1				41	-		**221**
Closed Forest	91			66			19	2		4		**96**
Inland Water	71	6	3		16		-		45	1		**132**
Mangrove Forest	13					5			8			**6**
Open Forest	8,148			30	11		7,452	134	114	393	14	**7,867**
Open/Barren												**152**
Perennial Crop	5,082	226	84		88	1	10	2	4,459	212		**5,189**
Shrubs	3,948	30	9		12		386	14	369	3,128		**3,757**
Wooded grassland												**14**
Grand Total	**18,048**	**614**	**221**	**96**	**132**	**6**	**7,867**	**152**	**5,189**	**3,757**	**14**	**18,048**

(5) Prepare Physical Land Asset account for each land cover class. The account consist of an Opening Stock, Additions, Reductions, and Closing Stock as minimum components.

a. Create table for the Asset Account, similar to the structure below, in a separate worksheet:

Asset Accounts		Annual Crop	Built-up	Closed Forest	Inland Water	Mangrove Forest	Open Forest	Open/ Barren	Perennial Crop	Shrubs	Wooded grassland
Opening Stock											
Addition											
Annual Crop											
Built-up											
Closed Forest											
Inland Water											
Mangrove Forest											
Open Forest											
Open/Barren											
Perennial Crop											
Shrubs											
Wooded grassland											
Reduction											
Annual Crop											
Built-up											
Closed Forest											
Inland Water											
Mangrove Forest											
Open Forest											
Open/Barren											
Perennial Crop											
Shrubs											
Wooded grassland											
Closing Stock											
Net Change in Stock											

b. Using the example of Annual Crops, do the following:

- Under REDUCTIONS: Copy the values in the row corresponding to other land covers in the Annual Crops Row to the rows shown below (14 under Build Up Area, 4 under Inland Water, 153 under Perennial Crop, and 19 under Shrubs.)

- Under ADDITIONS: Copy the column values corresponding to other land covers in the Annual Crop column to the rows shown below (13 under Build-Up, 6 under Inland Water, 226 under Perennial Crop, and 30 under Shrubs)

Asset Accounts		Annual Crop	Built-up	Closed Forest	Inland Water	Mangrove Forest	Open Forest	Open/ Barren	Perennial Crop	Shrubs	Wooded grassland
Opening Stock		529									
Addition		275									
Annual Crop											
Built-up		13									
Closed Forest											
Inland Water		6									
Mangrove Forest											
Open Forest											
Open/Barren											
Perennial Crop		226									
Shrubs		30									
Wooded grassland											
Reduction		190									
Annual Crop											
Built-up		14									
Closed Forest											
Inland Water		4									
Mangrove Forest											
Open Forest											
Open/Barren											
Perennial Crop		153									
Shrubs		19									
Wooded grassland											
Closing Stock		614									
Net Change in Stock		85									

c. Do the same for all the rest of the land covers. A shortcut to the process is as follows:

- For Addition:

    i. Highlight the cells from Annual Crops to Wooded Grassland (cells C5 to L14)

    ii. Do Copy then in the Physical Land Asset Account worksheet position the cursor at Cell C4 (that is, the row corresponding to Annual Crops, under Reductions)

    iii. Do Paste Special, and then Values then ENTER.

- For Reduction:

    i. Highlight the cells from Annual Crops to Wooded Grassland (cells C5 to L14)

    ii. Perform the Copy function. Then in the Physical Land Asset Account worksheet place cursor in Cell C15 (that is row of Annual Crops, under Reductions)

    iii. Do Paste Special, click on Values and Transpose in the dialogue box, then press ENTER.

    iv. Remove the values in the diagonals, starting with Annual Crops down to Wooded Grassland.

(6) The Closing Stock is simply Opening Stock + Addition in Stock – Reduction in Stock. The resulting summary table for the asset account looks as follows:

Constructing Physical Land Asset Account.xlsx - Microsoft Excel

Asset Accounts	Annual Crop	Built-up	Closed Forest	Inland Water	Mangrove Forest	Open Forest	Open/ Barren	Perennial Crop	Shrubs	Wooded grassland
Opening Stock (Year 2010)	529	166	91	71	13	8148		5082	3948	
Addition	275	110	30	116	1	415	152	730	629	14
From Annual Crop		14		4				153	19	
From Built-up	13			1				41	-	
From Closed Forest						19	2		4	
From Inland Water	6	3				-		45	1	
From Mangrove Forest								8		
From Open Forest			30	11			134	114	393	14
From Open/Barren										
From Perennial Crop	226	84		88	1	10	2		212	
From Shrubs	30	9		12		386	14	369		
From Wooded grassland										
Reduction	190	55	25	55	8	696	0	623	820	0
To Annual Crop		13		6				226	30	
To Built-up	14			3				84	9	
To Closed Forest						30				
To Inland Water	4	1				11		88	12	
To Mangrove Forest								1		
To Open Forest			19	0				10	386	
To Open/Barren			2			134		2	14	
To Perennial Crop	153	41		45	8	114			369	
To Shrubs	19	0	4	1		393		212		
To Wooded grassland						14				
Closing Stock (Year 2014)	614	221	96	132	6	7,867	152	5,189	3,757	14
Net Change in Stock	85	55	5	61	(7)	(281)	152	107	(191)	14

(7) Evaluate the results and their implication on land management including policies. The next change in stock is simply Closing Stock – Opening Stock. A negative Net Change in Stock means a reduction in the asset between 2010 and 2014.

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