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Economic valuation of ecological functions and services of natural ecosystems

Guide on the use of simple methods

Jacques Somda, Aboubacar Awaïss

Central and West Africa Programme - (PACO)

Sida

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FOREWORD

The economic valuation of ecological functions and services of natural ecosystems makes it possible to give evidence to the rationale behind conservation policies on these ecosystems. Most of the planning and development decisions on these natural ecosystems are driven by economic factors, notably their capacity to generate income or to provide food to the riparian population.

Although economic valuation methods have some limitations, the conservation and sound use of natural ecosystems require the consideration of economic parameters. Therefore, giving a monetary value to the goods and services provided by natural ecosystems is a crucial step towards demonstrating the economic relevance of their conservation and / or exploitation. The monetary valuation of natural ecosystems should be understood as an effort towards standardizing the various ecological values of an ecosystem that is actually used by the population, in order to facilitate a comparative analysis of the various uses.

The present guide is a contribution of the International Union for Conservation of Nature to a wider application of simple methods for the monetary valuation of goods and services provided by natural ecosystems in West Africa. It is based on four studies conducted on four wetlands: two studies on the Sourou valley (Burkina Faso and Mali), one on the Basse Casamance (Senegal) and one on the Natural Mangrove Park of Cacheu (Guinea Bissau). The preliminary findings of these studies have made the actors involved in wetlands management and conservation eager to further understand the economic valuation concepts and methods that were used.

This guide aims at making accessible the main concepts and methods of economic valuation of the monetary value of goods and services rendered by natural ecosystems in general. This is the rationale behind the development of a guide on simple methods that is accessible for all actors engaged in the economic valuation of ecological goods and services.

Prof. Aimé J. Nianogo
Regional Director

USERS OF THIS GUIDE

This guide on the use of simple methods for valuing natural ecosystems is designed for all actors involved in the economic valuation of ecological services. It was deliberately simplified in order to enable all economist and non - economist actors to take ownership of it. It allows quick understanding of the most commonly used economic valuation concepts and methods applied by natural ecosystem evaluators. It is not claiming to address all issues relating to the economic valuation of ecological services. However, it enables non specialists of environmental economics to understand the basic principles and to further engage in the application of economic valuation of ecosystems.

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This document was written with the inputs of many persons and institutions. We are particularly grateful to Sida for the financial support, without which, the dynamics of economic valuation of natural ecosystems would have taken more time to exist in West Africa. This support helped to bring the debate on this current theme to various conservation and economic actors in five West African countries (Burkina Faso, Mali, Senegal, Guinea and Guinea Bissau) and to refine the assessment of the information needs on the economic value of biodiversity and natural ecosystems.

We extend our appreciation to consultants who tested the economic valuation tools that allow us in identifying the simplest tools that can be applied in the West African context. We are particularly grateful to Drs Abdoulaye Zonon and Jean-Marc Ouadba who tested the tools in the Sourou Valley in Burkina Faso; Dr Cheick Oumar Traoré and Mr. Abdoulaye Idrissa Maïga for the test in the Sourou Valley in Mali; Mr. Justino BIAI and Mr. Alfredo Simão DA SILVA for the Natural Park of the Cacheu River in Guinea Bissau; and Mr. Bourama DIEME and Dr Adrien COLY for the National Park of Basse Casamance in Senegal. More than a hundred participants in different workshops on the dissemination of the findings of four studies have contributed to the refinement of the selection of simple tools for the economic valuation of natural ecosystems. Finally, we wish to thank Dr Omer Combary who revised the earlier version of the document and made significant improvements. Authors alone bear the responsibility for any flaws that still remain in the document.

I. INTRODUCTION

Natural ecosystems provide goods and services for the well-being of the community. However, most of these goods and services are provided outside the market. Therefore, there is no indicator of the value that allows revealing what users are willing to sacrifice to use or conserve a unit of these resources. This lack of indicator of value in the form of price has led economic agents to implicitly assign zero value to environmental goods and services at the time of making decision; resulting in overexploitation of natural ecosystems.

The economic valuation of natural ecosystems looks into resource allocation in a way that will sustainably improve human well-being without degrading natural resources. It is therefore critical to decision-making and sound management of natural resources. It makes it possible to: (i) earmark adequate budgets for the restoration of degraded natural ecosystems, (ii) highlight the importance of natural ecosystem functions when these are competing with hydro-agricultural and industrial works and (iii) convince project managers to undertake actions towards protecting natural ecosystems.

The economic valuation thus allows conservation of natural resources and avoids the use of huge expenditure for the restoration of the services provided to humans. It helps to value in monetary terms the effects of human activities on the environment. However, most decisions to develop natural ecosystems do not take account of the total economic value of ecological services. This leads to the rapid and continuous degradation of natural ecosystems.

Despite the methodological limitations of economic evaluation of ecosystems, estimating the total or partial economic value of ecological services is essential, especially to African countries. Natural resource management policies transform natural ecosystems in view of improving people's livelihoods. However, these policies are often implemented without prior knowledge of the initial contribution of ecosystems to the well-being of communities and to the national economy.

This failure to recognize the real value of natural ecosystems often leads to policy decisions that generate low value ecological services instead of services that yield great economic value. This contributes to undermining the well-being of West African populations and slowing down the economic and social development. This is the rationale behind the development of this economic valuation of natural ecosystems. The guide aims at making available to all actors involved in the evaluation, the simplest methods for measuring the economic value of natural ecosystems. The selected methods do not require specific knowledge on environmental economics theory, economic and/or econometric statistical methods.

II. FUNCTIONAL APPROACH TO NATURAL ECOSYSTEM SERVICES

Natural ecosystem services include all ecosystem aspects that people directly or indirectly benefit from. The typology according to the functions of natural ecosystems helps to meet the requirements of economic evaluation. It helps avoiding double counting of natural ecosystem services in the total economic value and producing a more accurate analysis in relation with the evaluation objectives (Fisher et al., 2009; Morse-Jones et al., 2010; Bouscasse et al., 2010).

II.1 SERVICES RENDERED BY NATURAL ECOSYSTEM

The functional approach is the most commonly used to classify natural ecosystems services. The comprehensive identification of natural ecosystem services and their uses makes it possible to account for them in economic evaluations. Figure 1 shows that natural ecosystem services can be analyzed using a logical framework in four components:

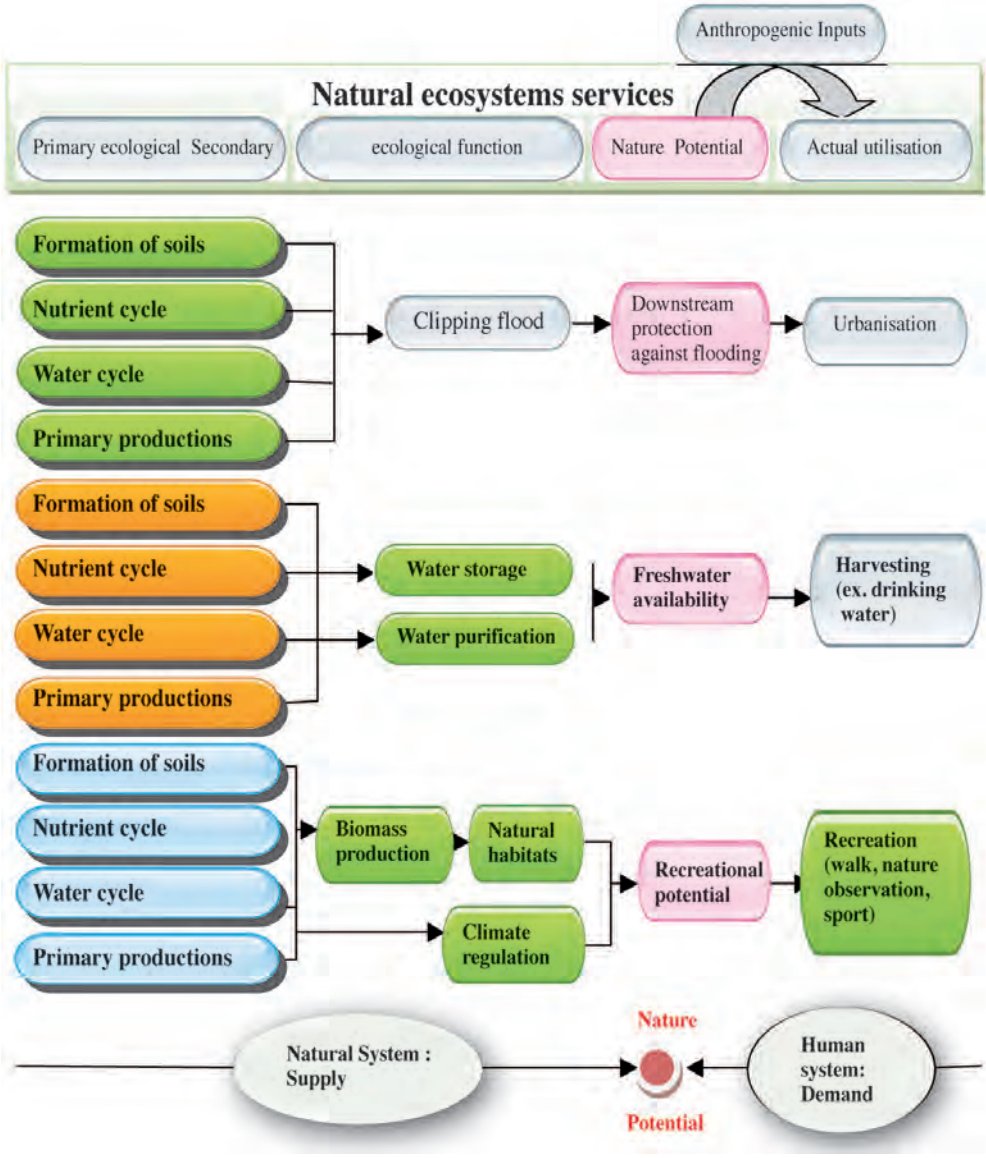
i) The primary ecological function
Primary ecological functions are the services required for the production of all other natural ecosystems services. They are originated from the functional processes of ecosystems that occur without human intervention and this, irrespective of their direct utilization by human (Collectif, 2010). These are notably production services that directly yield ecosystems products such as soil formation, nutrients and water recycling and primary production.

ii) The secondary ecological function
Likewise the primary ecological functions, secondary ecological functions are biological processes that operate and maintain the ecosystems. These are services obtained from the ecosystem regulatory processes such as maintenance of air quality, climate regulation, water regulatory processes (ground water recharge, levelling-off peak floods etc.), water purification and waste treatment, biological regulations (plant diseases), pollination, and storm regulation.

iii) The potential of nature
The potential of nature represents the potential value associated with the various services provided by a natural ecosystem in the absence of any use by Man. It can only be under effective utilization if anthropogenic inputs, such as infrastructures, are brought into the natural ecosystems by human beings.

iv) Actual use
Economic, recreational and cultural activities are the benefits which Man enjoys through the effective use of ecological services of natural ecosystems. The actual use of such services can be materialized through religious and cultural values, scientific interest, educational value, inspiration for arts and architecture as well as the beauty of landscapes.

Figure 1 : Structuring services of natural ecosystems: the case of wetlands



Source: Adapted from Bouscasse et al. (2011)

The structuring of natural ecosystems services in a logical chain preventsdouble counting of such services. According to Bouscasse et al. (2010), the following characteristics may induce double counting of ecosystem values:

- The possibility for an ecosystem service to provide several benefits to different sub-groups of population;
- Interconnections among ecosystem services in such a way that some services are directly useful to human being (end services), but can also be mobilized in processes using other services (intermediate services) ;

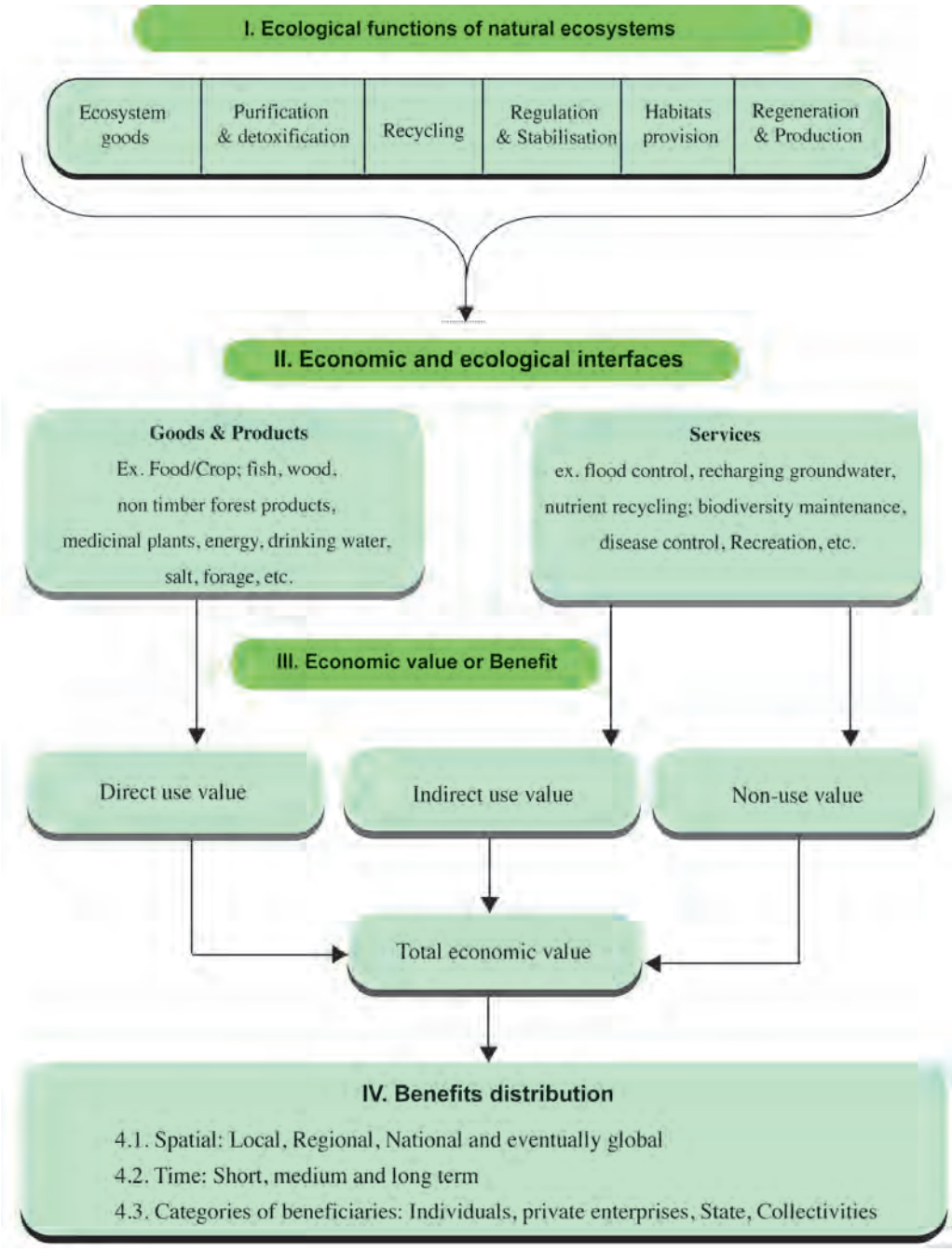
- The degree of heterogeneity of ecosystem services in time and space. Ecosystem services are produced at a given place and benefit to a population living in the same place or elsewhere; the very definition of the service depends on the benefit considered. Given that people consider benefits (or services) of the same ecosystem differently, the benefits may come from competing services and hence may not be compatible with the others.

II.2 FROM ECOLOGICAL FUNCTIONS TO ECONOMIC FUNCTIONS OF NATURAL ECOSYSTEMS

Natural ecosystems and the biological diversity that they contain provide a variety of goods and services. Maintaining these goods and services is essential to the well-being and economic prosperity of human beings. Fully understanding the linkages that reflect the shift from ecological functions of natural ecosystems to their utilization helps to develop a theoretical and operational framework for economic valuation.

Figure 2 shows the logical chain from production to distribution of ecological goods and services in an economy. Bringing in human inputs makes it possible to tap on the ecological functions in order to provide the goods and services that are likely to improve human well-being. The economic value of all these environmental goods and services distributed in time and space determines the total economic value of the natural ecosystem.

Figure 2 : Integrated framework for estimating the monetary value of natural ecosystems



Source: Adapted from Farber et al. (2005)

III. THE APPROACH TO ECONOMIC VALUATION OF ECOLOGICAL SERVICES

The approach to the economic valuation of a natural ecosystem should make it possible to account for all its ecological services, understand its functioning system and interactions with the external environment. To this effect, the approach to total economic value helps to consider the various economic values of ecological services.

III.1 THE TOTAL ECONOMIC VALUE OF A NATURAL ECOSYSTEM

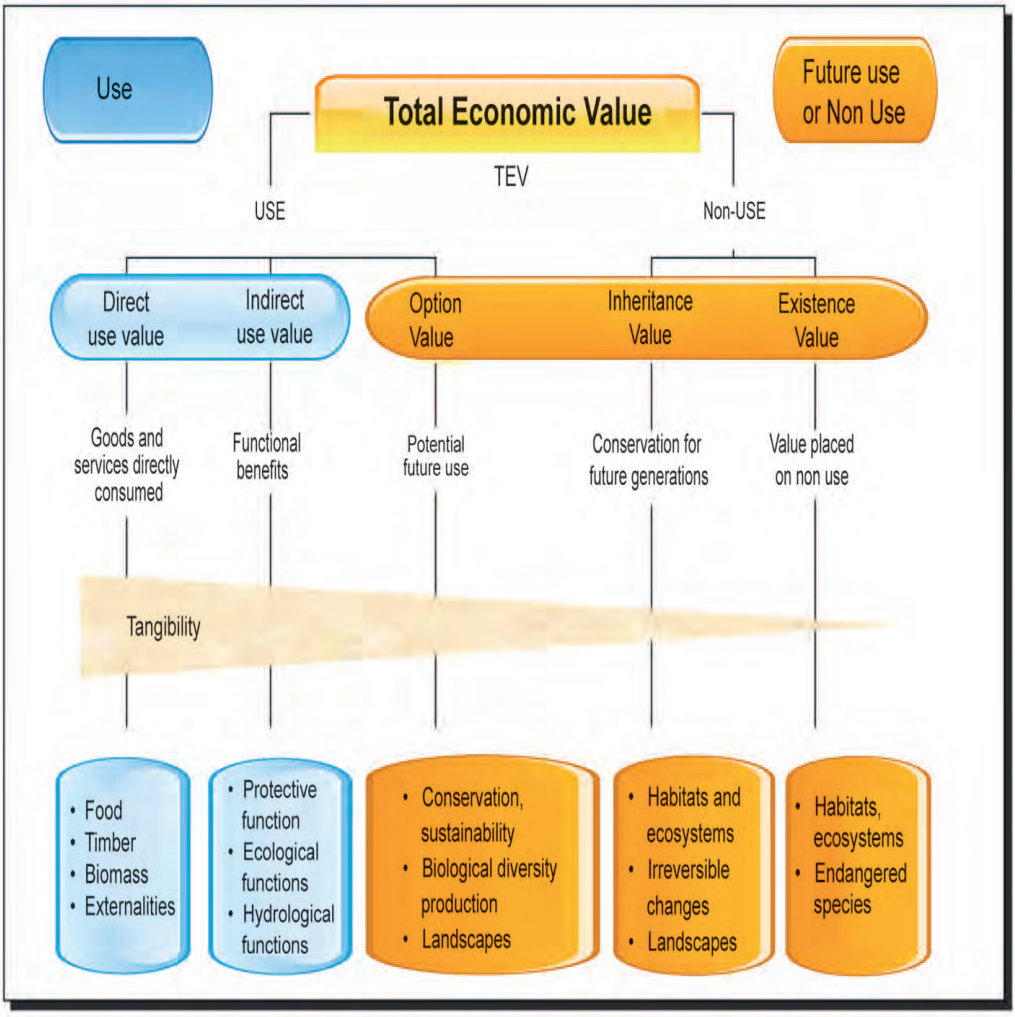
The total economic value provides a theoretical and operational framework for the economic valuation of a natural system. It represents an overall measurement of all ecological goods and services of an ecosystem. The total economic value differentiates the use values from the non use values or future use.

- Use values include: (i) direct use through the use of ecosystem goods and services that can be directly consumed, (ii) indirect use through benefits derived from functions provided by the ecosystems and (iii) future use or optional value through potential uses of ecosystems. These values may be linked to an existing or non existing market.

- Non use values refer to people's readiness to pay for the conservation of a good that they do not actually use, do not intend to use or they cannot use (Pearce et al., 2006). Such values include: (i) inheritance values through conservation for future generations, and (ii) existence values through the value placed on the very existence of the ecosystem.

Figure 3 illustrates the economic valuation framework of the total economic value of natural ecosystems. It highlights the fact that some ecosystem services are more tangible than others. For instance, direct use values that include the production of food, timber, biomass, and. other externalities are more tangible than existence values. As a result, valuation methods for the monetary value of more tangible goods are simpler to apply than those for less tangible goods.

Figure 3 : Conceptual framework of the total economic value of natural ecosystems



Source: Adapted from Munasinghe (1992)

The estimation of the total economic value requires that the evaluator takes a comprehensive approach in several steps.

III.2 STEPS TOWARDS ECONOMIC VALUATION OF NATURAL ECOSYSTEMS

Economic evaluation of a natural ecosystem requires an understanding of the studied system, its operation, and its interactions with other related sites as well as its effects on the economic, recreational and cultural activities. To this effect, De Groot et al. (2007) proposed four steps in the economic valuation of wetlands ecosystems. This approach has been adapted into a five-step economic valuation of natural ecosystems.

III.2.1 Step one : Analysis of policy processes and management objectives

The first step in the economic valuation process consists of taking cognizance of the context in which the natural ecosystem is being tapped on. The idea is to have a full understanding of policy processes, management objectives and interests at stake to the public authorities and grassroots communities. The main elements in the analysis of policy processes and management objectives to be considered are:

- The social capital and actors

The social asset includes informal social networks, institutions, relationships and norms used by communities to exchange resources and information. Actors are the people or organizations that have an interest in a given natural ecosystem. It is therefore essential to thoroughly identify and analyze the strengths and weaknesses, as well as the opportunities and threats that the social asset and actors represent to the ecosystem concerned.

- Background, statements and policy measures

The policy background should be analyzed in order to determine the mutual linkages among policies, the way they function together or against each other, in order to fully understand the potential and barriers.

- Policy process and priorities

An analysis of existing policy and gaps helps determining policy priorities.

- Institutions and organizations

Institutions (social rules, procedures and standards) and organizations (government, private sector and civil society) play a role as an interface between policy and population. Their analysis helps to understand: (i) why do gaps exist between policy statements and what is observed in practice, and (ii) the degree of mainstreaming micro level realities into the policy development process.

- Livelihood

The analysis of policies relating to sustainable livelihood requires clear understanding of priorities in terms of livelihood, sectoral policy involved and the diagnosis of the relevance of policies in these sectors.

This step requires a critical literature review of policy processes and management objectives. For this purpose, the use of reading grid of official documents, published or not may be necessary. Documents analysis may be updated with interviews using a semi – structured guide with main policy – makers involved in the ecosystem use. During such interviews, information could be given to policy-makers on the objectives of the economic valuation and the process in which their participation is expected. This enables the verification of their interests in conservation and / or use of the ecosystem being evaluated.

III.2.2 Step two : Analysis and participation of stakeholders

The economic valuation of natural ecosystems is only possible if the actors concerned are well known and their participation secured. Identifying the main actors from the start of the process helps to: (i) ensure their participation in all stages of the valuation process, (ii) determine the main policy and management objectives, (iii) define the main relevant services, (iv) estimate the economic value of ecosystem services and (v) make comparisons among the various uses of ecosystem services.
Apart from policy-makers involved in the first step, there are other actors whose decisions at much lower levels influence the functioning of ecosystems. These actors are among others, the users (communities, households, individuals) of the services of the ecosystem concerned and organizations (local, national and international) involved in one way or the other in the management of the ecosystem.

The actions undertaken by these actors have influences on the functioning of the ecosystem under valuation and hence on its economic value. These are therefore the main actors of the economic valuation of the ecosystem and as such they should be well informed. At this stage, it is important to collect information on ecosystem goods and services used and their importance to the well-being of the actors. Information on the various uses of the ecosystem will enable the verification of the consistency and relevance of the policy objectives (step 1) and those of the other actors.

The main elements to be considered in the analysis of actors are: (i) information on the characteristics of groups or individuals affected by the decisions, (ii) a categorization of actors or groups of actors based on their significance and influence with regard to the ecosystem under review, (iii) explanation of potential conflicts among major groups and (iv) identification of domains where trade-offs are possible.

Stakeholder analysis can be done based on the collection and use of secondary data on the actors involved in the use of ecosystem services. Secondary data may be drawn from earlier surveys, recent data or specific studies conducted in the area hosting the ecosystem. Such data may come from several sources (Municipality, local NGOs, organizations and institutions involved). The use of secondary data has the advantage of being less expensive. But under African conditions, such data are often incomplete and may required update.

Stakeholder analysis can also be done using primary data from questionnaire survey. This approach is best used when there is virtually no information on the actors. It helps gather data on a large number of respondents to enable statistical analysis of the findings. The design of a questionnaire requires training on survey techniques. But in general terms, the procedure to design a questionnaire should include the following steps: (1) define survey objectives, (2) define the sample group, (3) prepare the questionnaire, (4) administer the questionnaire and (5) interpret the findings.

III.2.3 Step three : Functional analysis

Functional analysis of a valued ecosystem consists of identifying and quantifying as much services as possible of this ecosystem. It involves a critical literature review and also complementary surveys or interviews to ensure that the major services of the ecosystem have been identified and quantified.
Finally, it is important to make sure that all actors and policy makers concerned by the assessed zone have agreed with the major services identified and quantified in appropriate units (ecological, socio-cultural and economic indicators). The quantity of services agreed on will be multiplied by their prices to obtain the economic value of the ecosystem.

Determining the economic value of an ecosystem is only possible if the functions are clearly identified and the services adequately quantified. In other terms, the monetary value allocated to a natural ecosystem depends on how accurate identification of functions and quantification of services are. Step 3 constitutes the corner stone for the determination of economic value. Its implementation requires the skills of specialist of the ecology of the ecosystem involved. The actors identified during the previous step are critical to the success of the functional analysis. The commonly used methods for analyzing ecosystem functions are:

• **Data reviews :** this is the search for, collection and use of data available in literature on the functions of the ecosystems concerned. Sources for this type of data are either national or international research institutes, or technical departments involved in the management of the ecosystems. The development of reading grid is required so as to target the literature search. Once the data is collected, it should be checked and updated to ensure its validity.

• **Questionnaire-based interviews :** Questionnaire-based interviews are often the only method for collecting data on ecological functions of an ecosystem because of the low level of research activities in the domain. A good questionnaire for functional analysis of ecosystems should include the category of the primary function, secondary functions related to each primary function, the available natural potential of each service delivered by each secondary function and the actual use made of the natural potential. All these components should be derived from Step 1 on policy analysis and from Step 2 on the analysis of actors as described earlier. The goal of the questionnaire-based interview is to translate the characteristics of the ecosystems (process and elements) into a detailed and exhaustive list (if possible) of ecosystem services that will be quantified in appropriate measurement units (physical or other).

III.2.4 Step Four : Estimating the monetary value of services

Step four aims at evaluating in monetary terms, the economic value of natural ecosystem services. The estimate of the monetary value of ecosystem services uses a pricing system that is based on either revealed preferences, or declared preferences. Revealed preference-based prices are equivalent to the market price of the end product of the ecosystem while declared preference-based prices are derived from a market assumption. The use of either type of price for estimating the monetary value depends on the method used. Section V of this document will present in a more detailed manner, the methods for evaluating the monetary value of ecosystems.

III.2.5 Step Five : Communicating the values of the ecosystem

The assessment of the monetary value of ecosystem services has interest only when it meets a demand. Potential requesters of such information are identified in Step 1 and 2. It is therefore important that at the end of the ecosystem valuation process, findings are adequately communicated to policy makers and actors who have participated in the study. The main objective of communicating ecosystem values is to raise discussions around management policy options that have been made or are being made.

In the case of on-going management policy options, the findings can lead policy makers and other actors concerned to taking corrective measures that take into account the various economic values of the services provided by the ecosystems. In the case of a future management policy option, the findings can contribute to making a decision based on the estimated economic potential of the ecosystem. Communicating estimated economic values of an ecosystem is a critical step towards promoting behavioural change and policy choices that would enhance the management of a given ecosystem.

Although the five steps in the analysis seem to follow sequences, it may be necessary to revert to a previous step to revise the valuation process, improve the analysis and refine information needs. The implementation of the approach to economic valuation of ecological services provided by natural ecosystems requires the use of sound monetary valuation methods.

IV. MONETARY VALUATION METHODS OF NATURAL ECOSYSTEMS

Valuation methods are processes through which the monetary value of the variation of the quality / quantity of environmental goods and services is revealed. The idea is to estimate the monetary value of a variety of goods and services supplied by a natural ecosystem to populations.

IV.1 CRITICAL REVIEW OF MONETARY VALUATION METHODS

The monetary valuation of a natural ecosystem is a complex exercise which often requires the combination of several methods. Irrespective of the methods used, a description of other non tangible values is necessary. Bouscasse et al. (2011) group the various methods for natural ecosystem monetary valuation into four categories :

i) Deductive methods

The economic values of environmental services are inferred through the costs that would have been incurred in case such services disappear or become altered. Deductive methods include the avoided cost method, the substitute cost method and the replacement cost method. These methods are relatively intuitive and generally better understood and accepted in discussions with actors. They however do not allow the incorporation of the entire economic value attributed to natural ecosystems (and notably the non use value) and they can be difficult to implement when one is simultaneously interested in several services (double counting problems), as some of the services may be sometimes dependent on others.

ii) Revealed preference methods

Revealed preference methods deduct the value of services provided by the environment from existing situations and decisions actually made by individuals. The ambition of these methods is to observe the behaviours of ecosystem users which are supposed to reflect their preferences and hence the value that they give to natural resources. These methods include the market price method, the transport cost method and the hedonic price method. The methods make it possible to disaggregate the total economic value; however, the sum of economic values obtained does not necessarily represent the total economic value due to the fact that some uses are less tangible and their prices difficult to estimate.

iii) Declared preference methods

Declared preference methods help to estimate the value of an ecosystem (or of one of its functions) by using a substitute hypothetical market to fill the gap caused by the absence of a real market which could be used to set the price of the ecosystem. They include among others, the contingent valuation method and the joint analysis method. These methods help to fully understand the largest variety of values (use and non use) and ultimately, to better understand the complexity of the total economic value of a natural ecosystem. However, disaggregating the total economic value in different uses is highly complex.

iv) The benefit transfer (or value transfer) method

The benefit transfer method consists of using the findings of existing similar studies to estimate the monetary value of a natural ecosystem. It thus uses secondary data. This method generally helps to obtain an initial estimate of the value of an environmental good or service. This may be complemented based on needs (political use, etc.) with a primary study of the contingent or transport cost- type of study.

Table 1 is an illustration of a short critical overview of major ecosystem monetary valuation approaches and techniques. It describes the capacity of techniques to capture the full range of economic values of ecosystems, some of their benefits and disadvantages.

Table 1 : Overview of ecosystem economic valuation approaches and techniques

Approaches	Techniques	Nature of the value	Benefits	Disadvantages
Deductive methods	Avoided cost, substitute costs and replacement cost methods	Direct use values, indirect use values	Intuitive method	Does not allow to assess the non use value
Declared preferences	Contingent Valuation	Direct use values, indirect use and non use values	Can be used for all types of values	Prone to a lot of bias Requires a lot of data
	Choice modelling	Direct, indirect use and non use values	Can be used for all types of values. Non biased.	Complex analysis Requires a lot of data
	Participatory economic Valuation	Direct, indirect use and non use values	Can be used for all types of values. Requires few data	Subjective
Revealed preferences	Market price analysis	Direct use values Market products	Reflects market prices. More limited application	Requires a lot of data
	Cost-based methods	Indirect use value	Reflects market prices. More limited application	Requires a lot of data
	Productivity methods	Indirect use value	Reflects market prices. More limited application	Requires a lot of data
	Preventive expense methods	Indirect use value	Reflects market prices. More limited application	Requires a lot of data
	Travel cost method	Tourist value	Reflects market prices. More limited application	Requires a lot of data
	Hedonic price method	Use value attributed to change in the environmental quality	Reflects market prices. More limited application	Requires a lot of data
Benefit transfer	Use of previous empirical studies	Direct, indirect use and non use values	Requires few data Cost – effective	Existing studies non applicable

Source : Bouscasse et al. (2011), IUCN (2005) and Rodriguez (2008)

There are no rules to select the most appropriate methods for the monetary valuation of a natural ecosystem. The monetary valuation team should have good command of the various methods in order to make a judicious choice depending on ecosystem services and valuation purposes.

IV.2 INTRODUCTION TO SOME SIMPLE MONETARY VALUATION METHODS

Based on a critical review of monetary valuation methods of natural ecosystems, four methods were selected for a detailed presentation owing to the simplicity of their implementation.

IV.2.1 The market price-based method

The market price-based method estimates the value of goods and services supplied by a natural ecosystem using their prices on the market. It can be used in the monetary valuation of end or intermediate ecosystem goods and services. Ecosystem goods that are considered to be end goods are the products obtained from collection, catching and harvesting by human beings with little or no inputs except labour. Such end products may be sold in the market and therefore have a market price. In case they are not sold in the market, one can then use the prices of perfect substitutes supplied by the human system in terms of ecological functions.

In general terms, the method is applicable to goods obtained from directly consumed service delivery. Examples of such goods are: non timber forest products, fishing products, medicinal plants, soil fertility, hunting products, etc.

However, when goods that are actually used are strongly influenced by man-made inputs, the market price method can no longer be applied without caution. In that case, the influence of anthropic inputs on the final production of the goods considered should be taken into consideration. The productivity function-based approach is then the most appropriate method.

The implementation of the market price-based method requires the development of a data collection form for the quantities, prices and number of actors involved in the actual use of the ecosystem goods considered. The economic value is estimated by multiplying quantities by prices and number of actors. The value thus obtained is referred to as the direct use value.

The market distortions and /or failed policies can be such that the real economic value of ecosystem goods and services does not adequately reflect market transactions. The method is also influenced by the changes that affect supply of and /or demand for ecological goods.

IV.2.2 The travel cost-based method

The travel cost-based method evaluates the economic value of an ecosystem that is used for recreation purposes based on expenses made by users that travel to the site. The basic idea is to estimate people's willingness to pay in order to use a leisure place with the money and time that they devote to travel to the site.

The implementation of the travel cost-based method requires the evaluator to be able to determine the surface area of the recreation place and subdividing it into areas in which travel costs are more or less the same. Within each area, a sample of visitors should be selected for information collection on the cost of visiting the ecosystem, reasons for travelling to the place, frequency of visits, features of the site and socio-economic variables such as origin of the visitor, his or her income, age, level of education, etc.

The data collected will help to estimate the rate of visitors to each zone, the total number of visits per day and per capita in the location, travel costs including direct expenses (fuel, visit taxes, food, equipment, accommodation) and time spent during the trip, etc. It is also possible to estimate econometric models to test the link between the visit rate and various variables. The economic value obtained is termed as the indirect use value.

The travel cost method does not allow assessing the non use values of an ecosystem. The economic value obtained is also highly sensitive to the regression function which is estimated for testing the link between the rate of visits and other explanatory variables of the model. In addition to requiring a lot of data, the method lies on very restrictive assumptions on the consumer's behaviour.

IV.2.3 the ecosystem service replacement cost method

The cost replacement method consists of evaluating the costs that would be incurred in case the ecosystem services disappear or their quality is altered. The economic value is estimated on the basis of the costs of the artificial product used as a substitute for ecosystem goods and services. The method is applicable to all ecosystem goods and services that have market substitutes.

An ecosystem service can be replaced by a service delivered through an anthropic system (Farber et al., 2002). For instance, soil fertilization by natural recycling of nutrients can be replaced by the use of chemical fertilizers. The cost of replacement of such ecosystem services by artificially obtained goods or services may be seen as the value of this ecosystem service or good that has been replaced. The implementation of the method requires the evaluator to be able to determine the benefits generated by the ecosystem goods and services, the way they are used by actors involved, the magnitude and extent of such benefits. Also, there is need to identify the most likely alternative product or service, the infrastructure or technology that would provide similar levels of ecosystem benefit to a similar population.

The monetary valuation is inferred through the costs of introduction and distribution or installation and functioning of the alternative product or substitute for the ecosystem good or service. The value obtained is known as the indirect use value. The main limitation in this method is the fact that it is often difficult to find a perfect alternative or substitute for an ecosystem good or service. This may create a doubt about the validity of the value obtained which may be underestimated or overestimated.

IV.2.4 The contingent valuation method

The contingent valuation method consists of estimating the monetary value of an ecosystem based on people's willingness to pay in order to prevent the degradation or improve the goods and services supplied by a given ecosystem for which no market or substitutes exist. It creates a fictitious or hypothetical market for the ecosystem good or service and the interview respondents state whether they are prepared to pay for it or not (O'Doherty, 1996).

The implementation of the contingent valuation method entails that the evaluator is capable of correctly identifying the ecosystem services to be valued and drafting a data collection questionnaire accordingly. The questionnaire should make it possible to handle any format responses, the occurrence of nil values, refusals and biased answers.

The limitations of the method come from the hypothetical bias which indicates a risk of having answers that do not reflect the real stakes, due notably to the monetary overestimation or underestimation of the ecosystems. Despite these drawbacks, the contingent valuation method is the most commonly used to assess the total economic value of ecosystem goods and services, more particularly because it helps to capture non use values.

Table 2 summarizes ecosystems services that can be valued using simple methods as well as the required technical skills for their implementation.

Table 2 : Simple methods for ecosystem monetary valuation

Valuation methods	Goods and Services concerned	Technical skills required for implementation
Market price	Collected goods (NTFP), hunting goods (game), fish catching	• Capacity to identify the products concerned ; • Average knowledge of survey techniques ; • Simple statistical calculations
Travel costs	Maintenance of beneficial species, productive ecosystems and biodiversity that provide recreation services	• Average knowledge of survey techniques ; • Average statistical skills
Service replacement cost	• Drainage and nature-based irrigation; • Protection against storms; • Floods control	• Average knowledge in production economics ; • Sound statistical skills
Contingent valuation	All ecosystem goods and services	• Relatively sound knowledge in demand economics ; • Sound knowledge of survey techniques; • Sound statistical skills

Source : Inspired by Bouscasse et al. (2011) ; IUCN (2005) ; Rodriguez (2008)

The methods discussed here can be used alone or in combination depending on the objective of the ecosystem monetary valuation. If the objective is to disaggregate the total economic value, then the valuator will have to combine several methods while avoiding double counting. On the contrary, if the objective is to consider the total economic value as a whole, the valuator will then select the holistic method. Regardless of the method chosen, a multi-disciplinary approach is required at all stages of the valuation and this should call for collaboration between economists and ecologists.

V. SCOPE OF THE ECONOMIC VALUATION OF NATURAL ECOSYSTEMS

Despite the efforts made to improve economic valuation methods of natural ecosystems, many factors still make some people believe that the monetary values are under estimated or over estimated (Vorhies, 1999; Stuip et al. 2002). These risks of underestimating or overestimating the economic value of natural systems should not hide the importance of this information for decision-making purposes.

V.1 CAUTION IN THE USE OF ESTIMATED ECONOMIC VALUES

Monetary valuation of an ecosystem has inherent limitations due to the complexity of the functioning of ecosystems and also to the challenge to transcribing all values into a single monetary measurement unit. Ecosystems have diverse functions that can be quantified using a variety of measurement units. It is not therefore easy to make a decision in such a context of heterogeneous measurement units of ecological function, hence the interest in using currency as a measurement unit. One should be aware that estimated monetary values do not accurately match the value of all goods and services delivered by the ecosystem. They however constitute major tools for facilitating comparison among the various management policies.

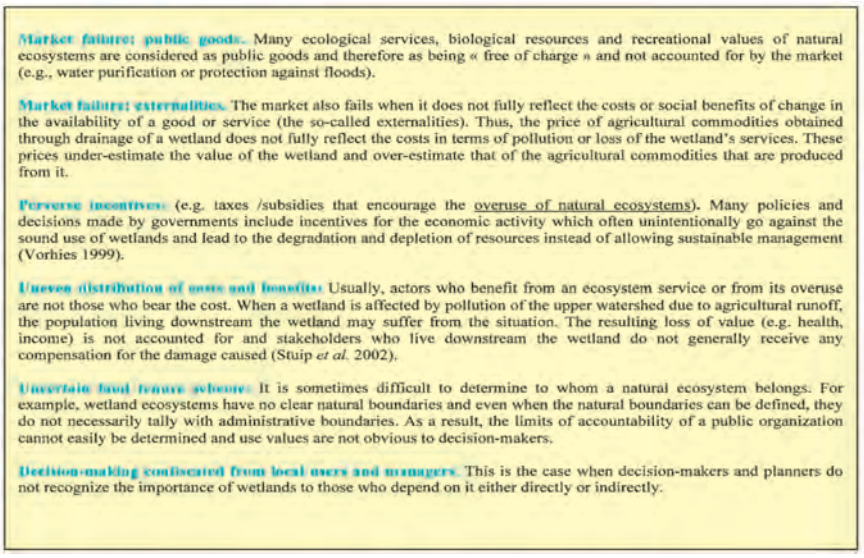
It is important to have a good understanding of the information conveyed by estimated monetary values during the economic valuation of ecosystems. The monetary value of an ecosystem (agricultural, livestock or any exploitation system) reflects the contribution of an ecological function to the production of an end good or service. It can constitute either an intermediate product used in final production (production of hydro-agricultural land development system for example), or an end product (case of collection products, hunting products and fish catching).

The method used to estimate the monetary value is a key element in understanding the valuation. Economic valuation methods for ecosystems are different from the income methods. These methods are geared towards the valuation of the contribution of ecosystem functions to the production of goods or services. On the contrary, income statement methods aim at analyzing the profit made out of the operations system put in place which combines ecosystems goods or services with anthropic ones. The economic values of ecosystems thus constitute components of the income statement and can therefore be highlighted to inform decision-making in view of the anthropic development of ecosystems.

By accounting for intermediate anthropic consumption alone, the income statement method considers that the use of intermediate services or goods in the production of end goods is at no cost. Therefore, the absence of ecosystem goods and services as intermediate consumption in the income statements, overestimates the contribution of the enterprise's operations in wealth creation. This is what makes enterprises and authorities engage into the degradation of ecosystems and of their functions.

Box 1 summarizes a set of reasons why the value of natural ecosystem is underestimated.

Box 1: Reasons behind the underestimation of the value of natural ecosystems



Market failure: public goods. Many ecological services, biological resources and recreational values of natural ecosystems are considered as public goods and therefore as being « free of charge » and not accounted for by the market (e.g., water purification or protection against floods).

Market failure: externalities. The market also fails when it does not fully reflect the costs or social benefits of change in the availability of a good or service (the so-called externalities). Thus, the price of agricultural commodities obtained through drainage of a wetland does not fully reflect the costs in terms of pollution or loss of the wetland's services. These prices under-estimate the value of the wetland and over-estimate that of the agricultural commodities that are produced from it.

Perverse incentives: (e.g. taxes /subsidies that encourage the overuse of natural ecosystems). Many policies and decisions made by governments include incentives for the economic activity which often unintentionally go against the sound use of wetlands and lead to the degradation and depletion of resources instead of allowing sustainable management (Vorhies 1999).

Uneven distribution of costs and benefits: Usually, actors who benefit from an ecosystem service or from its overuse are not those who bear the cost. When a wetland is affected by pollution of the upper watershed due to agricultural runoff, the population living downstream the wetland may suffer from the situation. The resulting loss of value (e.g. health, income) is not accounted for and stakeholders who live downstream the wetland do not generally receive any compensation for the damage caused (Stuip *et al.* 2002).

Uncertain land tenure scheme: It is sometimes difficult to determine to whom a natural ecosystem belongs. For example, wetland ecosystems have no clear natural boundaries and even when the natural boundaries can be defined, they do not necessarily tally with administrative boundaries. As a result, the limits of accountability of a public organization cannot easily be determined and use values are not obvious to decision-makers.

Decision-making confiscated from local users and managers. This is the case when decision-makers and planners do not recognize the importance of wetlands to those who depend on it either directly or indirectly.

Source : Adapted from Vorhies (1999) et Stuip et al. (2002)

Despite the limitations in the monetary valuation of natural ecosystems, the information produced is critical for decision-making.

V.2 THE RELEVANCE OF THE ECONOMIC VALUATION OF A NATURAL ECOSYSTEMS

Policy decisions on ecosystem management in the world in general and in Africa more specifically are often based on the development of one or few services provided by the ecosystems (logging, farming, fishing for example). The lack of information on other ecosystem services makes them less visible. Yet, the decisions made on the basis of partial information have the disadvantage of producing adverse secondary effects that can undermine the expected primary effects of the policy decision.

Economic valuation helps to make the various ecosystem services more visible through their estimated economic values. Although it is not possible to value all goods and services of an ecosystem, an economic valuation helps to cover a wide range of services based on information provided by the actors concerned by the ecosystem. It therefore has the advantage of triggering a participatory decision-making process on the management of the ecosystem based on qualitative and quantitative economic indicators.

The estimated monetary values should be seen as performance indicators of the ecosystems as providers of goods and services. Their role is to inform decisions on the management of ecosystem, covering the wide range of goods and services that they provide to the society. Thus, when a decision is made to value an ecosystem good or service, the decision-maker should be aware of the existence of other economically valuable goods and services. Destroying other economically sound goods and services while developing a given good or service may lead to the decline of the well-being of the society. This alteration of people's well-being may be caused by the development of an ecosystem good at the expense of another good for at least three reasons :

• **Risks of discrimination :** The economic agents whose well-being the policy-makers are trying to enhance may have heterogeneous preferences. It may happen that the good or service that is developed is not the one that has the highest economic value because it is used by just a small given segment of the society. The estimation of the monetary value of ecosystem goods and services helps to address discrimination by taking other goods and services into account.

• **Inappropriate support policies :** the ecosystem good and service price policy may be unfavourable to the effective development of the target good or service. As a result, the signals received by economic agents may underestimate the value of the good or service in question and lead to its overuse, thus degrading the ecosystem. Economic valuation of ecosystem goods and services helps to suggest evidence-based support policies that increase the value or the price of such goods and services.

• **Unsuitable development technologies :** the technologies used for the development of the targeted ecosystem good or service may prove to be unsuitable in the sense that they unintentionally destroy the other economic values. Economic valuation helps to customize development technologies and make them suitable for the conservation of the remaining ecosystem goods and services.

V.3 UPDATING THE ECONOMIC VALUE OF NATURAL ECOSYSTEMS

In the course of the use of a natural ecosystem, the various monetary values that were estimated change over time. It is therefore necessary to update the monetary value of ecosystems on a regular basis. If the management policies that were adopted are conducive to the conservation of ecosystem services, they should generate future values that are greater than or similar to current values. If this is not the case, the monetary value of the ecosystem will decline because of the decreasing performance of ecological functions and hence of the goods and services that the ecosystem provides.

It is therefore clear that the monetary value may serve as an indicator of the quality of ecosystem management policies. This way, the valuation can inform decision-making. The first economic valuation of an ecosystem may be seen as the baseline situation. It can be used to put in place a monitoring and evaluation system in order to update ecosystem economic values and complement the ecological monitoring exercise. Updating economic values creates a dynamics in natural ecosystem management policy which take account of the evolution of the human and environmental system.

VI. CONCLUSION

The loss of natural ecosystems has direct economic impacts which are generally underestimated. Making their economic values visible for policy-makers and societies helps to see development and environmental conservation as the two faces of the same coin. Major progress has been achieved in the development of ecosystem economic valuation methods. These methods are being continuously improved specifically for cultural and regulation ecosystem services and their recurrent application helps to fine tune them. The methods range from the simplest to the most sophisticated and make it possible to estimate the monetary value of ecosystem goods and services in view of making evidence-based decisions in the management of ecosystems.

Knowing the ecological and economic values is therefore indispensable to reconcile conservation of natural resources and economic development. Ecosystem monetary valuation methods contribute to the production of knowledge to inform management decision making. Sound valuation of ecosystems can improve the relationship between national accounts and macro-economic indicators. But their use is hindered by the weak human resources in Africa and very few studies have been conducted in the continent (Vorhies, 2006).

Yet, knowing the monetary value of natural ecosystems for managing them has advantages for African countries. The first advantage is that knowing the various economic values of ecosystem goods and services can be an incentive for improving policy in order to achieve poverty reduction goals for the populations that depend on these ecosystems. The second advantage is that estimating the monetary value of intermediate consumption from ecosystem goods and services is a step towards its incorporation in the income statements and hence in national accounts and Gross Domestic Product. In fact, estimating the monetary value of ecosystem goods and services helps to highlight this value in the income statements of natural resource-based enterprises.

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GLOSSARY

Well-being: Term designating the satisfaction of an individual or a community.

Public Good: When a person can benefit from the existence of an ecological good or service without reducing the advantage that someone else can get from the same good or service.

Willingness to pay: Amount of money that a person is ready to pay for acquiring a good or using a service independently from the fact that it has a market price or that the good or service in question is free of charge.

Ecology: the science of interactions between living organisms (including human beings) and the environment, and among living organisms.

Ecosystem: an ecosystem can be defined as a complex and dynamic entity composed of plant and animal populations, micro-organisms and their biotope (geological, soil and atmospheric), interacting in a functional manner. As such, human beings are part of ecosystems.

Contingent valuation: direct valuation method using a questionnaire to know what people are willing to pay for.

Economic valuation: Monetary quantification of the value of a good or service.

Ecological function: Processes inherent to the various biological, chemical and physical elements of a wetland such as the nutrients cycling, biological productivity and recharging groundwater.

Anthropic input: A range of human infrastructures used to tap on a natural ecosystem.

Market price of a substitution good: Use of the real market price of a similar good or service to value the non market use of the wetland.

Natural resources: goods and services that are directly supplied by nature without any processing.

Ecosystem service: ecosystem services cover all aspects of ecosystems from which humans directly or indirectly benefit.

Non use value: value that is not derived from current, direct or indirect use of a wetland, for instance, the cultural heritage.

Direct use value: value derived from direct use or interaction with wetland resources and services, for example, the value of fish.

Indirect use value: Indirect support and protection assured to the economic activity and goods by the natural functions of wetlands or their regulating services. For example: floods mitigation.

Existence value: non use value that is simply related to the fact that a heritage exists.

Total economic value (TEV): the notion of total economic value provides a comprehensive measurement of the economic value of any environmental good or service .It is divided into use and non use values which in turn can be divided into sub categories.

Wetlands: wetlands are transition zones between terrestrial and aquatic environments. They are characterized by the permanent or temporary presence of fresh, salted or brackish water at the surface or at low depth.

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