Botswana Ecosystem Accounting

Final Scoping Report

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Contents

Abbreviations

DEA	Department of Environmental Affairs, within the Ministry for Environment, Tourism and Wildlife
EEA	Experimental Ecosystem Accounting
NDP	National Development Plan
SEEA	System for Environmental Economic Accounting
SNA	System of National Accounts
UB	University of Botswana

1 Introduction

This Scoping Report provides the findings of a mission to Botswana from 8 to 17 July 2014, conducted by Juan-Pablo Castañera (World Bank) and Lars Hein (consultant). The missions worked together with the Department for Environmental Affairs (DEA) and the national focal point for WAVES in Botswana, Mrs Portia Segomelo. The mission benefited from the excellent support provided by both the DEA and the Botswana WAVES Coordinator. The mission was conducted in collaboration with the national consultant Jaap Arntzen, Centre for Applied Research, Gaborone.

The aim of the mission was to examine with the national counterparts the potential scope of an ecosystem account to be developed in Botswana, and develop a basic action plan for the development of ecosystem accounts. An additional objective of the mission was to explain the concept of ecosystem accounting to all key stakeholders, both in a workshop (held on 14 July) and during follow-up meetings (see Appendix 1 and 2).

This report describes the findings of the mission, respectively:

(i) the policy context of ecosystem accounting and how ecosystem accounting can support decision making with regards to key policy issues relevant in Botswana;
(ii) the potential scope of the Botswana ecosystem accounts including available data and data gaps;
(iii) the potential options to establish the institutional structure required for the developing ecosystem accounts; and
(iv) an outline of an action plan including time table and outputs.

The findings for each of these four topics will be discussed in the next chapters.

2. Policy context of Ecosystem accounting in Botswana

2.1 Introduction

Natural capital accounting (NCA) is a tool to measure and monitor the state of natural resources and their contribution to economic activity, with the aim of mainstreaming natural resources and ecosystems into development planning and improve natural resource and ecosystem management. Therefore, the ecosystem accounts to be developed need to take into account the biophysical and monetary aspects of ecosystem and the contribution they make to the economy, and the policy context of development planning and natural resource management.

Building upon the experiences gathered in the domain of natural capital accounting in the last decades in in a range of countries (including the Australia, the Netherlands, the Philippines and the UK), the World Bank coordinated WAVES program is assisting currently 8 countries with testing various forms of natural capital accounting including ecosystem accounting. These 8 countries include Botswana, which has been at the forefront of integrating sustainability concerns in policy making since a number of years, as also expressed in the Gaborone Declaration initiated by the President of Botswana. In the past year, WAVES has supported the development of Water and Mineral Accounts in Botswana, and WAVES is also supporting the development of Energy Accounts[1]. The fourth, more comprehensive type of account to be developed in Botswana are the ecosystem accounts.

2.2 Ecosystem accounting

Ecosystem accounting involves the physical and monetary measurement of ecosystem services supply and the capacity of ecosystems to supply services in a way that is aligned with the measurement approaches prescribed for national accounts (as reflected in the System of National Accounts; SNA). It is complementary to the Central Framework of the System for Environmental Economic Accounting, (SEEA CF) which is, as of 12 February 2012, a global statistical standard for environmental economic accounting (UN et al., 2014). Ecosystem accounts are a recent development which differ from the traditional environmental an environmental economic accounts in the sense that they aim to analyse natural capital from the perspective of spatially explicit ecosystem assets. This spatial approach is grounded in the spatial variability of ecosystem use, ecosystem service flows, and ecosystem asset and condition. A first guideline for experimental ecosystem accounting was developed in 2013 (EC et al., 2013), and further development and testing of ecosystem accounting methodologies is ongoing (e.g. Edens and Hein, 2012; Schröter et al., 2014).

A first important property of ecosystem accounts is that ecosystem services are distinguished from ecosystem benefits, aligned with the study 'the Economics of Ecosystems and Biodiversity (TEEB, 2010), with the service capturing the contribution from the ecosystem, and the benefit representing the way people use the ecosystem service. For instance, standing stock of timber represents a service, and harvested wood a benefit. Wood harvest requires an input from the ecosystem (standing timer) as well as, in this case, labor and equipment (e.g. a saw) to materialise. Two key elements of ecosystem accounting are ecosystem assets and ecosystem services flow. An asset represents the 'capacity of the ecosystem to generate services, now and in the future' (EC et al. 2013). In order to understand the flow of services in the future, it is important to understand the 'condition' or 'state' of the ecosystem. For instance, soil degradation may affect rangeland and agricultural production in future years. For each service, there is therefore a need to identify specific condition indicators as part of an ecosystem account.

Monetary valuation in an accounting context focusses on measuring production. A key difference between welfare-based valuation (e.g. Bateman et al., 2011) and production-based valuation approaches

[1] Earlier versions of water and mineral accounts were developed since the 1990s, but these did not follow the SEEA framework. Preliminary livestock accounts were also developed.

is that the latter only includes the value of production and excludes consumer surplus. Production is valued through exchange values, which can be related to market values for those ecosystem services that have representative market values (cf. SNA, 2008). The monetary value of the asset represents the net present value of the expected flow of ecosystem services, under current management and prevailing climatic conditions among others. Further details on valuation in an accounting context are provided in EC et al., (2013) and examples are provided, for example, in Schröter et al (2014) and Sumarga and Hein (2014).

2.3 Policy context and the potential role of ecosystem accounts

Botswana has a strong tradition of development planning, which extends from the national to the district level. Currently, Botswana implements its 10th National Development Plan (NDP) and preparation for the next development plan have just started. Development planning is further driven by a wide range of sectoral policies (e.g. tourism, agriculture and industry) as well as thematic policies and strategies (e.g. revised rural development policy, economic diversification drive, poverty eradication strategy and citizen empower schemes). Similarly, natural resource management is guided by a wide range of resource policies, strategies and acts (e.g. dealing with land, water, forests, veld products) and environmental issues (e.g. biodiversity conservation, veld fires, EIA, aquatic weeds and community based natural resource management). Currently, a national strategy on sustainable development and a climate change and variability policy are in preparation. The topic of 'Environmental sustainability' is the responsibility of a thematic working group (one out of the 4) that coordinates, among others, environmental inputs into the NDP11 preparations.

In general terms, ecosystem accounts can support policy making in the following way:

(i) they present a comprehensive overview of ecosystem capital including the different services provided by different land use and administrative units;
(ii) they indicate interdependencies between ecosystems and economic activities;
(iii) they allow measuring changes in ecosystem capital over time; and
(iv) additionally provide a number of other potential applications that can support environmental management.

For example, ecosystem accounting allows analysing in which part of the landscape extraction rates, for instance the grazing of fodder in a rangeland, exceed the capacity of the ecosystem to supply the resource. In this mission, it was examined how these general applications are of relevance to the environmental and resource management issues faced by Botswana. Based on elaborate discussions with DEA and a range of stakeholders, both during a stakeholder workshop (Appendix 1) and follow-up interviews (Appendix 2) the following policy issues relevant for the ecosystem accounts were identified during the mission, based on the meetings with the various stakeholders.

The main policy issue is how to **ensure that natural resources (in particular ecosystem resources such as natural parks, rangelands, forests, agricultural soil and water resources) can be used in a more productive and sustainable way in support of inclusive economic development**. More specifically, this relates to eliciting the relation between ecosystems and economic growth and diversification, poverty reduction, employment creation, transboundary resource management, resource degradation, climate change adaptation, and supporting the NSSD implementation. Some specific additional elements relevant in this broader context are described below.

1. **There is a lack of integrated and quantitative data on natural resources in support of policy making and implementation**. There is broad information base on natural resource management issues and ecosystem conditions in Botswana. However, as in many other countries, this information is spread over a large number of government and research institutes. Also the information is patchy, in the sense that information sets are available for different years, with some information outdated. Since policy making in the environmental and

development fields requires an integrated overview of the issues at stake, the lack of concentration of information was identified as a major bottleneck to decision making. The consequence of the fragmentation is that policy makers take decisions without the required information and data as it takes too long to make this information available for the decision making process. Examples of data base exist. For example, the Environmental Information System (EIS, see www. eis.gov.bw) of the DEA was set up to fulfil the role of central information depository but it is limited in scope, and information is not regularly updated by the line departments. Similarly, the Okavango Delta Information System exists (ODIS) but it is limited in scope and infrequently up-dated. In comparison with the ecosystem accounts, this information is also less comprehensive and structured, and does not provide a monetary component as the Ecosystem account would. Hence, a major benefit of a functional and updated Ecosystem account in Botswana would be that there would be an up-to-date, comprehensive and structured information base, integrating ecology and economic activities that can respond to various policy requests for information at a short notice. A key consideration in the establishment of the accounts is that the supply of thematic information to the Ecosystem account, and the possibility to have access to information stored in the Ecosystem accounts, needs to be negotiated between the different ministries and agencies involved.

2. **There is a need to enhance the information supply to National Development Planning**. The DEA carried out environmental audits of NDP9 and 10 during their preparation. However, environmental concerns were often neglected during the final stages of the plan preparations. Ecosystem accounts and other resource accounts such as water, mineral and energy have the potential to more systematically integrate environmental concerns into the NDP process. The preparation of the NDP11 has just started and is scheduled to take 18 months for completion. The NDP will indicate priority issues in terms of resource management, such as land degradation, issues to be addressed and identify future development opportunities. Preparation of the NDP would benefit substantially from an information base that shows the linkages between ecosystem resources and economic activity, and that identifies key threats and opportunities (for instance in terms of additional development opportunities) for ecosystem management, also in terms of where these threats and opportunities are located. Ecosystem accounts show how ecosystem degradation will affect economic activity, and where potential exist to further develop ecosystem assets, in a sustainable manner. Once developed and implemented over multiple years, ecosystem accounting can also be used to monitor the effectiveness of national and local policies aimed at ecosystem rehabilitation or at the more intensive exploitation of resources that are at present still underutilized. Because of the spatial approach, ecosystem accounts provide insight in how different ecosystems are changing in terms of their capacity to support economic activity, allowing for example comparison of policies that have taken place differently in different geographical areas.

3. **Support for the implementation of ecosystem management plans such as the Okavango Development Management Plan, the Makgadikgadi Framework Management Plan, the Revised BDSAP, the Forest Inventory Project and the BioChobe project.** The government has developed comprehensive, integrated development and conservation plans which need to be implemented. Ecosystem accounts could be used to guide and monitor implementation of such plans, and to identify spatial areas where ecosystems would allow, in a sustainable manner, more intense use, and areas where additional measures are needed to safeguard long-term economic productivity.

4 **Transboundary resource management**. Water management. Stakeholders from the Okavango area expressed an interest in discussing if and how the ecosystem accounts could assist with transboundary water management issues. The scope of the ecosystem accounts, aligned with the national accounts, is foreseen to be a national or, more likely given constraints in terms of data and capacity, sub-national. Hence it would not cover the overall Okavango watershed. A watershed level, transboundary ecosystem account maybe developed at some stage in the future but would pose additional challenges in terms of bringing data together – even though the basic biophysical modelling techniques required would be the same for a

national or transnational account. Hence the ecosystem account would not be able to provide the full dataset required for water management planning in the overall Okavango basin. What was identified to be of interest, however, is that the ecosystem account would provide a detailed, spatially explicit, overview of how economic activities in the delta depend on water and in particular the ecosystem resources dependent on water. This would provide a basis from which the potential economic impacts of changes in water flow in the Okavango River for Botswana can be calculated, provided that the Okavango area is included in the spatial scope of the Botswana ecosystem account. There is also scope to provide support to other Transfrontier Resource conservation management in which Botswana is engaged, depending upon where the ecosystem accounting approach will be tested and implemented..

2.4 Linking up with existing projects and initiatives

A number of ongoing projects and initiatives are of particular relevance for Botswana, as briefly described below.

- **The SADC MESA Initiative**. The MESA initiative aims to deploy remote sensing analysis in support of environmental decision making focussing on fire risks, rangeland condition and food security and climate change. It is a regional project, with involvement of the Ministry of Environment, Tourism and Wildlife. The main scientific partner in Botswana is the Botswana College of Agriculture that has in-depth expertise in terms of rangeland ecology and management. The MESA initiative and the ecosystem accounts are complementary: the MESA initiative would greatly expand the data available from remote sensing observation including rangeland status and fire occurrence, and is also intended to operate over a prolonged time period rather than being a one-off inventory. The ecosystem accounts are complementary to MESA in the sense that they would link ecosystem change to economic impacts, providing the tools to analyse the monetary implications of the environmental trends to be observed by MESA. It appears as if there is scope for exploring opportunities for collaboration, but these have not yet been discussed with the MESA program given that the key MESA people were engaged in a workshop at the time of the mission.

- **Potential support to carbon (REDD+) projects in Botswana**. There are no REDD+ projects in Botswana yet, but a REDD+ strategy is planned to be developed. This strategy requires information on carbon stocks and carbon sequestration rates in different locations, as well as baseline information on land use change. Carbon stocks and sequestration can be covered in ecosystem accounts, and by establishing an ecosystem accounts for multiple years a baseline for analysing land use change is obtained.

- The **BIOFIN**[2] coordinators for Botswana indicated a keen interest in working with WAVES Botswana, in particular with the ecosystem accounting component, in the view of the potential of the ecosystem accounts to provide information on the economic benefits generated by ecosystems, and to which sectors they contribute, as well as the analysis of trends in ecosystem condition. This could be supportive to the analysis of funding opportunities and needs for biodiversity in Botswana. At the same time, BIOFIN could be helpful in terms of making additional data available for the ecosystem accounts, in particular on biodiversity. The BIOFIN project indicated a tentative interest to focus on the same area as the WAVES Botswana ecosystem accounts in view of the synergies between the projects, which was agreed to require further discussion at the level of DEA, UNDP and WAVES Botswana and with the Ministry for Finance and Development Planning.

[2] This project operates in 18 countries including Botswana and aims to analyse funding gaps for biodiversity conservation by comparing available funding and funding needs given the specific activities that would be required for effective biodiversity conservation.

The above are examples of policy benefits that may be derived from ecosystem accounting in general. The choice of the pilot area determines to what extent these benefits apply and materialise. Note that it is important for the application of ecosystem accounting in support of policy formulation and policy impact monitoring that there is a **long-term commitment to** developing and maintaining the accounts. This requires that the benefits of such accounts for both development planning and natural resource management are evident. Much of the value of the accounts is in their capacity to analyse ecological trends and subsequent economic implications over time, and in addition the resolution and quality of the accounts would increase over time when more experience is gained in Botswana with ecosystem accounting.

3. Potential scope of Botswana ecosystem accounts

3.1 Introduction

Scoping of the ecosystem account involves:

i. the delineation of the area to be covered;
ii. the ecosystem services to be included; and
iii. the ecosystem properties to be addressed.

In the course of this mission, a tentative scoping of the ecosystem account has been conducted, based on the inputs obtained from a broad range of key stakeholders in ecosystem management in Botswana (see Appendix 1 and 2). The tentative scope is described below, with the remark that the scope may need to be modified or further specified in the course of the coming months when further discussions on ecosystem accounting in Botswana will take place.

3.2 Area to be covered

The specific area to be covered depends upon the policy interests of the key stakeholders, which may be driven by imminent environmental concerns and a lack of data to support decision making, as well as data availability.

The amount of work required for developing an ecosystem account is determined by three factors:
(i) the size of the area;
(ii) the variability of the area (in time and in space); and
(iii) the resolution of the analysis. The more heterogeneous/patchy the ecosystem is, the finer the resolution required for the account.

In Botswana, the individual ecosystems generally cover large areas, in particular in the West, North and Central parts of the country (in the east and southeast the ecosystems are more patchy related to the more frequent occurrence of croplands and the concentration of people in this area).

In the case of Botswana, the stakeholders indicated an interest in covering the Kalahari, Makgadigadi and Okavango areas in the ecosystem accounts, identifying the following policy concerns:

1. A lack of data in particular in the Kalahari area. Stakeholders indicated that much of the past work on environmental information was focussed on the Okavango and Chobe areas, whereas the Kalahari covers a large part of the country and there are significant causes for concern regarding environmental degradation (including recurrent and increasing fire risks, land degradation from overgrazing, and wildlife-livestock conflicts.

2. The Okavango has received ample attention from past studies and is a RAMSAR and World Heritage site. It is a key area for tourism and wildlife, and at the same time it is vulnerable to climate variability and climate change, development projects in Angola and Namibia that would affect the cross boundary inflow of water into the Okavango, and land degradation. Government has led the preparation of the ODMP for the Botswana part of this shared river basin. Given the availability of a relatively large amount of data for Okavango, including a household survey and an ecosystem services valuation study, this area is of importance for the ecosystem account.
3. The Makgadigadi wetlands are an additional important area, connected to both the Kalahari and the Okavango systems. Plans exist to nominate the Makgadikgadi for UNESCO Biosphere Reserve certification in 2015. It is subject to fires and has recurrent wildlife-livestock problems. Government led the preparation of the MFMP, which is currently being implemented. Several studies have been conducted in this area in the field of natural resource management, and there is basic data availability on ecosystem properties and uses.
4. A potentially interesting area to include is Chobe District. Chobe is the only forest area in the country, receiving somewhat more rainfall than the rest of the country. There are wildlife – livestock conflicts, there is intermediate data availability, and the area is of high importance for biodiversity conservation.

The specific selection of the site to be included in the ecosystem account needs further discussion. One option would be to select an area based on ecological boundaries, but this would make it more difficult to align with statistical datasets that are collected for administrative boundaries. The ecosystem diversity within the administrative units is dealt with through the use of GIS that allows analysing ecosystem condition, capacity and ecosystem service flows for individual units distinguished in the GS (pixels/BSUs). This is conform experiences with ecosystem accounting in other countries, where sometimes a watershed boundary and sometimes an administrative boundary was selected. In all cases, because of the GIS approach, the ecosystem account is able to deal with multiple, different ecosystems within the accounting area. The options are presented below.
:

1. An ecosystem-based case study area, potentially as much as possible aligned with district and or other administrative boundaries, focusing on key ecosystems such as the Okavango, Makgadigadi and potentially Chobe and Kalahari. A concern is that there is not yet a land cover map for Makgadigadi, but this would become available by the end of 2014. It would be relatively ambitious if all these ecosystems were included, and there will be a challenge to integrate statistical data since no administrative boundaries are followed.
2. A limited account (low ambition level), focussing on one or two administrative districts, for instance Ghanzi and/or Ngamiland in the ecosystem account. The selection of one or two administrative units facilitates the integration of statistical data that is collected for such units, and if both areas are selected this would include the Central Kalahari Game Reserve (relatively easy to collect the required data using satellite images that are available and processed already (MODIS) and the Okavango delta (policy priority, high data availability).
3. A medium ambition level account: focussing on the two districts of Ghanzi and Ngamiland supplemented with the part of Central district that covers Makgadigadi. It needs to be verified when the land cover map (an essential element of the account) for Central District would become available (latest information at the time of the mission was late 2014). An advantage is that there is relatively high data availability for Makgadigadi, that it is a policy priority, and that there are strong ecological linkages between this ecosystem and the ecosystems of the Kalahari and Okavango (wildlife migration for isntance).
4. A high ambition level account, which further extends the area to also include Chobe district and the Chobe fores. This is a policy priority, and the land cover map is available for Chobe, but this would require mapping an additional ecosystem service, wood production, which is a key service in Chobe.

Further discussions including consideration of political aspects that were outside the scope of this mission is required to identify the final pilot case study area. Note that a first selection needs to be made for the pilot phase, in a subsequent phase a larger area could easily be included. The selection of the size of the

area also depends on the resources that can be made available (which was not known during the time of the mission) – a group of 3 to 5 experienced experts would be more easily able to cover an area consisting of a larger area, for instance including Central district, Chobe, Ghanzi and Ngamiland.

The resolution of the ecosystem account, in the first phase of the account, could be 1 by 1 kilometer (i.e. the size of the Basic Spatial Unit of the account, or BSU[3]). This resolution corresponds with the availability of processed MODIS satellite images, which are available at the same resolution. The MODIS images include freely downloadable files including Net Primary Production, and the images are georeferenced and merged (not requiring further merging of individual images as would be the case with Landsat images). Of course, spatial information may be available in Botswana at finer scales, in these cases it is proposed that information is aggregated to conform to the 1 km resolution scale. In a second phase of developing the accounts, it can be examined how the accounts can be further developed, either by expanding the area, increasing the resolution, or adding additional ecological processes or ecosystem services.

3.2 Ecosystem services to be included

Given the preferences of the stakeholders and the prioritized ecosystem management issues, the ecosystem services that would be included include the following:

a. *Livestock grazing*. Livestock grazing is a significant part of the Botswana economy, in particular when also food processing industries are included. At the same time, livestock grazing is making intensive use of the land, and in particular the pasture resources of Botswana. The stakeholders indicated that animal feed rather than water was the key constraint to livestock grazing in most of the country, and that there are indications that amount of livestock is high compared to the carrying capacity of the pastures (it needs to be noted that this carrying capacity is a complex topic, and that it is very variable between years as a function of among others rainfall). In addition, the increasing frequency of fires (at present close to one fifth of Botswana burns every year) is putting additional pressure on the rangelands, as witnessed by among others changes in species composition and soil degradation. The aim of the ecosystem account is to analyse the contribution of the ecosystem to the livestock sector, in particular the supply of animal feed. This varies per year as a function of rainfall and varies locally as a function of species composition (including the presence of *acacia spp* with low palatability), and among the key factors to be analysed are Rain Use Efficiency (which indicates the degradation status of rangelands, the indicator is widely used in the Sahel, see e.g. Hein et al, 2008 and can be easily calculated by dividing NPP over rainfall) and species composition (indicating the relative availability of palatable species). The ecosystem accounts should include both the annual offtake (the consumption of grass and other species by animals, per year) and the capacity of the rangelands to supply these resources, i.e. the carrying capacity. Both factors have been measured in the past in Botswana, and NPP can be derived from MODIS satellite images. Animal feed consumption can be related to livestock stocking densities. Given that the capacity will vary considerably between years as a function of rainfall, changes in these aspects should be measured over time.

b. *Tourism*. The purpose of the ecosystem account is to measure the contribution of the ecosystem to tourism. In physical terms, this can be measured in terms of days spent on wildlife tourism, either by boat (Okavango) or safari tour on land. The various forms and types of wildlife tourism should be separated, and the wildlife density maps can serve as ecosystem condition indicator relevant for this service. In monetary terms, the contribution of the wildlife to the tourism sector can be expressed as resource rent. There is still a need to discuss how the capacity of the tourism ecosystem service can be evaluated, this needs to be done on a case by case basis. The

[3] See the SEEA Experimental Ecosystem Accounting guidelines (EC et al., 2013)

first ideas, as discussed in the SEEA EEA editorial board and follow-on technical discussions are that the capacity equals the flow for this service, unless here are reasons to assume otherwise (for instance in case there are indications of the number of tourists exceeding the carrying capacity of the area, or in case there are new infrastructure or other developments that would promote additional tourism in the near future, or in case there are clear trends in tourism numbers). There are some data available on tourism (in particular in the 'Experimental tourism satellite account 2009'), and recently the collection of additional data on tourism has started. In addition, within the Ministry of Environment, Wildlife and Tourism there is the tourism registry (all tourism enterprises have to register for a permit and need to provide information on expected/received number of guests/overnight stays, number of beds, location of trips organised, etc.). These information sources should all be combined and integrated in a GIS in order to map where tourism activities are taking place, in order to attribute the resource rent that is generated by the sector spatially across the areas where wildlife tourism is taking place, per rato of the intensity of the visits.

i. *Wildlife habitat*. Biodiversity is an ecosystem condition indicator. In addition, wildlife habitat is highly relevant for the tourism sector and it is also a final service in itself (since people appreciate and are willing to pay for nature conservation). However, the non-use value aspect of wildlife habitat is very difficult to include in an account. Accounting principles do not include consumer surplus (and a major part if not all of the biodiversity non-use value is reflected in the consumer surplus and therefore outside the scope of the account). Hence, only part of the total economic value of this service is reflected in an ecosystem account (or can be included in the national account). It is however very important to analyse the service comprehensively in physical units. In principle, the areal surveys conducted by the MEWT, which result in GIS maps of species abundance, provide the entry point to map this service in terms of flow (i.e. in terms of actual presence of species). Note that, in terms of capacity, the actual numbers of wildlife species can be larger or smaller than the capacity. It can be lower in case there has been hunting, for instance, and it can be higher in case there are populations that are high compared to the carrying capacity (for instance in case wildlife is concentrated in specific areas because it has been chased away from other areas). In the longer term, capacity and actual numbers should converge, in particular in case of relatively stable environmental conditions. Several models are available to analyse capacity, such as the Maxent (Maximum Entropy) model, but description of the model is outside the scope of the mission report (see Sumarga and Hein 2014 for more details). An issue to be considered is that capacity for wildlife and livestock grazing are interdependent, wild grazers and livestock consume, in part, the same grass resources. This requires specific attention when the accounts are developed.

ii. *Carbon sequestration*. Carbon sequestration is the only regulating service for which the capacity equals the flow (since it does not matter where carbon is captured, carbon capture is always a benefit for people given global climate change[4]). From technical perspective, carbon sequestration equals NPP minus soil respiration. NPP is provided by available MODIS images, however soil respiration rates are highly spatially and temporally variable and are often known only by approximation for specific ecosystem types. Hence this service can also be analysed by looking at changes in carbon stock over time in specific ecosystems, based on available surveys and samples (including both above and below ground carbon) in so far as these surveys are available. It is advised that both methods are applied and compared in order to obtain an idea of this service. The specific valuation method for carbon, and the associated price, is still debated but there is a tendency to use the marginal social damage costs, for which several estimates are available from the literature (ranging from some US$10 to US$100 per ton CO2) with most studies and guidelines for CBA proposing values in the order of US$ 20 to US$30 / ton CO2 (note: these are different from the prices in carbon markets). The ecosystem service carbon capture relates to the flow of carbon (capture or emission, e.g. because of fire), the stock (storage) of carbon is an ecosystem condition indicator.

[4] See Schröter et al., 2014 for further details

Note that additional ecosystem services can be included in a later phase; it is proposed based on the interactions with the stakeholders that these four are priority ecosystem services: they are policy highly relevant and there is a relatively high confidence that data availability would allow preparing of ecosystem accounts with these services at this point in time.

It is anticipated that the ecosystem accounts in Botswana would be developed following a step-wise approach, focussing on the ecosystem services and condition indicators that are most easily accessible and that have the largest policy impact. In a first phase (see Section 4 on planning), it is advisable to limit the accounts to the services described above. However in a next phase, it could be examined if additional services can be added. In this case potential services are:

Wood production. a first candidate for expanding the number of services in the account is wood production, in particular because the Chobe forest reserve is included, and because the linkages between deforestation and hydrology (see below). Forest's capacity to supply woody biomass (mostly used for firewood) can be related to NPP and species composition, however wood use is more difficult to quantify and may require the use of additional household surveys to quantify wood consumption for various purposes per capita and per family, and interpolating data from the survey using kriging based on population density and correcting for factors such as income.

Crop production. Crop production is taking place in particular in the eastern and south-eastern part of Botswana. It is also a more patchy type of land use, with fields typically being in the order of up to 16 hectare. Hence, this would require working at a finer resolution compared to the services above. Given that it is a significant economic sector, and that there are signs of land degradation, in particular erosion and soil depletion, it is of potential policy relevance to include crop production in the ecosystem accounts. However, this would require a finer resolution.

Air filtration: The stakeholders indicated that PM 10 pollution from dust and fires is affecting air quality in Botswana, however there appear to be few monitoring stations for PM10 or other air quality indicators. Therefore this service is difficult to include in the accounts, but this may become feasible once more information on air quality becomes available, building upon experiences in including this service in ecosystem accounts in other countries such as the Netherlands.

Water regulation: There is a concern among the stakeholders that deforestation, in particular is affecting hydrology of local rivers and streams. In general, a well preserved forest may store water during the rainy season and gradually release it during the dry season, in this sense maintaining dry season water flows. Loss of forest cover and associated loss of topsoil in hilly forest areas decreases the storage capacity. Including this service would require the construction or relatively sophisticated hydrological models.

3.3 Ecosystem condition indicators

Further work is needed in order to identify the relevant ecosystem condition indicators, but tentatively the key variables to be included in the ecosystem account include (but are not limited to) the following. Note that the ecosystem condition indicators should be included in the form of maps.

- Rainfall (and its spatial and temporal distribution). Since water is a key constraint to ecosystem productivity, rain is a key indicator determining ecosystem services supply. Rainfall may vary strongly from one year to the next, and both series of rainfall are needed as well as an average value and a rainfall probability curve (see Weikard and Hein[5]).
- Land cover. The Department of Surveys and Mapping has produced a land cover map (completed for the country with the exception of Central District) with 56 individual classes (aggregated to 15 classes in the pdf maps offered by the Department). The GIS files are available at the Department (and are produced in ArcGIS)

[5] See Hein and Weikard 2008 and Weikard and Hein 2011 for an example of how probabilistic rainfall curve can be included in a bio-economic model for a rangeland.

- Soil type. Soil maps are available for Botswana and are an indicator for ecosystem condition, affecting soil organic matter contents, infiltration rates, etc.
- Species composition. Dominant species, both in the grass layer and in the tree layer should be mapped, based on available surveys of vegetation cover.
- Rain Use Efficiency. Rain Use Efficiency (RUE) can be calculated by dividing NPP over rainfall, and it expresses how efficient vegetation uses rainfall for the production of biomass. It is an indicator of degradation, that can be used to forecast (trends in) NPP as a function of rainfall. It is widely used in order to understand the status of rangelands worldwide (Hein and De Ridder, 2006, Hein et al., 2011)[6].
- Carbon stock. Carbon stock is an indicator for degradation status, and is linked to the services of grass production for livestock, wood production and carbon sequestration. There is a clear difference between carbon sequestration and storage and a high carbon stock may or may not be correlated with a high sequestration ratio. Below ground carbon also needs to be included in the account, as far as data are available, and is likely to be significant both in terms of root biomass and in terms of peat soils locally occurring in the Okavango delta.
- Soil organic Matter. Soil organic matter (SOM) is correlated with soil carbon, and is an indicator of soil fertility. A reduction in SOM will affect both range and agricultural productivity by means of indicating a reduced amount of nutrients available to the plants, and it may also be correlated with low infiltration rates and low water holding capacity of the soil.
- Fire risk. Building upon existing datasets available within the Department of Forest and Range Resources(METW), to be updated with maps from the MESA, the fire occurrence / risk should be spatially mapped, expressed in for instance chance of occurrence per year.

Further ecosystem condition indicators need to be identified based on expert understanding of the dynamics of Botswana's ecosystems during the development of the account.

[6] In Botswana the RUE as an indicator for rangeland productivity may be influenced by the encroachment of acacia spp following degradation of range (at the expense of grass species). Hence further work is needed in order to understand the potential suitability of RUE as a rangeland condition indicator in Botswana.

4. Options for institutional embedding of the ecosystem accounts

Development of an ecosystem account requires three key types of expertise: GIS, ecology and economics. These disciplines need to be integrated in order to model the relation between ecosystem condition and its capacity to supply ecosystem services, and to analyse the spatial distribution of condition, capacity, service flows and their monetary values. This requires a team of dedicated, technical people with the capacity to develop spatial models, and link these to monetary values. Potentially, the **team** would consist of around 3 senior people, a GIS modeller, an ecologist and an economist. In order to ensure fast progress, the GIS capacity may be augmented with a junior GIS modeller. Similarly, it would be preferable of junior ecologist and economist increase the ecological and economic capacity respectively. The involvement of junior staff will also benefit the sustainability of the project given the high rate of turn-over of qualified, technical government staff. The dedication and financing of these positions need to be discussed by the relevant government agencies and the WAVES program and falls outside of the scope of this mission (this issue was not discussed during the scoping mission).

The team would need to be available to work on the development of the ecosystem accounts close to full-time, in particular the GIS modeller needs to be available full time in order to make rapid progress. The team would need to be placed in a suitable government agency, for which the following options have been identified:

Department of Environmental Affairs. The Department manages is mandated with the coordination of natural resource management in the country, hosts the EIS and employs one GIS expert (who was in the field during the time of the mission), and it has experience in bringing together information from different sources. In addition, there are three environmental economists within the DEA who were previously involved in the construction of Water, Minerals and Livestock Accounts as well as valuation of the Okavango and Makgadikgadi Wetlands. It also develops management plans for major ecosystems (Okavango, Makgadikgadi, Chobe), coordinates the Climate Change portfolio, regulates tourism sector, coordinates implementation of all Multi-lateral Environmental Agreements and chairs the Environmental sustainability Thematic Working Group. However, the department is somewhat short in terms of overall GIS and modelling skills, and it is unclear if the department has access to the GIS software and hardware required for developing the accounts. Sustainable Development

Department of Surveys and Mapping. This department is well equipped in terms of GIS/cartographic capacity, has in-house a range of important spatial databases including the land cover maps, and has an ArcGIS license. However the department has not yet specific expertise with integration and modelling of ecosystem services, nor sufficient expertise in ecology and economics. The availability of a critical mass in terms of GIS expertise is a clear advantage, and the department has indicated its willingness to explore different options to collaborate in the development of the ecosystem accounts.

Statistics Botswana. The World Bank team visited the Environmental Accounting Unit of Statistics Botswana (SB) and were informed of the potential interest of this agency to collaborate in the development of ecosystem accounts. A major advantage of working with SB is its experience in developing statistics and linking these to the national accounts and policy making process, and the presence of statistical data. Possible disadvantages are the limited capacity of SB and its current transitioning into a parastatal. SB has a small GIS unit focussing on cartography, which has no capacity as yet with modelling ecosystem service. There is also potentially a lack of the required ecology and economics skills in the Environmental Accounting Unit. A potential issue for SB is the experimental nature of the ecosystem accounts, compared to accounts for which standards have been developed already.

The three government agencies described above appear best placed to host the ecosystem accounting team, with the Department of Surveys and Mapping potentially having a comparative advantage in terms of its GIS capacity and datasets. The DEA appears to be most suitable in terms of the mandate of coordinating natural resource management and biodiversity conservation.

Given the above considerations, a potential option would be to have the Ministry of Environment, Wildlife and Tourism and that of Lands and Housing as primary custodians of this process. The mandate to execute at technical level can internally (within those ministries) then be delegated to the Directors of Environmental Affairs and Surveys and Mapping, respectively.

It is important that the institutional aspects are thoroughly discussed with the Ministry of Finance and Development Planning to oversee all accounts because of: (i) the inter-relationships that exist between all accounting components; (ii) the need to maximise on the available WAVES support which will be sourced for GIS, ecology and economy as well as communications; and (iii) on-going institutional set-up that Ministry of Finance is working on to set up a Natural Capital Accounting unit to service all accounting activities. In this context, this Ministry to decide to potentially allocate additional resources required for establishing the team, also with a long-term view (at least 5 years and preferably 10 years).

In developing the institutional structure, there are four **key issues** to be considered (in addition to the physical hosting of the unit):

1. Need for long-term vision and commitment. As described earlier, building the accounts will take time, with first results coming in around 1 year from now if all proceeds smoothly (see also Section 5). A main added value that the accounts provide is providing the possibility to compare ecosystem capital between years, and the quality, resolution, coverage and accuracy of the accounts will increase over time as a function of the experiences to be gained. This long-term commitment should be considered in the development of the institutional set up, for instance by ensuring that budget for developing the accounts is made available for a certain time period (at least, say, 5 years).
2. Need for capacity building. There is a clear need expressed by the stakeholders for capacity building in the field of ecosystem accounting including the spatial modelling part, the valuation, and the linking of the accounts to the national accounts. Once the team is in place there is likely to be a need for a specific training course (for instance 1 week, in line with the experiences form the Philippines) in which the ecosystem accounting team is provided training as well as support for developing a detailed work plan. There is likely to be a need for follow-up training as well as technical input, in which a combination of the Centre for Applied Research, the consultancy agency EcoSurv, the University of Botswana and the Botswana College of Agriculture can play a main role, in terms of support for the modelling of specific elements of the accounts (e.g. modelling rangeland productivity, etc.).
3. Need for external technical assistance. No department has as yet committed any of the three the required staff positions for the accounts. While capacity is being built, there will be need for significant external technical assistance. The form that such assistance will take needs to be further discussed. The options include project funding of positions in the coordinating department, involving technical assistance from external institutions. However, at the same time there is a need to institutionalise the developments and maintenance of the accounts, independent of temporary project funding.
4. Need to address high staff turn-over. All government agencies visited expressed concern that staff with specific technical skills, including GIS skills are at risk of obtaining attractive offers from the private sector, in particular after receiving training. This issue appears generic to the context of Botswana and cannot be resolved in the context of this project, but there is nevertheless a need to consider incentives for staff to stay on for a sustained period. It also means that it would be prudent to train a number of staff so that the work does not implode when, for instance, the key GIS modeller would leave the team.

The role of the Technical Working Group. A Technical Working Group (TWG) for the ecosystem accounts has been established, and met for the second time during the mission. The TWG includes representatives, mostly technical staff, from a range of ministries and departments, University of Botswana and some NGOs. It was discussed with the TWG that it would serve as an advisory body to the technical team developing the ecosystem accounts, including quality assurance, providing data from the different line ministries, and promoting outreach to the line ministries. The meeting frequency is still to

be determined but may be in the order of 4 times per year, depending on the preference of the team to develop the accounts and the preferences of the various line ministries involved.

The development of ecosystem accounts can benefit from capacity and expertise outside government. These include linking with on-going research programmes in environmental science, ecology, GIS/RS modelling and environmental economics, utilisation of student research capacity (e.g. UB dissertations, projects, etc.) and use of consulting capacity available in the country (e.g. CAR). This requires further careful consideration of:

a. the time lines of other on-going projects and the synergy that can be achieved;
b. the capacity and (time) availability of academic researchers and students; and
c. the capacity and time availability of consultants.

Given that ecosystem accounting is an innovative field, and that Botswana has set a course in which it would play a leading role in Africa and potentially globally, there are a range of exciting research opportunities and synergies between the development of the ecosystem accounts and research in the field of environmental sciences and ecological and environmental economics. These efforts would build upon the research already conducted in Botswana in these fields including the MESA project. Hence, he project would offer the scope to pursue an approach where research projects, including BSc, MSc, and PhD research, would be conducted on specific issues aligned with the development of novel approaches for the accounts, in partnership with universities abroad.

In addition, it is advised that UB, BAC and potentially suitable consulting companies would be asked for their potential interest in terms of technically supporting the development of the accounts based on their current expertise with ecosystem change, fire management, remote sensing and GIS analysis and modelling, water management, forest management, economics, etc. It is recommended that such support is provided based on an 'at demand' arrangement where the ecosystem accounting team would have the possibility to draw upon specific expertise at UB, BAC and potentially in the private sector according to the team's priorities and needs[7].

[7] This may require the preparation of a MoU or other form of partnership arrangement, however the details of such a set-up are outside the scope of the current mission, and can only be specified once the ecosystem accounting team has been set-up. A meeting with Prof. P Dube from UB confirmed that there would be a potential interest from the side of UB to explore if such an arrangement could be set up according to the interests, needs and requirements of both UB and the ecosystem accounting team

5. Action plan and next steps

The mission identified, together with the stakeholders, the next essential steps in terms of developing the ecosystem accounts in Botswana:

1. **Defining the institutional structure**. A first priority is to analyse how many people can be funded to develop the ecosystem account (and where these funds are coming from), through which arrangement and for what time frame, and where this team should physically be based. The basic considerations for defining the institutional structure are described in the previous chapters. In this phase, also the potential modality for external assistance and collaboration with the University of Botswana and the Botswana College of Agriculture, CAR and others as well as with the TWG could be examined (however only after the team is established since then it will become clear what expertise is covered in the team and what the main needs for support are). It is also recommended to explore if a connection to the MESA program can be established including a data sharing arrangement.

2. **Establish the ecosystem accounting team**. As described above, the team requires GIS, ecology and (environmental and/or macro-) economics expertise. The GIS expert should be schooled in GIS modelling rather than cartography alone. Experience with Python modelling in GIS would be a definite advantage, otherwise the person would need to be capable of gaining experience with python modelling in the short term, perhaps using on-line training course or a short specific course abroad. The ecologist would preferably have experience with both modelling and rangeland ecology, potentially in combination with remote sensing analysis. The economist would need to have a thorough understanding of economic valuation methods for natural resources, but also needs to be willing to master the macro-economic of the national accounts.

3. **Training course and development of a detailed work plan.** Once the team is in place a detailed work plan can be developed. An option is to do this, conform the approach followed in the WAVES Philippines program, during a 1 week training course, which is partly about becoming more familiar with the ecosystem accounting methods, and partly about, together with an international expert, developing the detailed work plan based on potential modelling approaches and revisit of the policy needs and priorities. Based on the detailed data inventory, it is also possible to adjust/fine-tune the scope of the Botswana ecosystem account based on emerging insights. The work plan should also lead to the further specification of data gaps. The work plan should also establish for which year(s) the accounts should be developed. Several stakeholders indicated the need to understand long-term trends in order to ensure policy relevance, and it may be opted to create an account for a recent year as well as one or two years in the past, e.g. 5 and/or 10 years ago.

4. **Development of a data management structure and collect all available, relevant data**. Once the team is established, it should start collecting all relevant data available in Botswana, the broader SADC region, and the scientific literature. The data should include spatial data on ecosystems and ecosystem use, temporal data on trends in ecosystems and ecosystem use, statistical data, for instance on economic activity depending upon ecosystems, and survey data. It should also include, for instance, the tourism company register at the Ministry of Environment Tourism and Wildlife, that provides data on tourism operators. Where possible, the team should check the accuracy of the data, through cross checking different data sources and where feasible field surveys.

5. **Establish data gaps and collect additional information**. Three potential data gaps have been identified with regards to the potential scope of the accounts as defined in Chapter 3. First a lack of tourism data, in particular in terms of recent data on visitor numbers and on the way visitors spent time in Botswana's parks. The Tourism registry provides an entry point for obtaining information on tourist behaviour (since it records numbers of beds and in principle, overnight stays), but a survey is needed to verify and update this information including tourist expenditure. Second, there is a need to conduct a household survey among livestock holders, building upon existing datasets on rangeland management, in order to retrieve the information to calculate the resource rent generated by rangelands. Third, there is a need to conduct a remote sensing study to analyse rangeland condition

for the selected years for the account, depending upon how much information can be retrieved form the MESA project. Development of the specific TOR for these data collection activities would be part of the development of the detailed work plan, and can be carried out once the technical team has collected all relevant data including form the tourism accounts, the tourism registry and ongoing efforts to collect tourism data in Botswana.

6. **Construct the ecosystem account**. Once the team is in place, and data are collected, the team can start creating the ecosystem account. At the same time, data gaps should be filled, which means that some of the work (creating accounts based on available information and collecting additional data) should proceed at the same time. This is anticipated to take from 8 to 12 months, with intermediate results available for sharing and dissemination after around 6 months.

7. **Communicate results to policy makers and evaluate the ecosystem account.** There is a need to ground the whole development of ecosystem accounts in the policy context of Botswana in order to make them as policy relevant as possible, with specific reference to the NDP11 preparation process (although it will be difficult to generate many relevant results in a year) and the Gaborone Declaration implementation process. In addition, throughout the development of the accounts, there should be regular interactions with senior policy makers in order to be advised on updates in policies of relevance for the accounts, and to inform policy makers of progress and potential applications. Hence, both after around 6 months and after 8 to 12 when the full first version of the ecosystem accounts are developed there is a need for a workshop in which the results are communicated to policy makers and the policy relevance is evaluated. Based on an evaluation following the first year, a work plan for the next phase should be developed.

8. **Refinement of the ecosystem accounts**. In the 2nd year in which the analysis will take place, a refinement of the ecosystem account can be pursued, for instance in terms of spatial resolution, additional ecosystem condition indicators, additional ecosystem services, and/or in terms of additional area to be covered, as described in Section 2 of this report.

A Gant chart showing timeline and outputs is provided below.

Gant chart 'Ecosystem accounting in Botswana'.

Action	2014 Q3	2014 Q4	2015 Q1	2015 Q2	2015 Q3	2015 Q4		Output (measurable)
Define institutional structure	*							Institutional structure defined and agreed, posts funded.
Establish team		*						Team of 3 to 5 people hired and established
Training course and development of work plan			*					Training course provided, action plan developed
Development of data management structure and collect data			*					Data management system in place, data sharing arrangements with key stakeholders in place
Capacity building and technical support (demand driven)				*	*	*		MoUs in place, Technical input provided as reflected in reports
Meetings with TWG (1 per quarter)	*	*	*	*	*	*		Minutes of meeting
Meetings with policy makers and other high level stakeholders				*		*		Workshop Report including commitments and feedback points from stakeholders

References

Bateman, I.J. A.R. Harwood G.M. Mace, R.T. Watson, et al., 2013. Bringing Ecosystem Services into Economic Decision-Making: Land Use in the United Kingdom. Science 341, 45.

Edens, B., Hein, L., 2013. Towards a consistent approach for ecosystem accounting. Ecological Economics 90, 41-52.

European Commission, Organisation for Economic Co-operation and Development, United Nations, World Bank, 2013. System of Environmental-Economic Accounting 2012: Experimental Ecosystem Accounting. United Nations, New York.

European Commission, International Monetary Fund, Organisation for Economic Co-operation and Development, United Nations, World Bank, 2009. System of National Accounts 2008. United Nations, New York.

Hein, L and N. de Ridder, 2006. Desertification in the Sahel; a reinterpretation. Global Change Biology 12: 1-8.

Hein. L. and H.P. Weikard, 2008. Optimal long-term stocking rates for livestock grazing in a Sahelian rangeland. *African Journal for Agricultural and Resource Economics.* 2(2), 15-26.

Hein, L., N De Ridder, P Hiernaux, R Leemans, A De Wit, M Schaepman, 2011. Desertification in the Sahel: Towards better accounting for ecosystem dynamics in the interpretation of remote sensing images. Journal of Arid Environments 75 (11), 1164-1172.

Howarth, R.B., Farber, S., 2002. Accounting for the value of ecosystem services. Ecological Economics 41, 421–429.

Schröter, M., Barton, D., Remme, R., Hein, L., 2014. Accounting for capacity and flow of ecosystem services: A conceptual model and a case study for Telemark, Norway. Ecological Indicators 36, 539-551.

Sumarga, E., L. Hein, 2014. Mapping Ecosystem Services for Land Use Planning, the Case of Central Kalimantan. Environmental management, 1-14

UNSD, 2013. System of Environmental-Economic Accounting 2012: Implementation Guide, Draft version prepared for the London Group meeting on Environmental Accounting. Article available at: http://unstats.un.org/unsd/envaccounting/londongroup/meeting19/LG19_6_1.pdf

United Nations, European Union, Food and Agriculture Organization of the United Nations, International Monetary Fund, Organisation for Economic Co-operation and Development, The World Bank, 2014. System of Environmental-Economic Accounting 2012: Central Framework. United Nations, New York.

Weikard, H.P. and L. Hein, 2011. Efficient versus Sustainable Livestock Grazing in the Sahel. *Journal of Agricultural Economics* 62(1), 153–171