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Title: Economic valuation of selected direct and indirect use values of the Makgadikgadi wetland system, Botswana

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Abstract

Economic valuation of wetlands aims to investigate public preferences for changes in the state of the wetland and the natural resources it constitutes in monetary terms. It provides a means of quantifying the direct and indirect benefits that people derive from wetlands. In addition, it informs management planning and practice about resource options, optimal allocation and also provides information for conservation of the resource. The Makgadikgadi wetland is a unique system that mostly consists of dry pans during most part of the year despite the fact that this year (2010), the pans were fairly wet. This study aimed at estimating the value of groundwater recharge and community-based natural resource management (CBNRM) activities within the Makgadikgadi wetland resource and how these services and goods contribute to the local and national economy. The Total Economic Valuation approach was adopted and this considers both the direct and indirect use values of the resource. In essence, the study concentrated on one direct use value (use of resources through CBNRM) and one indirect use value (groundwater recharge). In regards to CBNRM, three community based organizations (CBOs) were selected for the study and static and dynamic cost benefit models for these CBOs were developed. The groundwater recharge value was largely determined through desktop review and interviews with stakeholders such as representatives from the Division of Groundwater within the Department of Water Affairs. The results indicate a small positive contribution of CBOs towards the economy of Botswana and a high potential for communities to derive substantial benefits from the projects because currently benefits realised by communities are limited. CBOs involved in joint venture partnerships with tourism and hunting enterprises benefit more from utilizing the wetland's resources. With regards to groundwater recharge, recharge often occurs in areas away from the physical location of the wetland and may not be easily attributable to the wetland. However, the study assessed the value taking into consideration the various sectors which rely on the groundwater resource. The groundwater recharge value is significant (about BWP 10 million) but lower when compared with the value generated by the Okavango delta (BWP 16 million). Given future increases in water demands, groundwater abstraction will exceed recharge thus hampering the availability of the resource for the future generations and maintenance of the environment.

Key words: community-based natural resources management, economic valuation, groundwater recharge, wetlands

1. Introduction

Wetlands are among the earth's most important and productive resources and have been termed the "kidneys of the landscape and biological supermarkets" (Barbier *et al*., 1997). This is so because of the various functions they perform in the ecosystem (McCartney and Houghton-Carr, 2009). Wetlands directly and indirectly support livelihoods as they provide food for people and help them earn income from the use of the wetlands' resources. Management of wetlands therefore requires attention to ecological integrity of the systems, social wellbeing and security as well as economic efficiency to enhance sustainable management of the resources. However, activities such as overgrazing, land clearing, burning and overexploitation of natural resources around wetlands are contributing to the deterioration and complete loss of wetlands in some parts of the world. These threaten the continuity and stability of wetland ecosystems. In turn, these may potentially also impact on communities that rely heavily upon these resources especially the rural poor and vulnerable groups of the society. Examples of wetlands in southern Africa include the Okavango and Zambezi deltas in Botswana and Mozambique respectively, Barotse flood plain in Zambia, eastern Caprivi wetlands in Namibia, lower Shire wetland in Malawi, Rufiji floodplain in Tanzania and the Makgadikgadi pans in Botswana which is the focus of this study.

Given the significance of wetlands, it is important to understand their value in both qualitative and quantitative terms so as to guide their sustainable utilisation and management. Economic valuation is an attempt to assign quantitative values to services and goods provided by the wetland resource despite the (un) availability of market prices (Barbier *et al*., 1997; Emerton *et al*., 2004). It tries to direct attention to the use and non-use values of the resource in monetary terms. Valuation of the services and goods provided by the wetlands is of paramount importance as it contributes to better decision making, illustrates the contribution of the wetland to society's wellbeing and high dependence on the resource. Furthermore, valuation is a powerful tool that can aid in catalyzing and improving the utilisation and management of wetlands (Emerton, 1998; Turpie *et al*., 1999). Valuation is key to promoting efficient use of water resources and conforms to the principles of Integrated Water Resources Management (IWRM) which among other things recognizes water as an economic good with a value. Once the value is clearly articulated, it would aid in directing coordinated development and management of the resource involving a wide array of stakeholders (participatory approach in the management of the resource) and this is in line with principle two of the 1992 Dublin's Principles which states that "water development and management should be based on a participatory approach, involving users, planners and policymakers at all levels" (Global Water Partnership, 2000). In addition, results of valuation can potentially contribute to the achievement of Millennium Development Goal 7 which seeks to achieve environmental sustainability. Economic valuation is also highly recommended in the 1997-2002 Ramsar Strategic Plan which was approved during the 1996 Conference of Parties to the Ramsar Convention (Barbier *et al.*, 1997).

This paper is based on the Makgadikgadi wetland system in Botswana which is an inland palustrine wetland system and is one of the largest wetlands in southern Africa. Given the various goods and services the Makgadikgadi wetland provides, there is need for co-ordinated and holistic management as well as sustainable utilisation of the resource. To enhance this process and to ensure sustainability of the resource, it is therefore essential that the various

resource users and uses be adequately understood and as such economic valuation is well placed to reveal this significance and facilitate the balancing of resource utilisation and conservation for the current and future generations.

The main focus of this economic valuation study was on the community- based use of the natural resources within the wetland and as such, three community based organisations were considered: Nata Conservation Trust, Gaing-o Community Trust and Xhauxhwatubi Development Trust. As part of the indirect use value of the wetland, groundwater recharge was also considered in the study.

The research was carried out as part of a wider research project: Makgadikgadi Wetland Framework Management Plan (FMP), Botswana. The main objective of the FMP project is 'to improve people's livelihoods through wise use of the wetland's natural resources'. This ongoing project is carried out by Centre for Applied Research in partnership with the Department of Environmental Affairs, Ministry of Environment, Wildlife and Tourism, Gaborone.

2. Study area

The Makgadikgadi wetland is situated in the Makgadikgadi Basin in the north eastern and central parts of Botswana (Figure 1). The catchment area of the wetland system is vast as it extends into Zimbabwe through the Nata River system. It is also linked to the main Okavango drainage system through the Boteti River. The total surface area of the wetland area is 25,900 km^2 (Ecological Support Services, 2002). The wetland system is composed of two seasonally inundated pans which are the Ntwetwe and the Sua Pans. There are also subsequent smaller pans which are part of the wetland system. The two major pans constitute 8,000 km^2 and 6,000 km^2 respectively. These pans are surrounded by grasslands, tree and bush savanna as well as Mophane woodlands and they are also fed by five seasonal rivers, the main one being the Nata River (McCulloch *et al*., 2008). The hydrological regime of this unique wetland is thus determined by internal drainage controls such as surface and groundwater as well as external factors such as climate variability. Rainfall is highly variable and average annual rainfall is 400 mm with Rakops village being the driest in the region (Ecological Support Services, 2002). In terms of groundwater, the Makgadikgadi wetland has mostly shallow wells and minimal deeper saline brine. The quality of groundwater resources is variable and in some areas, very saline given the occurrence of salt pans. The Makgadikgadi is endowed with a variety of ecological habitats which provide for a diversity of flora and fauna including woody vegetation, short bush and tree savannah and various grass species as well as small to large mammals and aquatic animals. When flooded, it attracts a variety of water birds including the severely globally threatened species such as the water crane, lesser flamingos and the white pelicans (McCulloch, 2003).

The FMP area comprises seventeen settlements with a population of 51,131 (CSO, 2001). The communities rely upon traditional livelihoods activities such as mainly arable and livestock farming as well as collection of veld products. Employment in the public sector is common and there is limited employment of the local communities in the mining sector because of the need for high skilled manpower in the sector. Social welfare programmes also play an important role

in availing income for the communities. This is mainly through programmes such as drought relief or Ipelegeng which are similarly undertaken in other villages throughout the country at large. Although limited, tourism plays a significant role in the Makgadikgadi as the wetlands provide a pristine tourism areas and abundant biodiversity which are vital for enhancing the tourism sector in the region. The Makgadikgadi National Park and the Nata Bird Sanctuary offer a vast array of wildlife and bird species some of which are regarded as being rare. Other wildlife endowed areas are the Wildlife Management Areas which are also utilised by the communities.

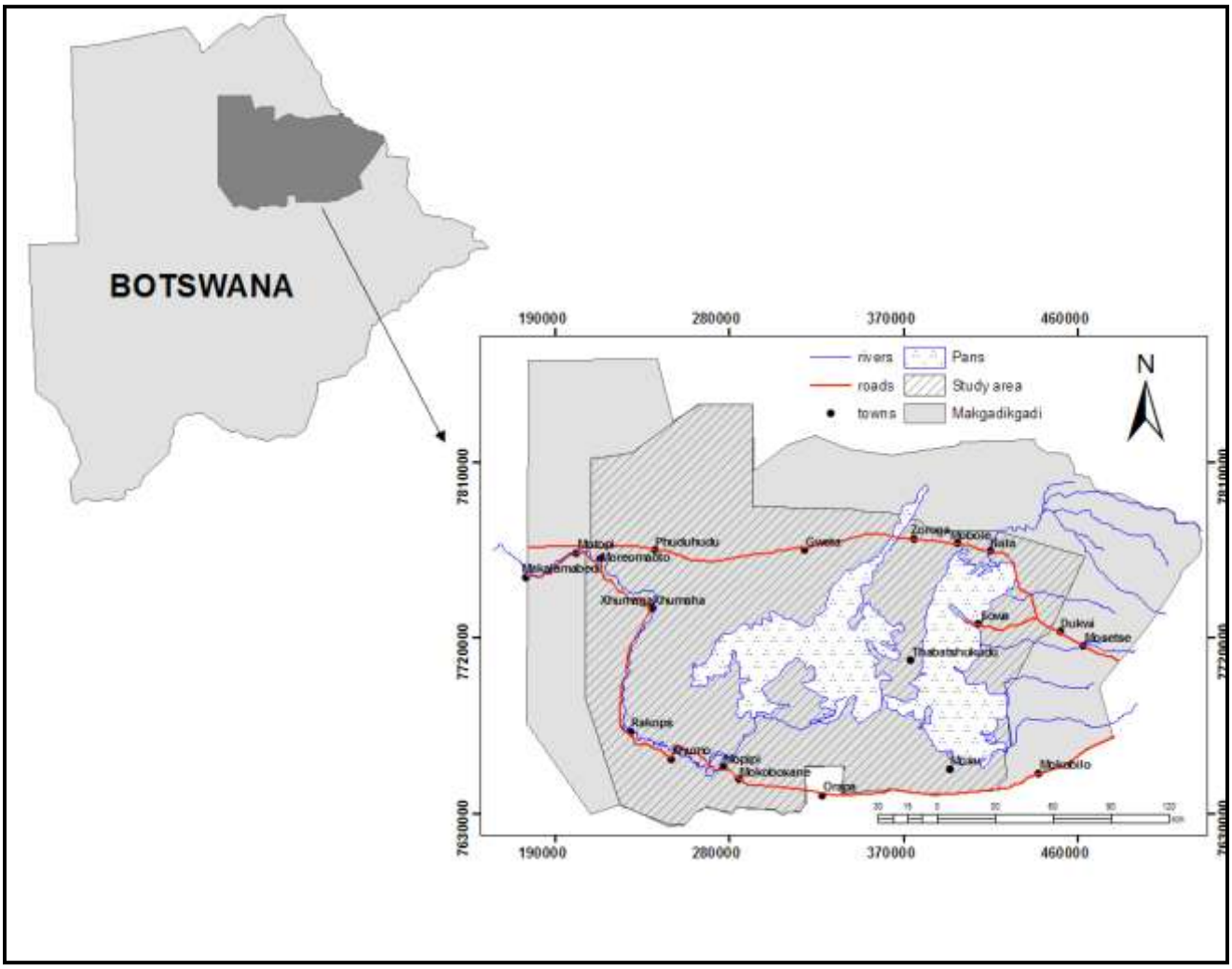

Figure 1: Map showing the location of the Makgadikgadi wetland

3. Methods

The study adopted the Total Economic Valuation framework within which direct and indirect use values were analysed.

3.1 Estimation of the direct use value of the wetland's resources to the CBOs

In-terms of sampling of projects, currently there are three operational CBOs in the area and these were selected for the study. Focus group discussions and interviews were undertaken with the communities, trust members and other stakeholders. These were used to gain insights as to how the wetland is utilized, how the trusts operate, their activities, challenges, benefits and prospects for the future. Structured and semi-structured interviews were held with the chiefs, members of the Trusts, representatives from the following government departments: Department of Tourism, Department of Environmental Affairs, Department of Veterinary Services, Department of Crops and Extension Services. With regards to non-governmental organisations, an interview was held with a representative from the Kalahari Conservation Society which mainly supports conservation activities in the country as well and CBNRM projects.

Development of the Community-Based Organisations' Enterprise models requires assessment of financial information of the CBOs. Financial reports of the trusts provided data used in the financial and economic analysis of the wetland. For Nata Community Trust, the financial data was not readily available from the trust but rather it was intensively sought through their past project facilitators and supporters, in this case, Kalahari Conservation Society (KCS). Their records dated as far as 1992 and therefore the data attained was fairly substantial for utilization in the development of the CBO models. For Gaing-O Trust, data was only available for 2009 as they had no access to the past records. Nevertheless the data was useful for the modelling. Donor funding data was available for a number of years (1997 to 2010).

The enterprise models were developed based on those of Barnes (2001, 2008), Barnes *et al.*, (2002) and Turpie *et al.,* (2006). They largely follow the models developed for the CBNRM programme in Namibia and those in the Okavango Ramsar site. The enterprise models consist of financial and economic models clearly detailing static, dynamic, budget and cost-benefit excel spread sheet models. These models are purely based on empirical data and assumptions brought together through interviews with the trust operators and resource users as well as through assessment of their financial records. The CBO enterprise models measure both the financial and economic efficiency of the projects. The former is measured so as to assess the profitability of the project from the project and investors' perspective and in this case, the measures are annual net income, financial rate of return and the financial net present value. In addition, the financial profitability is measured from a point of view of the community itself, that is, how much they are accruing from a project as a community. Measuring economic efficiency on the other hand considers contribution of the project to gross and net national incomes, economic rate of return as well as the economic net present values in economic prices. Ultimately these would show the economic value of these projects as an investment based on the costs and benefits that are directly associated with the projects and their use of the wetland's resources.

i. Static budget models

Static budget models depict an annual income statement for the enterprise at full production. The static *financial* models therefore measure the annual financial net profit attained while the enterprise was at full production. These take into account depreciation on owned capital, interest and amortization on borrowed capital, government fees, rentals and royalties received by the CBOs. The static *economic* models on the other hand, measured the annual change in value

added to the gross national income (GNI). This was calculated as gross output less intermediate expenditures, leaving all the income earned by the enterprise's internal factors of production including the labour, land, capital and entrepreneurship involved in the enterprise. The value added thus included the annual profits, salaries and wages, payments to and of capital, rentals, royalties, and taxes resulting from the enterprise activities all measured at their opportunity cost to the nation. Calculation of GNI as a measure of *national* as opposed to *domestic* income, considered foreign inflows and outflows. The most important measure for the static budget models as indicated was the GNI, but also measured was the net national income (NNI), which was GNI less depreciation.

In order to value the inputs and outputs so as to reflect the opportunity costs, shadow pricing was applied. Shadow pricing, as applied in the economic analysis, involved adjustments to allow for unemployment, excess demand for foreign exchange, and domestic transfers. Thus the values were measured from the perspective of society.

ii. Dynamic cost-befit models

The dynamic cost-benefit models in this case measure financial and economic returns over five, seven and ten year periods. In appraising projects, the resultant measures are the Internal Rate of Return (IRR) and the Net Present Value (NPV). The NPV analyses the overall value or viability of a project, taking into consideration the time value of money at the opportunity cost of capital or discount rate. The IRR is the discount rate at which the NPV is equivalent to zero. Therefore should the NPV be negative and the IRR less than the discount rate, then the project is deemed as being non-viable, earning less than the next best investment. Moreover, the higher the IRR, or if the IRR is greater than the discount rate, then the project is more desirable to invest in. The benefits and costs flows were in constant prices, excluding inflation, and they were discounted at a real rate of 10 % for both financial and economic models. The 10 % discount rate is the preferred rate in Botswana as stipulated in the Botswana Planning Officers Manual and Bank of Botswana (MFDP, 1996). All capital expenditures were included and depreciation or appreciation of capital value was accounted for in the asset residual value in the final year of the cost benefit analysis.

The models were tested through a sensitivity analysis by changing some variables. This was undertaken in-order to determine the robustness of the models and the strength of the conclusions that could be attained from them.

3.2 Groundwater recharge value

For this component, four sectors were identified as being the major groundwater users in the Makgadikgadi area. These include livestock farming, households, mining and wildlife. For livestock, data was attained from the Nata and Letlhakane Departments of Veterinary Services as well as from the national livestock census data of 2006. The Veterinary Services provided information for the various cattle crushes mainly located at the cattle posts. Data from the agricultural statistics is given by the agricultural sub-district, in this case: Letlhakane, Ngamiland East and Tutume. A proportion of these districts fall within the Makgadikgadi project area and therefore the following assumptions have been made:

- For the Letlhakane district, 71.5 % of the livestock falls within the project area and is evenly distributed;
- For Tutume district, 17 % of the livestock falls within the project area; and
- 6% of livestock in Ngamiland East district falls in the Makgadikgadi Framework Management Plan project area.

In estimating the water consumption by livestock, daily water requirements per head of livestock were used as designed by the Ministry of Local Government (Table 1). For each type of livestock, the water requirements have been multiplied by the number of animals in that category so as to derive how much water they consume. Taking into consideration that animals do not drink from boreholes all year round, it has been assumed that 75 % of the year, livestock drink from groundwater resources and the rest of the time they get water from surface water resources assuming it rains. The total abstraction for livestock consumption has therefore been assumed to be equivalent to the recharge.

Table 1: Water requirements per head of livestock

	Daily (l)	***Annual (m^3)***
Cattle	50	18.25
Goats	5	1.825
Sheep	5	1.825
Donkeys	20	7.3

Source: Lange and Hassan, 2006

With regards to mining, two mines are operating in the Makgadikgadi area; Botash and Orapa Diamond Mine. Botash has its own well field and buys potable water from the Dukwi well field through the Water Utilities Corporation. For Botash, average water abstractions have been estimated based on the annual abstraction data from CSO (2009). The mine accounts for 11% of the abstraction from Dukwi well field with an estimated recharge of 33 % of the total water usage by BOTASH mining activities. In regards to the Orapa mine, two well fields have been considered as they fall within the project area (well fields 2 and 4). A quarter of the average total water abstractions from these well fields for 2007 and 2008 have thus been considered for the recharge value.

For the wildlife sector, nine boreholes within the Makgadikgadi National Park are currently operational. Daily pumping rates have thus been considered and the total rate was multiplied by 365 days to derive the annual abstraction from the boreholes. It was therefore assumed that the boreholes pump water at least four hours per day.

For the settlements, the information required were water consumption data and the number of people occupying the area. Since the last population census was in 2001, the data was projected for 2009 using a factor of 2.1% (growth rate). For the water consumption, in the absence of accurate water consumption figures for each settlement, daily per capita water demands are required to enable the estimation of water consumption. In essence, the Review of the National

Water Master Plan (2006) stipulated the suggested water demand figures as designed by the Department of Water Affairs (DWA) for use in the entire country (Table 2).

Table 2: DWA Design Manual recommendations

	Litres per person per day
House connections	60
Yard connections	125
Standpipes	30

Source: SMEC and EHES, 2006

Using the information from Table 2, total annual water demand in m^3 was estimated as follows:

$$TWD = \frac{av.p.c \times p}{1000l}$$

Where:

TWD = total water demand in m^3

av.p.c = average annual per capita water consumption in litres

p = population

l = litres

Water abstraction has been assumed not to exceed recharge given that most settlements are small. Therefore, the recharge rate has been assumed to be 65 % of the total groundwater abstraction

For this study, the water costs have been estimated based on those from the Maun Groundwater Development Project and those used in the economic valuation of the Okavango wetland (Turpie *et al*., 2006). A value of P2.75 / m^3 has therefore been used as the unit value of groundwater in the Makgadikgadi area.

The overall groundwater recharge value of the Makgadikgadi wetland was therefore estimated by multiplying the sum of the recharge /abstractions values from each sector by the unit value of groundwater. A sensitivity analysis was undertaken to determine the effects of changes in the livestock numbers, changes in the unit price of water and the percentage changes of groundwater recharge as a result of mining activities.

4. Results and discussions

Within the framework of Total Economic Valuation, the FMP project assessed the following value components:

Direct use values	Indirect use values
Livestock	Wildlife refuge
Crops	Carbon sequestration
Natural resources	Science and education
Tourism	Groundwater recharge[1]
Mining	Water purification

4.1 *Characterisation of Makgadikgadi wetland resources for different resource users*

4.1.1 *Wetland users*

The major users are the local communities, particularly the farmers and the natural resource harvesters. Both arable and livestock agriculture are major activities around the wetland and play a significant role in improving the livelihoods of the locals. However, farming is undertaken mostly for subsistence purposes and on a limited scale, for commercial purposes because of lack of access to the market as well as lack of resources to start up commercial farms. Commercial farmers are therefore those who are regarded as being the wealthy members of the society. More than half of the commercial farmers are not originally from the Makgadikgadi area. These are individuals who acquired land for farming in these areas and have thus benefited from using the wetland's resources. Communities also engage in harvesting of natural resources and the harvesters range from the youth to the elderly women and men. As remarked by Turpie and others (2006) on the economic use value of the Okavango delta, natural resources' products as a result of the existence of wetlands form a critical part of the local communities' way of life. Natural resource users are mostly collect wild foods, plants, grasses, firewood and medicinal plants. Fishing is not common because the wetland is dry for most of the year. The wetland area is endowed with minerals including diamonds and soda ash and as such, two of the largest mines in the country are located in this area (Orapa diamond mine and BOTASH). These contribute significantly to the local and national economy through the revenues and employment opportunities generated. The Makgadikgadi is also an important area for tourism as it possesses rare biodiversity such as birds (especially flamingos) as indicated in the important bird life monitoring activities of the Bird Life organisation in Botswana (McCulloch *et al.*, 2007). Furthermore, wildlife resources and the attractive salt pans are also prominent features of the wetland area. Due to the tourism attractions that the area possesses and the abundance of wildlife and other biodiversity, the communities through the CBNRM programme, are also users of the wetland's goods and services.

4.1.2 *Wetland's goods and services*

Makgadikgadi wetland system directly and indirectly supports thousands of people living in and around the wetland in various ways through the goods and services it provides. The focus group discussions with the resource users revealed that for the direct benefits, agriculture, especially livestock farming. Crop farming is also undertaken in the Makgadikgadi area as well and dryland farming is the most common form of crop farming but households in areas like Rakops and Xhumaga practise floodplain (*molapo*) farming in areas that are seasonally flooded.

[1] Determined through this study

4.2 *Estimated direct use value of wetland resources to different CBOs*

4.2.1 *Financial models*

The financial values indicate whether the project at hand is viable to the community and the project itself as well as the investor. Table 3 gives the results of the financial models for the three CBOs. The financial returns for Xhauxhwatubi Trust are more favourable than the other two trusts. Although the trust incurs substantial financial costs, the income generated is still significant. The financial capital invested into the project is also considerable but despite that, the net benefits are significant. It is noted that Xhauxhwatubi has access to favourable resource conditions and on the overall the area has prime wildlife tourism potential hence the high returns.

Gaing-O and Nata both generate negative net present values and low rates of return with Gaing-O generating the least. The two trusts incur least capital financial costs although the difference is not that pronounced as compared with the high income generating Trust. The direct economic gross value added to national income by the CBNRM programme activities in the Makgadikgadi area therefore amounts to some BWP 990,000.

Table 3: Base case financial values for the three operating CBOs in the Makgadikgadi area (BWP, 2010)

	Nata	***Gaing-O***	***Xhauxhwatubi***
Total financial capital	1, 117960	1,595,084	1,791,507
Capital investment per hectare	49	275.01	158.82
Financial gross income	167,598	444,980	1,271,750
Fixed financial costs	228,971	354,092	511,222
Variable financial costs	29,748	130,510	140,574
Annual net cash income	-91,122	-39,622	619,953
Financial rate of return	7.41%	6.16%	14.60%
Financial net present value[1]	-294,813	-627,322	820,855

1. Using a discount rate of 10%

In terms of the community financial values, these indicate the extent to which communities have an incentive to invest in the project (Table 4). The results show that the Gaing-O and Xhauxhwatubi Trusts can derive positive returns on their investments. They are also getting a higher rate of return on whatever they are investing in. The annual cash income that may accrue to the Nata Trust community is minute and thus the communities may have little interest in investing in the project. On the ground, the communities expressed little interest in the project because currently they do not gain much from the project thus deemed it as being less significant to the community. However, they are hopeful that the envisaged investment in the Nata sanctuary might improve the situation.

Table 4: Base case financial returns to the community (2010)

	Nata Trust	***Gaing-O Trust***	***Xhauxhwatubi Trust***
Annual community cash income (BWP)	-27,733	86,397	849,953
Cash income (BWP / ha)	-1.21	14.90	75.35
Financial rate of return (%)	11.55%	17.59%	34.12%
Financial net present value (BWP)	147,901	796,613	2,505,170

It is notable that the current arrangements do not provide for distribution of benefits to the individual households but to the wider community at large. This is primarily because there are no benefit distribution mechanisms in place and there is poor involvement of the community members in decision making processes on how the revenues generated could be spent. Most of the benefits accrue to the members and employees of the CBO. Donor and government funding is the most dominant feature of the community financial analysis because most of these projects rely on donors especially for capital and to some extent operation costs. Therefore the returns accrued by the communities are considerable if the subsidies attained are substantial.

4.2.2 Economic models

The economic values give an indication of the viability of the projects from the perspective of the nation at large, in this case, national development or national income. The projects are economically efficient and contribute positively to the national economy of Botswana (Table 5). In the analysis, the return in national income and excludes donor contributions from outside the country. This return thus reflects the direct use value of the projects. Xhauxhwatubi Trust has more capital requirements and generates the highest returns to the national economy. The annual net benefits as well as the net present value are significantly higher for Xhauxhwatubi as compared to the other trusts.

Table 5: Base case economic values for the three operating CBOs in the Makgadikgadi area (BWP, 2010)

	Nata	***Gaing-O***	***Xhauxhwatubi***
Total economic capital	1,027,812	1,474,320	1,656,321
Total economic capital per hectare	45	254.19	146.84
Annual gross value added	-28,550	133,927	920,772
Annual net value added	-110,012	-12,091	757,139
Net value added per hectare	-4.78	-2.08	67.12
Economic rate of return	10.81%	11%	27%
Economic net present value	77,312	180,912	2,326,942
Number of jobs created	9	10	14

Economic capital cost per job	114,201	163,813	184,036

For the sensitivity analysis, changes were made to the Nata Conservation Trust CBO models and the variations were in effect to the capital expenditures, the increase in income as well as a change in the discount rate. A 50 % variation in the capital expenditures affects the economic and financial viability of the project in a significant way. According to Table 6, a 50 % decrease in the capital requirements results in an increase in the rate of return economically and financially whereas the viability is weakened after considerable changes in the capital costs. This severely affects the project's financial viability as compared to the economic and community's perspectives. In fact, the rate of return from the point of view of the community fairs higher thus the results clearly show that economic and community returns are highly sensitive to changes in capital expenditures.

From the models developed, the financial and economic values derived indicate the significance of the three trusts in-terms of the revenues generated through the use of the resources within and around the wetland area. Furthermore, the models also illustrate the incentives for communities to manage their resources sustainably through CBNRM. Despite the wide range of potentially high revenue generating activities that the CBOs are engaged in as well the significant amounts of revenues invested by the donors, the communities do not receive substantial benefits from these projects particularly at household level. Some of the contributing factors to such skewed distribution of benefits are mismanagement of the financial resources and poor governance. Governance of CBOs has been a major challenge in Botswana as indicated in several reports (Arntzen *et al*., 2003; Rosemeijer, 2003; von Malitz, 2007). It has however been difficult for the Government to monitor the activities of some of the CBOs as well as ensuring that the CBOs manage community resources equitably.

Table 6: Effects of change in capital expenditures for the Nata Trust

	IRR (%)			*NPV (BWP)*		
	Economic	Project	Community	Economic	Project	Community
Capital expenditure						
50 % of base case	18.72%	13.06%	21.58%	577,164	253,955	696,669
Base case	10.81%	7.41%	11.55%	77,312	-294,813	147,901
150 % of base case	6.55%	4.07%	6.82%	-422,542	-843,583	-400,869

4.3 Groundwater recharge value

Literature indicates that wetlands have a role to play in groundwater recharge (Barbier *et al*, 1997; Bullock and Acreman, 2003; Brander *et al*., 2006; Turpie *et al*., 2006). Some wetlands hold water over a wide area such that where it contributes to groundwater recharge it consequently becomes available for abstraction and hence water supply for the surrounding areas.

Settlements

Groundwater is highly crucial to a number of individuals and communities largely for the supply of water for domestic and agricultural purposes among others. Given the per capita water demand figures stipulated by the Ministry of Local Government, the total annual groundwater abstraction for the settlements is estimated at 0.76 Mm^3 for 2009. In light of these estimates, the recharge is estimated to be 0.5 Mm^3 per annum. This constitutes at least 65 % of the total abstraction for the settlements.

Livestock

Agriculture forms a critical part of the economy of Botswana and livestock is essential to this activity. A significant proportion of the rural dwellers (about 68%) are largely involved in livestock keeping for various purposes including sales, household consumption, gifts and drought power. Its importance is additionally enhanced by its cultural function. Despite the decline in the contribution of livestock farming to the economy of Botswana, with better management, the industry is still seen as having the potential to reduce vulnerability and poverty among the rural population (DEA and CAR, 2007; and CSO, 2009). Given this, it is therefore expected that the demand for water for livestock will increase in the future. Using the cattle crush and agricultural statistics data, livestock water consumption estimates are indicated in Table 7. An assumption has been made that livestock drink from a groundwater resource at least three quarters of the year (nine months). It has also been assumed that water abstraction for livestock does not exceed recharge and therefore abstraction is equivalent to recharge.

Table 7: Livestock water consumption in the Makgadikgadi (Mm^3/annum)

	Cattle crush (2009)	***Agricultural statistics (2006)***
Cattle	2.08	2.76
Goats	0.03	0.18
Sheep	0.06	0.01
Donkeys	0.04	0.11
Horses	0.07	0.03
Totals	2.28	3.08
Nine months consumption	1.71	2.31

Wildlife

DWNP in conjunction with the KCS developed nine boreholes and five watering holes in the Makgadikgadi National Park to increase access to water for the survival of wildlife within the park. The hourly water abstractions from the boreholes is 53.88 m^3 and assuming that the boreholes pump water at least four hours a day, the total annual water abstractions are estimated at 78,645 m^3 . These boreholes have been installed with solar pumps and therefore when the solar power is insufficient, pumping is very limited hence the low number of pumping hours. Since this estimate is low, the recharge level has therefore been assumed to be equivalent to the recharge.

Mining

Botash and Orapa diamond mines rely solely on groundwater for the production and processing of minerals. Botash uses process water from its own well field within the Makgadikgadi and obtains potable water from the Dukwi well field through WUC. Abstraction is on average around 600 ML per annum with an estimated recharge of 200 ML. On the other hand, the Orapa diamond mines also source water from their own well fields. The estimated abstraction rate from these well fields is 1.36 Mm^3 /annum with an estimated recharge of 340 ML (a quarter of the abstraction). Groundwater depletion around the mines is common especially around the Debswana mines hence the 25 % assumption has been applied as accruing to the recharge.

In light of the estimated abstraction and recharge levels by the various sectors, the annual groundwater value was estimated. Considerations have been made with respect to the numbers of livestock and the period of time they consume water in a year. Using the data from the Department of Veterinary services, the nine month livestock water consumption assumption and the BWP 2,75 / m^3 cost of groundwater, the Makgadikgadi wetland system is estimated to give a groundwater recharge service of BWP 8.6 million as indicated in the table below. The livestock sector is the largest water user followed by the mining sector. Together these sectors account for over eighty percent of groundwater consumption.

Table 8: Groundwater recharge value of the Makgadikgadi

Consumption/recharge by sector - m^3 *(2009)*	***Cattle crush (9 months)***	***Agricultural statistics (9 months)***
Domestic	495,833	495,833
Livestock	1,708,407	2,313,515
MNP	78,665	78,665
Mining	837,642	837,642
Total consumption (Mm^3)	**3.12**	**3.73**
Total groundwater recharge value (BWP million)	**8.58**	**10.25**

5. Concluding remarks

It is important to assess the economic values of the Makgadikgadidi wetland given the various goods and services provided. The study demonstrates that community's use of resources around the wetland through CBNRM projects is limited. However, the existing projects are economically viable but financially they are not (except Xhauxhwatubi Trust, which derives significant income from its hunting joint venture partner). Currently, the communities do not accrue much benefits from these projects and where revenues are generated, the beneficiaries tend to be those who are employed by the CBO but not the community at large. Moreover, these community projects are highly donor dependent and therefore in the absence of such support, they cannot sustain themselves. Hunting and tourism based projects generate high values both financially and economically largely because of the resources royalties and rents derived from leasing of land and high value hunting quotas. CBNRM is not pronounced, as demonstrated by

the only three operating CBOs in the area, therefore there is potential for further development of CBOs given the availability of resources within the wetland and the willingness from the communities.

Mining and the livestock sectors are undoubtedly the highest water users in the region. The groundwater recharge value is high given the demand for groundwater in the area. The groundwater recharge value for the wetland is lower if compared with the BWP 16 million value estimated for the Okavango delta in 2006. The discrepancy is largely related to the sizes of the two systems, temporal variability of ecosystems that the wetlands encompass as well as the population and livestock numbers. Of concern however is the ongoing groundwater mining around the wellfields. This is mostly in regards to diamond mining and Botash activities.

The study therefore recommends that:

1. Given their potential importance for poverty reduction and rural development, CBOs need support to improve and sustain their performance. Such support should come from government, civil society and constructive partnerships with private companies. Hunting revenues are essential for the financial performance of CBOs. In addition, community water resources management projects should be encouraged to enhance understanding and realization of benefits of IWRM. Capacity building of CBOs in water resources management should therefore be promoted;

2. Direct and indirect use values of the wetland should be recognised in national wetlands strategies, natural resource management, IWRM policies and strategies as well as economic and development procedures. These values could be reflected, for instance in the prices of products and services derived from the wetland. In essence, inclusion of values in decision making would facilitate informed coordination, sustainable utilization and management of the resources within and around the wetland area;

3. Groundwater recharge should be enhanced so that the wetland could support the ecosystem adequately. Groundwater mining should be minimal and water demand management techniques should be encouraged and recharge enhancing land use practices stimulated.

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