HUMAN IMPACTS, WATER RESOURCES AND ECOSYSTEM MAINTENANCE IN THE OKAVANGO DELTA.

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ABSTRACT

The paper considers fresh water use in the Okavango Delta in two categories: abstractive and non-abstractive fresh water use. For each category the main uses and their issues are discussed and an assessment is made regarding the manner in which the Okavango Delta Management Plan (ODMP) addresses these issues. From the perspective of fresh water use and the ecosystem services required to support it, the paper critiques aspects of the ODMP. Human impacts relevant to water resource management are examined with particular attention to population growth and distribution, land transformation and human access. Water resources are examined from the perspectives of increasing household needs and other livelihood related needs vis-à-vis ecological needs in a protected area. It is argued that if the purpose of water resource management is to ensure long-term future fresh water availability as well as the maintenance of other important wetland ecosystem services that support people's livelihoods, then it needs to be incorporated into broader wetland ecosystem management objectives as contained in the ODMP. Integrated implementation of the plan is the major challenge for the Okavango Ramsar site.

KEY WORDS

human impacts, water resources, ecosystem services

Introduction

The Okavango Delta Management Plan (ODMP) is the major over-arching government initiative aimed at sustainable use of the Okavango Delta freshwater resources within the Ramsar Convention guidelines [1]. All aspects of water use are addressed in the plan but at varying levels. The major factors affecting water quality, including population distribution, land transformation, human access and pollution are also addressed, but again at varying levels. The paper discusses these issues based on a general analysis of the management plan [2] that is grounded in the experiences of the authors with the development of the plan over the past several years.

This work addresses fresh water use in two major categories: abstractive and non-abstractive fresh water use. For each category the main uses and their issues are discussed and an assessment is made regarding the manner in which the ODMP plans to address these issues within the context of its overall commitment to 'wise use' and integrated management of the Okavango Delta Ramsar site, which aims at sustainable use in a manner compatible with the maintenance of ecosystem properties [1,2]. From the perspective of fresh water use and the ecosystem services required to support it, this paper provides a critique of aspects of the ODMP.

Abstractive Fresh Water Use

Water abstraction in the upper Okavango basin in Namibia and Angola is currently of low environmental significance, but plans for large-scale water abstraction and irrigation as well as for hydro power in both countries [3] may, according to scenarios developed for the ODMP, have significant future impacts because the area that remains flooded throughout the year may be reduced by up to 40% in dry years [2]. This may also change flooding patterns and outflow at the distal end, affecting local ecosystem services (such as fishing) and reducing surface water available for abstraction, for example when the Thamalakane river in Maun dries up more frequently than in the past [4]. These international concerns are addressed through Botswana's participation in OKACOM, the permanent Okavango basin river water commission that is tasked with the development of an overall management plan for the basin using principles of equitable allocation, sustainable utilisation, sound environmental management and sharing of benefits [5].

In Botswana there is need for reliable supplies of domestic water to the larger villages around the Delta and above all for rapidly growing Maun. The groundwater aquifers in the Thamalakane and Kunyere faults are large but variably saline while changes of river flow patterns and flooding make recharge unpredictable. The hydrological model of the Okavango Delta indicates that whilst present surface and groundwater abstractions are minimally significant, the potential for upstream developments are likely to reduce permanently flooded areas and distal outflow and may thus affect groundwater recharge [2]. Climate change is indicated to worsen this

scenario significantly [4], particularly in the southern Delta where outflows will be affected.

The total quantity of water currently abstracted in the Delta is about 3.84 million cubic meters (MCM) per annum which represent a mere 0.04% of mean annual inflow. This is predicted to rise by 188% to 11.04 MCM per annum or 0.1% of mean annual inflow by 2020-25 [2]. Even when compared with the mean inflow in November, the month of lowest flow, this represents a barely significant 2.8% of that inflow. To sustain current per capita water availability, water abstraction levels need to increase at least in line with overall population growth. In Ngamiland during the recent decade this growth has been about 2.5% per year [6] and currently can be estimated to be approximately 2.2% per year, given that the birth rate is gradually declining while the death rate has increased somewhat due to HIV/AIDS related mortality. This rate implies a doubling of the overall population within 25 to 30 years. Assuming unchanged per person water consumption in the region, currently at about 78 liters per person per day for all uses [2], the water supply also requires doubling in the same period.

Table 1. Household access to water sources, Ngamiland 1991 and 2001.

Water Source	% Households Ngamiland	
	2001	1991
Piped water in house or yard	23	15
Communal pipe	54	37
River	9	17
Borehole	7	8
Other	7	23
Total	100	100

Source: CSO, 2002 [6].

Per person water consumption is, however, likely to increase as more households are provided with access to communal or individual standpipes, continuing the trend evident for the 1991-2001 period as shown in Table 1. Thus, in 2001 23% of households had access to piped water (in house or yard) against 15% in 1991 with an additional 54% (1991: 37%) of households with access to communal standpipes. This trend has since continued with more village water supply schemes coming on line. A related trend is that more and more young people leave the rural traditional sector for anticipated greener pastures in large villages and towns where water consumption tends to be higher as more households there have access to piped water. In addition, average household size is smaller in larger settlements, which tends to push up per person water consumption. For example in Maun the average household had 4.4 members in 2001 (having decreased from 5.5 in 1991) against 4.7 for the rest of the district [6]. Liu et al. [7] have shown that smaller households consume more resources per person because of their lower efficiency of resource use per capita compared to larger households where goods and services are shared by more people. More water may for example be used per person in smaller households for house cleaning as there is a larger per person floor space in smaller households. Thus, demand for water abstraction is growing on account not only of population growth but also due to increasing per capita water use that is related to improved access of households to piped water and generally declining household size.

Population distribution also plays a role in fresh water resource use when it is realised that the total number of settlements in Ngamiland increased from 474 in 1991 to 574 in 2001 [6]. Only 60 of these were classified as villages that qualify for government supplied water reticulation systems. The other 514 were classified as non-village settlements, providing a challenge to both regional water supplies and environmental conservation.

Fresh water abstraction also takes place for the purpose of livestock watering and for mining. In 2001, 11,447 out of 30,673 households (37%) in Ngamiland owned cattle, while 13,328 households owned goats (43%) [6] and the Okavango Ramsar site had at least 193,997 cattle and 98,975 goats [2]. During village meetings many communities specifically raised concerns about access to water for livestock watering in areas away from the river [8,9]. Rich farmers have constructed boreholes, but most small farmers rely on publicly accessible surface waters that are part of the Okavango wetlands in competition, sometimes, with local wildlife. This applies to a fairly large number of farmers even though the number of boreholes in the region increased from under 100 in the 1960s to over 1000 currently [10] with most of these used to water livestock. The effects on the Okavango ecology are mostly unknown, except for the problem of salinisation of shallow boreholes near river channels [11].

A further controversial aspect of livestock management concerns the many kilometers of veterinary fences that were built for livestock disease control. The fences have documented negative impacts on wildlife migrations [12], but also serve to reduce cattle incursions into the deeper Delta and thus act as a means of wetland protection. At the same time, however, they limit access of livestock to surface water, especially during the dry season.

With respect to mining, the Okavango has a history of water diversion engineering for the purpose of supplying water for mining activities as far away as Orapa in central Botswana [13]. Lack of reliable flow and resistance from communities resulted in the abandonment of most engineering schemes. Recently, there has been renewed interest in mining copper and diamonds in or near the Okavango Ramsar site. This raises the issue of how the usually substantial water requirements of the mining operations will be met. Although none of the mines has entered into production, no information is currently available about how expected water demands will be met.

The ODMP does not address the issue of population growth and declining household size. However, population distribution, i.e. where the people are settled, is addressed by incorporating the Ngamiland settlement policy into the ODMP. Not adequately addressed by either of these, however, is the problem of non village settlements, many of which are spontaneous and unplanned and therefore potentially detrimental to the integrity of nearby fresh water resources.

ODMP is quiet on the issue of water use for mining as mining is a fairly recent development, while in terms of livestock water use, ODMP plans to assess the feasibility of providing additional livestock watering points away from the Delta to reduce livestock wildlife interactions. Implementation of this initiative is highly dependent upon cooperation from the Department of Water Affairs and the Ministry of Agriculture.

Thus, although ODMP does address issues of water abstraction, there are some omissions that detract from a comprehensive water resource management approach. ODMP implementation, moreover, depends almost entirely on cooperation with national and district authorities such as the Ministry of Agriculture (for livestock issues) and the Department of Water Affairs (for surface and groundwater abstraction) [9]. As these authorities do not have specific environmental conservation mandates, the incorporation into ODMP of environmental considerations is a major challenge to the Department of Environmental Affairs as ODMP implementer given that it has limited authority over departments in other ministries.

Non Abstractive Fresh Water Use

Historically, the people of the region have depended on the Okavango river water for much more than drinking and cooking purposes [14]. The livelihoods of many families even today are dependent on water-associated activities such as fishing, floodplain cultivation, watering livestock and wetland based tourism. Kgomotso and Swatuk [9] analysed data from 43 village meetings (kgotla) held between January and May 2005 as part of the ODMP planning process. Stakeholders at the 'kgotla' meetings were overwhelmingly concerned with channel blockages and the flow regime of the Delta's waters. In 22 villages, communities complained that rapidly growing vegetation such salvinia molesta (an aquatic alien species also called water hyacinth) and reeds blocks their access to the river so they cannot use their boats [8]. They struggle to reach their fishing grounds and harvesting areas for thatching grass. For the people of Ngamiland, therefore, water is part of a livelihood system [15] that requires a holistic management framework sensitive to these needs. Institutions that control the use and management of these resources have however often failed to ensure security of access to the required resources [9].

Fishing

Fishing is a prevalent and important fresh water dependent livelihood activity practiced by people in the Delta. To sustain healthy fish populations, healthy ecosystems are a prerequisite. Access to natural waters is crucial for all fishing activities. Thus it is understandable why concerns related to fishing arose in most 'kgotla' meetings. They centred on lack of regulations to control fishing and lack of access to traditional fishing grounds. Declining fish stocks and increased competition and conflict between commercial, recreational and artisanal fishers were also common problems [8]. Although only 0.6% of the working age population of Ngamiland is employed in fishing according to the 2001 population census [6], this underestimates the contribution of fishing to people's livelihoods because subsistence fishing is largely ignored in such statistics. A 1998 comprehensive survey revealed that there were 3289 fishers in the Okavango Delta. 41 commercial gill net fishers were identified while the rest fished at subsistence level [16].

While subsistence fishing is characterized by supposedly environmentally friendly traditional fishing gear (spears, traps, baskets), commercial fishery is characterized by the use of modern, more environmentally aggressive gear such as power boats, gill-nets and refrigeration facilities. Surprisingly, even subsistence fishing can have direct negative effects on water quality. For example, one of the authors observed in March 2008 during a boattrip on the Boro river that fishers employed discarded torch batteries as weights for their nets as stones are hard to get in the Delta. The batteries are pierced by a nail which is then used to fasten them to the nets. This obviously allows for the battery chemicals to be released into the water. Oil spills from boat engines are another cause of concern.

Through ODMP regulations for fishing are to be revamped, while fish stock assessments will be carried out. Given cooperation by the relevant authority this may result in appropriate fish stock monitoring. However, in terms of water quality the use of boats (oil spillage) and batteries as fish net weights remain issues of concern that are not addressed directly by ODMP.

Flood Recession Farming

Flood recession farming is another livelihood activity that depends on natural (flood) waters. Although only 14.5% of the economically active population of Ngamiland is employed in agriculture [6] according to census data, field data collected by Kgathi et al. [15] show that arable agriculture is the most important livelihood activity for over 23% of households in rural areas of the Okavango Ramsar site. There are two distinct arable farming practices: flood recession farming (known locally as 'molapo') and dryland farming. The latter is entirely dependent on rainfall while molapo farming is carried out along river channels and floodplains and is dependent on seasonal flood waters (and rainfall). Crop yields are

higher in the molapo system because of moisture availability due to periodic flooding.

Just under 300 molapo fields were identified at a total of 588 hectares during mapping work carried out by the University of Botswana in preparation for the ODMP. During the recession of the floods the fields gradually dry up and strips parallel to the remaining water can be successively planted as the water recedes. Flood-recession farming takes place on small fields (averaging less than 2 hectares) separated by strips of 'natural' floodplain. So, extensive land-clearing does not usually occur, although locally some removal of riparian vegetation may take place. Other than that there is no clear evidence of large-scale negative environmental impacts on the wetlands, especially because most fields are cultivated at low input levels (e.g. fertilizers are rarely used) as evident from fairly low yields of 200 – 500 kg maize or sorghum per hectare. Molapo farming is thus generally not very water quality unfriendly but could become so through increased use of fertiliser and pesticides.

There are no particular ODMP measures to address these issues. This is partly because molapo farming is a neglected activity as people 'owning' molapo fields do not have modern use rights but rely on traditional rights that are not recognised as adequate for most government subsidies. This is a mixed blessing: as people have low security of ownership they tend to invest less (so use less fertiliser) but they also look after their land less with the long term in mind. So, even though molapo farming is an important livelihood activity and has potential water quality implications, it is not addressed in ODMP.

Dry-land farming is more suited to large scale mechanised farming . The extent of land cleared for dry-land crops is impressive around the western and southern margins of the Delta and on the Namibia side of the Okavango where little land remains in its natural condition [15]. This includes a small number of large irrigation schemes, clearly visible on satellite imagery, that require substantial water abstraction. In terms of water quality, however, an MSc study aimed at analysing effects on selected water quality parameters along the Namibia border concluded that measurable effects were currently minimal [17].

Wildlife Based Tourism

Wildlife based tourism is a major industry in the Okavango [15]. It is dependent upon natural fresh water areas where wildlife have access to water and the vegetation that grows along it. Change in this aspect of the ecosystem's services would affect tourism and the employment related to it. With about 100 000 tourists visiting the Okavango per year [2] direct water demands for tourism are becoming significant while indirect effects on wetland ecology relate to the mushrooming tourism infrastructure (camps, airstrips, game-viewing tracks) and increased waste disposal, particularly because tourism operates in sensitive portions of the Delta wetlands [10].

As most tourism in the region is wildlife based, the water needs of wildlife are an important factor in water resource management. Wildlife mostly uses available surface waters sometimes in competition with people or livestock. In some cases boreholes supply wildlife watering points. The major issues surrounding wildlife water use concern human-wildlife (elephant) conflicts and accessibility especially where wildlife migration routes become blocked by settlement sprawl or veterinary fences [10].

Until the start of the ODMP there was minimal research on tourism carrying capacities and impacts caused by tourism activities in the Delta were not precisely known. Little also was done to monitor tourism activities despite suspicions that illegal consumptive use of resources and unacceptable waste management practices might be taking place. This is partly due to lack of capacity within the relevant government departments to carry out regular inspections to ensure that operators comply with regulations and provisions of their lease agreements as laid down in agreed management plans [2]. It is a major weakness that these plans are not incorporated into ODMP, apparently because of their confidential status. Nevertheless, very positive suggestions are included in ODMP [2] to regulate and monitor tourism carrying capacity and related environmental impacts.

In the Okavango tourism can be regarded as an engine of conservation as most tourism is wildlife/ecotourism based and healthy ecosystems are needed to sustain this. Proclamation of protected areas and wildlife management areas designated for tourism are important mechanisms to achieve this. ODMP attempted to assess the overall status of protected areas, currently consisting of Moremi Game Reserve (4 888 km2) and a surrounding buffer of Wildlife Management areas (8 465 km^2), through development of a new land-use plan [2]. The suggestions emanating from this ODMP component were somewhat disappointing from the conservation perspective, because no protective measures were proposed for several ecologically important and potentially vulnerable portions of the Delta. This applies to the Panhandle area where water enters Botswana and to the area known as NG24 which is at the apex of the Delta where water is distributed to the actual Delta. Even though it appears crucial to apply some form of protection to this area, there is currently no approved management plan for NG24.

Many of the above mentioned livelihood activities depend on water availability and in some cases on particular ecosystem services provided by the natural environment. Many of these activities are interconnected and problems can therefore not be solved in sectoral fashion but require integrated management. Molapo farming, for example, is an activity that would suffer from change in the flooding patterns of the Delta system as has been experienced by farmers in the Shorobe area, north of Maun [8]. The integrated approach to implementation remains, however, the weak link of the ODMP.

For example, while land is usually allocated by the local Land Board, this does not apply to molapo land, which is allocated along traditional rules, while the Ministry of Agriculture is responsible for advising farmers on cultivation. Coordination between these actors is limited. The Land Board is also responsible for the implementation of the land-use plan incorporated into ODMP, although it lacks capacity to do this (Mr Mosojane, personal communication) as the Board is mostly structured to deal with land-parcel allocations.

Coordination is also problematic with respect to tourism. While lodges and camps are governed by a Land Board administered land lease (guided by an approved management plan), tourism operator licenses are managed by the tourism department. The Department of Environmental Affairs as ODMP implementer is tasked with coordination but has no real authority to do so.

Human Impacts

As shown, fresh water ecosystems can be negatively impacted by various human impacts. The combined effects of these can be visualised by mapping the 'human footprint' as a quantitative measure for the level of human influence on the land surface. This has been attempted by the global 'human footprint' project, a world-scale effort to map the level of human disturbance [18]. The human footprint was recalculated for the Okavango Ramsar site by Vanderpost [19], using methodology similar to that used for the global human footprint, but applying locally available data.

Measurement of the human footprint involves the allocation of scores to land areas on the basis of population density, land transformation characteristics, human accessibility and power infrastructure [18]. This was adapted to local conditions for example by including cattle-grazing and borehole construction as additional elements of land transformation [19], while non village settlements were also included in the analysis. Buffering and overlay techniques were used to allocate scores to land units and so create a map with scores for individual land units varying between 0 (minimal impact) and 46 (maximum impact out of a possible 100 globally).

The result of the mapping work as presented by Vanderpost [19] shows a 'light' human footprint for the Moremi Game Reserve and its buffer zone because few people live there permanently, although there are many activities, including tourism, hunting and fishing that impact on the natural waters of the area. A substantial population is resident just outside the Moremi buffer zone with the human footprint particularly strong along the western and southern margins of the Okavango wetlands [19]. These are the areas most in need of constructive management interventions. Highest footprint values are in and around Maun where over 40 per cent of the total district population is concentrated [6] as well as most recent increases in water demand.

When considering the issues contained in the human footprint map it is questionable whether the ODMP addresses adequately all the relevant components of population density/distribution (particularly the issue of unplanned settlements), land-transformation (particularly the assignment of protection measures for ecologically important portions of the Delta) and human access.

Issues of human access, for example, that include off-road driving, washing of vehicles in the river, oil waste from houseboats and motor boats [2] are only addressed indirectly in the ODMP. Road construction relies on planning by the relevant sector authority and compulsory environmental impact assessment, which has proven very difficult to monitor. Boat regulations and rules against off-road driving, but enforcement is problematic.

Nevertheless, ODMP contains sophisticated suggestions for water quality monitoring and for development of waste management strategies. As with many other issues implementation is the responsibility of the relevant sector authority, while ODMP (i.e. the Department of Environmental Affairs) has limited authority to impose implementation.

Discussion and Conclusion

In the Okavango Ramsar site water resource management takes place in a protected area. This implies that ecosystem services required for the maintenance of the wetland ecology of the protected area need to be given adequate attention. This has implications for both the quantity of water abstraction and the resulting minimum environmental flows that can support such services as well as for the quality of water that is needed to maintain the ecological health of the system.

The challenge for the ODMP is to adequately address the conservation-development interface that has emerged as quintessential for conservation and rural development in remote African regions [20]. Conservation has become a balancing act between ecological management and improvement of local people's livelihoods [21]. Unless conflicts between these objectives are resolved, long-term prospects for both may be compromised.

The multiple use demands for Okavango water are not limited to ecological versus developmental needs, but there are also various conflicting human use requirements. If water management is to ensure long-term future fresh water availability as well as the maintenance of other wetland ecosystem services, then water resource management of necessity needs to incorporate elements of wetland ecosystem management. While the ODMP provides a framework that allows this, the practical implications of managing conflicting water uses are quite

phenomenal. The challenge is to effectively integrate decisions of stakeholders and responsible regional government institutions given that each has its own limited sectoral mandate, while most departments respond to policy formulated at central state level with little scope for directly addressing local issues [9].

The ODMP is a comprehensive document that contains many initiatives, plans and ideas to address virtually all of the important water related issues. Given the history of its development (with which the authors are quite familiar) it is a remarkable compromise achievement. Nevertheless, ODMP has several omissions. These include the problem of non village settlements which are relevant with respect to both water supply management and potential human impacts on wetland ecosystems. Another omission relevant to the maintenance of fresh water ecosystem services is the lack of protective measures for ecologically crucial portions of the Ramsar wetlands.

More important than these omissions, however, is concern over ODMP implementation as it depends on actions by various ministries with the Department of Environmental Affairs (DEA) in a coordinating role. The individual departments are used to operate independently and are not accustomed to integration with other departments in other ministries. The DEA has no real authority other than using environmental impact assessment regulations. Implementation, thus, depends greatly on integrated cooperation by a multitude of stakeholders without a strong-armed implementation agency and is therefore the ultimate challenge for ODMP. It does not help DEA's case that up to now the ODMP has not yet been officially approved by government and is still in draft form.

References:

[1] Ramsar convention 2008. The New Guidelines for management planning for Ramsar sites. http://www.ramsar.org/key_guide_mgt_new_e.htm accessed 17 June 2008.

[2] Dept. of Environmental Affairs. 2008. Okavango Delta Management Plan. Dept. of Environmental Affairs, Gaborone, Botswana. xxiv, 190 p.

[3] Kgathi, D.L., Kniveton, D., Ringrose, S., Turton, A., Vanderpost, C.H.M., Lundqvist, J., Seely, M., The Okavango : a river supporting its people, environment and economic development. *Journal of Hydrology*, 331, 2006, 3-17.

[4] Wolski, P. and Murray-Hudson, M., Flooding dynamics in a large low-gradient alluvial fan, the Okavango Delta from analysis and interpretation of 30-year hydrometric record. *Hydrology and Earth System Sciences*, 10, 2006, 127-137.

[5] OKACOM website: www.okacom.org, accessed 17 June 2008.

[6] CSO (Central Statistics Office), 2002, 2001 Population and Housing Census: Population of Towns, Villages and Associated Localities (Gaborone: CSO).

[7] Liu, J., Daily, G. C., Ehrlich, P. R., & Luck, G. W., Effects of household dynamics on resource consumption and biodiversity. *Nature*, 421, 2003, 530–533.

[8] Bendsen, H., 2005. Results and Analysis of the Feedback Community Consultation Process on the ODMP. Harry Oppenheimer Okavango Research Centre, Maun.

[9] Kgomotso, P.K. and Swatuk, L. A. , Access to water and related resources in Ngamiland, Botswana: Toward a more critical perspective and sustainable approach. *Physics and Chemistry of the Earth*, 31, 2006, 659–668.

[10] Vanderpost, C., Human sprawl and the African wilderness of the Okavango. *South African Geographical Journal, 86,* 2, 2004, 65 – 73.

[11] Ringrose,S., Vanderpost,C., Matheson, W.,Wolski,P.,Huntsman-Mapila,P., Murray-Hudson,M. and Jellema,A., Indicators of desiccation driven change in the distal Okavango Delta, Botswana. *Journal of Arid Environments, 68*, 1, 2007, 88-112.

[12] Scott-Wilson, S. 2000, Environmental assessment of veterinary fences in Ngamliand. Summary Report. Prepared for the Department of Animal Health & Production, Government of Botsana, Gaborone.

[13] Potten, D.H., 1975: Aspects of the recent history of Ngamiland, Investigation of the Okavango as a primary water resource for Botswana. Technical Note No 5, FAO, UNDP, Govt of Botswana, Bot/71/506.

[14] Campbell, A. C. 1976. Traditional Utilisation of the Okavango Delta. Pp 163 – 174 in: Symposium on the Okavango Delta and its Future Utilisation. The Botswana Society, Gaborone

[15] Kgathi, D., L., Ngwenya, B., N. and Wilk, J., Shocks and rural livelihoods in the Okavango Delta, Botswana. *Development Southern Africa, 24,*2, 2007, 289 - 308.

[16] Mosepele, K (2001). *Description of the Okavango delta fishery*. Fisheries Section, Ministry of Agriculture, Gaborone, Botswana. 132 p.

[17] Andersson, J. 2005. Land cover change in the Okavango river basin - Historical changes during the Angolan civil war, contributing causes and effects on water quality. MSc thesis Linköping University, Sweden. http://jafetandersson.com/publications/

[18] Sanderson, E.W., Jaiteh, M., Levy, M.A., Redford, K.H., Wannebo, A.V. and Woolmer, G., The human footprint and the last of the wild. *BioScience, 52,*10, 2002, 891–904.

[19] VanderPost, C., Protected areas in Ngamiland, Botswana: investigating options for conservation-development through human footprint mapping. *International Journal of Environmental Studies 64*, 5, 2007, 555-570.

[20] Western, D., Conservation science in Africa and the role of international collaboration. *Conservation Biology, 17*, 1, 2003, 11–19.

[21] Barrow, E., & Fabricius, C., Do rural people really benefit from protected areas – rhetoric or reality? *Parks, 1,* 2, 2002, 67–79.