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BALANCING ECOLOGY AND ECONOMICS IN THE MULTIPLE USE OF WETLANDS ON COMMUNAL LANDS

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ABSTRACT

Major floodplain wetland systems are important centres of production in communal lands throughout southern and eastern Africa. These systems provide numerous goods and services essential to household livelihoods, such as food plants, building materials and fish, and productive areas for growing corps, as well as grazing for livestock in transhumance systems between the wetlands and surrounding savannas. Whilst the multiple use of these areas is important for livelihood security, with increasing population density, these uses begin to impact on one another and on the biodiversity conservation value of the wetlands, through disruption of ecological functioning. This study investigates the relative value of different wetland goods and services used in rural household production, the interactions between different production systems, and their sustainability. The current use patterns which have evolved under conditions of weak tenure and management, population growth and poverty, threaten to erode the value of these wetlands in future. Various policy options exist for improving the future management and value of the wetlands, including those which enable wise use practices, reducing excessive reliance on livestock, delimiting protected areas, and commercial agricultural development. The ecological and economic implications of such policies are discussed.

INTRODUCTION

Floodplain wetland systems occupy significant parts of the rural landscape in tropical and subtropical southern and eastern Africa, and are integral to the livelihoods of large numbers of people. Yet comparatively little quantitative research, whether ecological or socio-economic, has been carried out on these systems, and the values of these wetlands, though recognised, have not been well quantified or articulated in the past. There is now growing concern that Africaȏs major wetland systems are under severe pressure and undergoing widespread deterioration. Threats to these wetlands are many and varied, and include changed water flow regimes, conversion, pollution and overexploitation. Although the implication of such degradation of wetlands for biodiversity and peoples livelihoods may be recognised qualitatively, there is still greater pressure to reclaim or degrade wetlands than to conserve them (Barbier *et al.* 1997, Turpie *et al.* 1999). Recognising these pressures, there has been increasing interest among international conservation agencies in improving our understanding of the systems in terms of their ecological and socio-economic role and value, and the processes that threaten their integrity, in order to develop sound management strategies and policies.

The aims of this study are:

(1) to articulate current understanding on the use value of large, natural wetland systems in eastern and southern Africa to their local rural populations,
(2) to analyse the main threats to the integrity of these systems, distinguishing between proximate and ultimate causes of wetland degradation; and
(3) based on the above, to identify ways in which an optimal balance between maintenance of ecological functioning and enhancement of economic use value might be achieved.

This paper draws upon recent studies of several large floodplain-wetland systems in eastern and southern Africa: the Barotse Floodplain, Zambia, the eastern Caprivi wetlands and Lake Liambezi system, Namibia, the lower Shire wetlands, Malawi, the Zambezi delta, Mozambique, and the Rufiji floodplain and delta system, Tanzania. Natural resource use was studied in the context of rural livelihoods in each of these systems using a combination of social survey methods: household surveys, focus group discussions, key informant interviews, as well as other data collection techniques such as resource mapping, GIS mapping and direct observation. The methods and the results of these studies are described in more detail in Turpie *et al.* (1999), Turpie (2000) and Turpie & Egoh (2003), and key results are summarised in this paper.

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THE USE VALUE OF WETLANDS IN COMMUNAL LANDS

Definition of wetland values

The economic value of natural resources is typically categorised within the concept of ñtotal economic valueò into direct use value, indirect use value, option or future-use value, and existence (non-use) value (Pearce & Turner, 1990; Barbier, 1992). Direct use value can involve either consumptive use, such as through harvesting resources, or non-consumptive use, such as photographic tourism. Indirect use value is the contribution that ecosystem functions make towards other economic activity, for example, the contribution a wetland makes to the purification of water. Option value is the value of retaining a natural resource in case it yields value in future, and, for example, is one of the values of conserving genetic diversity. Existence value is a measure of the pleasure derived from simply knowing that a resource exists, a hypothetical example being expenditure by Europeans towards ósavingô shoebills in Uganda.

Direct use values are directly realisable as incomes, and in the context of this paper they represent the pressure to utilise wetland resources by people and society. Indirect, option and non-use values do not generally generate income at a local level, or only do this indirectly, and in the context of this paper they represent the ecological integrity of wetlands. The latter values are measurable in terms of their contribution to national economies and to societal wellbeing, but these values are not quantified here. The contribution of different types of value to total economic value of wetlands varies depending on the socio-economic context, and their relative magnitude would be expected to be different in wetlands of less-developed Africa from those in wetlands of more-developed North America. When it comes to large wetland systems in Africa, the most apparent value of wetlands is their direct consumptive use value. In poor societies, struggling to meet their basic needs, high priority will be put on these values which can generate income and employment.

The direct use value of wetlands depends to some extent on which ecosystem goods and services are used by how many people and in what way. Wetland ecosystems provide numerous goods and services that are utilised by their surrounding populations, the goods being the stocks of resources that can be used, and the services being the ecological functions that provide inputs into economic activity (Barbier *et al.* 1997). On communal lands in eastern and southern Africa, household economies are characterised by multiple use systems, in which many different resources are harvested from surrounding environments, soils are tilled for agricultural purposes, and lands are grazed in livestock-keeping activities. Having multiple sources of income is a risk-spreading strategy (Ashley & LaFranchi 1997), which is essential in areas where income from one source may be lost in some years due to drought, floods or disease. This insurance aspect is not captured in the values generated by current use, as described below, but should be borne in mind.

Crops and livestock

A comparative analysis of the use of resources by rural communities in different wetland areas across the region is provided by Turpie *et al.* (in prep), and summarised in Table 1. In all of the wetlands studied, the majority of households consider agriculture to be their primary activity, with almost all households having fields. Maize and rice are dominant crops, but households grow a wide range of crops and fruits, both for subsistence and where markets exist, for cash. The extent of land used for crop production is not large and is often concentrated in particularly productive sites, or near to homesteads. However, crop production has a high impact, involving, as it does, complete conversion of the natural vegetation.

Livestock are generally regarded as second in importance in the household economy (Turpie *et al.* in prep), with much more variability in numbers of households that have them, and the numbers kept. Livestock were largely absent from the Rufiji floodplain and both the Rufiji and Zambezi deltas, but are prevalent in the remaining systems. They are especially important in Barotseland and Caprivi, where 81 ï 87% of households keep cattle, and some 39% of households keep cattle in the Lower Shire area. In the latter case this might have something to do with the fact that the wetland area is confined in steep sided valley with limited access to upland areas. In all these systems there is some degree of transhumance, with cattle being moved between wetlands and uplands on a seasonal basis. Some cattle owners have houses on the floodplain and uplands, and in other cases there is co-operation between relatives and friends, so that in over a third of cases the wetland households keeping cattle for part of the year are not their owners (Turpie *et al.* 1999). Cattle are usually not moved more than 15 km from the wetland, but they may be moved up to 50km. Cattle are grazed on the floodplains after floodwaters have subsided and are moved to upland grazing areas when water levels begin to rise again. In Barotseland they generally spend July to January in the floodplain (Jeanes & Baars 1991), but this varies depending on the height of the previous seasonõs floods and between wetlands, depending on the timing of floods. Floodplain wetlands make a major contribution to regional grazing carrying capacities, with wetland carrying capacities, or theoretically optimal stocking rates (about 6 ha per LSU) being more than double that of upland areas (Jeanes & Baars 1991).

In the systems where cattle are kept, actual stocking densities are very high, and despite belonging to a smaller proportion of households, cattle densities in the Barotse and lower Shire wetlands are even higher (79 and 65 cattle per km^2 wetland) than in the eastern Caprivi wetlands ($39/km^2$). This translates more or less to 1.2, 1.5 and 2.56 ha per large stock unit (LSU) for the wetland areas, but the floodplain stocking rates are effectively half this, about 2.4, 3 and 5.2 ha per LSU, respectively, when the seasonal movements are taken into account. This is generally considerably higher than the long term ñeconomicò carrying capacity of these wetlands, at which animal production would be maximised. Livestock densities are thus closer to the maximal, ñecologicalò carrying capacity of the habitat, where production is driven down towards zero. In terms of income generation and habitat health, the grazing pressure can be described as excessive.

Crops and cattle production benefit one another to some extent, with cattle providing draft power and manure for croplands and crops providing fodder (stovers) for cattle. However, there is no relationship between the proportion of floodplain area under crops and the density of cattle (Turpie *et al.* in prep). Indeed, cropping takes place without cattle in the Rufiji floodplain and the delta areas, as well as in the Zambezi delta, with no apparent impact on household welfare. While the crop-livestock interaction may be important in some areas, competition for space might be a more important issue in others.

Harvested wetland resources

In addition to crops and cattle, a number of resources are harvested directly from the wetlands. Fishing is by far the most important natural resource harvesting activity in terms of its value, and about 50-80% of households are engaged in fishing, with the exception of the Lake Liambezi area due to most of the lake area having been dry for a long period (Table 1). As with all other household production, fishing is usually a part time activity, carried out as a secondary activity to cropping. A range of traditional and modern methods is used in all the study areas, with modern methods, especially gillnetting, becoming increasingly prevalent and more popular with the younger generations. Commercialisation is increasing, as is the tendency for outsiders fishing in wetland areas. The floodplain fisheries are dominated by bream and catfish, while prawns and estuarine fish species are important components of the delta fisheries. In all cases, the fisheries are heavily reliant on the functioning of the wetlands and their catchment flows, with catches being positively correlated with flood levels (Van Gils 1988, Gammelsrod 1996).

Table 1. Percentage of households harvesting selected wetland resources in seven different wetland areas in eastern and southern Africa (from Turpie *et al.* in prep).

<table>
<tr><th></th><th>Barotseland (Zambezi)</th><th>Caprivi-Zambezi</th><th>Caprivi Liambezi</th><th>Lower Shire</th><th>Zambezi delta</th><th>Rufiji floodplain</th><th>Rufiji delta</th></tr>
<tr><td>Crops</td><td>100</td><td>98</td><td>99</td><td>97</td><td>99</td><td>100</td><td>91</td></tr>
<tr><td>Livestock</td><td>81</td><td>87</td><td>81</td><td>39</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>Fish</td><td>54</td><td>75</td><td>15</td><td>53</td><td>78</td><td>56</td><td>61</td></tr>
<tr><td>Hunting</td><td>6</td><td>22</td><td>86</td><td>18</td><td>10</td><td>6</td><td>2</td></tr>
<tr><td>Grass</td><td>86</td><td>77</td><td>97</td><td>62</td><td>81@</td><td>26</td><td>2</td></tr>
<tr><td>Reeds</td><td>84</td><td rowspan="2">90*</td><td>56</td><td rowspan="2">66*</td><td rowspan="2">86*</td><td>15</td><td>7</td></tr>
<tr><td>Sedges</td><td>93</td><td>10</td><td>4</td><td>-</td></tr>
<tr><td>Ilala palm leaves</td><td>?</td><td>62</td><td>92</td><td>?</td><td rowspan="2">61#</td><td>93</td><td>37</td></tr>
<tr><td>Wild date palm</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>54</td></tr>
<tr><td>Mangroves</td><td>-</td><td>-</td><td>-</td><td>-</td><td>77</td><td>-</td><td>41</td></tr>
</table>

*reeds and sedges not distinguished in the survey
types of palm leaves not distinguished in the survey
@ higher proportion further inland than at the coast (93, 63)

Most studies suggest that a relatively small proportion of households (about 2 to 22%) are involved in hunting, with hunting households performing a specialist role and supplying meat to the rest of the community. This may well be the case in terms of specialist hunters, in terms of the time spent hunting and equipment used. However, a more recent study in the Caprivi-Liambezi area, using slightly more sophisticated methodology, suggests that hunting is much more widespread in rural communities. Some of the difference between proportion of households hunting in this area (86%) and in other areas may be real, however, since the vast open landscapes support high densities of small prey such as springhare, which dominate catches and do not require much specialisation. In other areas, such as Rufiji, hunters tend to bag larger antelope and other species that require more specialist skill.

There is much variability in the use of plant resources between wetlands, but in general they are more widely collected by a majority of households (Table 1). Reeds and sedges are important for a number of uses. Reeds *Phragmites* sp. are a fundamental element of building construction, and are used for fences, toilet walls, ceilings and floor mats, and also for the construction of fishing traps, spear handles and fishing rods. Where available, sedges, especially papyrus *Cyperus papyrus,* are used for making sleeping mats, and sometimes also for ceilings and coffins. Grass is used for thatching, and for constructing fences when reeds are in short supply or at some distance away (Turpie & Egoh 2003). It is also used for making brooms, tying in construction, and occasionally for fuel. Ilala palm leaves are used for making baskets such as winnowing baskets, ropes, tying in construction and in rice-growing areas, for making drying mats. Wild date palms occur more commonly in the delta areas, and the leaves are considered superior especially since they can be dyed using natural or commercial dyes. The dried leaves (ñ*ukindu*ò), are used for making sleeping ôbagsô in areas where papyrus is in short supply (Rufiji) as well as decorative floor mats and many other crafts. Food and medicinal plants are also harvested from wetland areas, with water lilies being the most important wetland food plant. Most other wild foods (mainly fruits) and most medicines used by floodplain households come from surrounding woodlands. In Barotseland, parts of the wetlands are so far from woodlands that aquatic plants are dried and used for fuel. At the coast, in the deltas of the Zambezi and Rufiji rivers, mangroves are an important resource providing fuelwood and building materials, and an important source of income.

The direct use values of African floodplain and delta wetlands

The total direct use value of the wetlands under study, i.e. income accruing to local households, including from agricultural and grazing uses, ranged from $3 million per year for the eastern Caprivi wetlands to $37.6 million for the Zambezi delta (Turpie *et al.* in prep). Values per ha ranged from $17 to $37 per year for all wetlands except the lower Shire wetlands, which had a value of $188 per ha per year. The relatively high value per unit area of the lower Shire wetlands is thought to be a function of the high population density in the area (Turpie *et al.* 1999). The different use values of the different wetlands are not necessarily all sustainable (see below), in which case they would be overestimates. On the other hand, some of these values may not reflect the full potential value of each wetland. Nevertheless, it stands to reason that direct use values of wetlands are related to the numbers of users, especially when the household livelihoods and requirements are so similar between the different systems (Turpie *et al.* 1999).

It is important to place these values in context. Households in the vicinity of major wetland systems derive their income and livelihoods from a number of activities and sources, including from use of upland areas and non-natural resource related sources. Some cash income is obtained from pensions and family members with jobs elsewhere, but crops, livestock and fishing provide the majority of household income. This includes the market value of all production that is consumed in the household (= subsistence value), and the market value of livestock production, whether used in payment, sold, retained, or consumed. Wetland plant resources (mainly reeds, papyrus, grass and palms) usually provide a smaller income. However, the market value of these resources does not reflect their immense utility in meeting household requirements. Crops typically contribute about a quarter of household income (Figure 1, Turpie *et al.* 1999), and income from sources such as jobs and pensions also provide a substantial portion. The way in which other resources contribute to income is highly variable. Two examples are given in Figure 1. In a cattle keeping area such as around Lake Liambezi, livestock productivity accounts for a large proportion of income, but in Rufiji, where cattle are absent, it is relatively minor. Fishing is currently unimportant in the Liambezi area, because the Lake is only just starting to refill after many years of being dry. Here, wetland plants, particularly grass from the extensive floodplain, make an important contribution to income (Turpie & Egoh 2003). In Rufiji, fishing far outweighs the contribution by wetland plants (Figure 1).

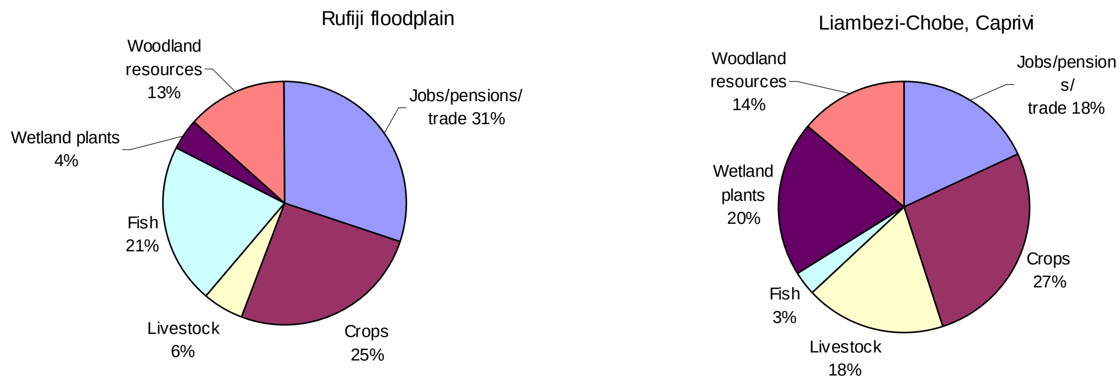

Figure 1. Percentage contribution of different sources of income to overall household income on the Rufiji floodplain (livestock = goats and chickens) and next to Lake Liambezi, Caprivi (livestock = cattle).

THE CAUSES OF WETLAND DEGRADATION

The supply of goods and services that contribute the direct economic use values described above is dependent on the healthy functioning of wetland ecosystems, and the way in which goods and services are utilised. Loss of these functions causes loss of the direct use values to local communities, but also the indirect values and non-use values associated with the wetlands that benefit society beyond the wetlands. For example, the non-use values attributable to the biodiversity of the wetlands, and the indirect use values associated with their flood amelioration capacity and fish nursery functions may lost if the wetlands are degraded. Many of these large wetland areas are considered to be degraded, and the processes that undermine wetland ecological integrity are probably intensifying. This has important implications, not only for wetland biodiversity and functioning, but for the populations dependent on them and for society as a whole.

It is important to understand the nature of threats to ecological-economic systems if there is to be any intervention to restore or maintain balance. It is also important to make the distinction between proximate and ultimate threats to wetland systems. More often than not, proximate threats to wetlands (those factors that directly affect biodiversity) may have multiple causes, and a chain of causation can be traced back before ultimate causation is pinpointed. Conservation biologists and managers tend to concentrate on finding solutions to the proximate causes of biodiversity loss. For example, in terrestrial landscapes, fragmentation of habitats is an important cause of biodiversity loss, and conservation planners seek to mitigate this effect by improving connectivity between fragments or using other means to increase gene flow between isolated populations. Fragmentation is caused by habitat transformation, which might, for example, be caused by agricultural policies which promote clearing of virgin forest for beef production. The agricultural policies, in turn, might be due to a distorted political view of the relative value of agricultural resources and biodiversity. Thus, causal chains leading to the proximate causes of biodiversity loss can be identified. It is not only important to recognise these links, but to identify the point in the chain at which intervention might be most effective. This might differ when dealing with different time scales.

A simplified causal chain to illustrate the process of wetland degradation in tropical African floodplain and delta systems is given in Figure 2. Some of the causes involve actions of the users themselves (e.g. overexploitation), and others are due to actions beyond the wetland areas.

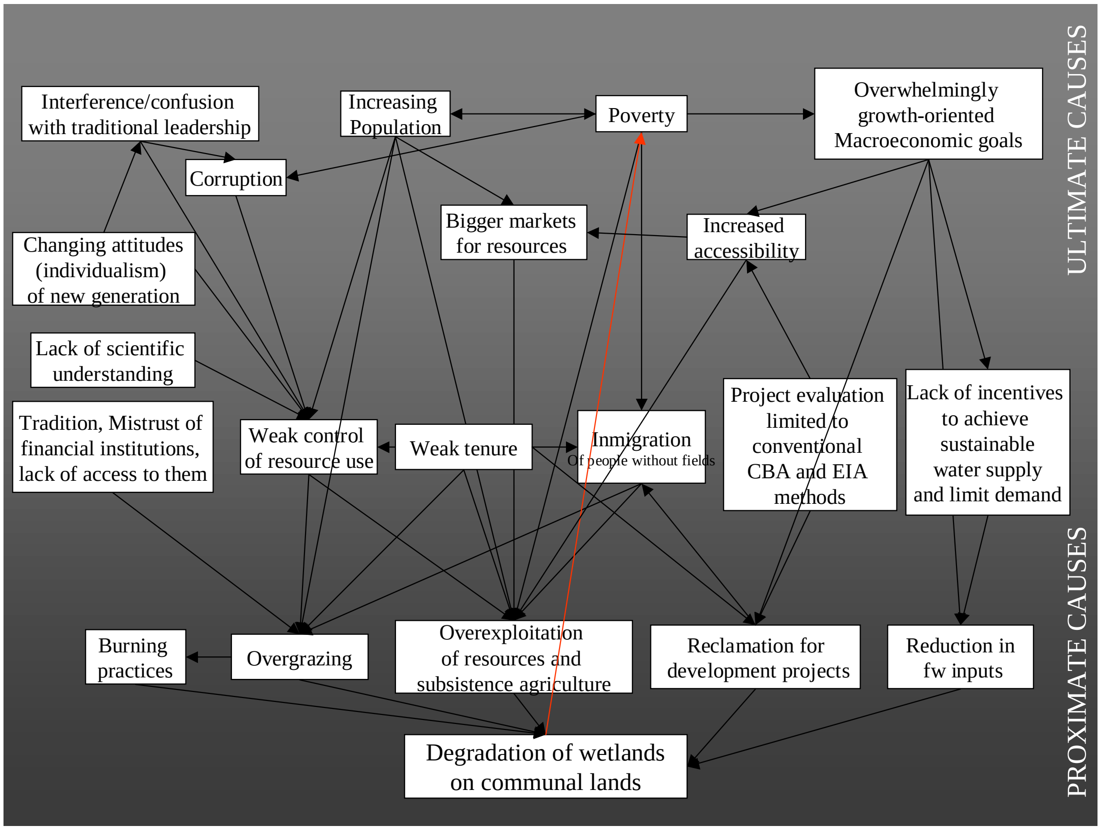

Figure 2. A causal chain describing some of the proximate and ultimate causes of degradation of wetlands on communal lands in eastern and southern Africa. Fw inputs = instream flows.

The most important proximate causes of wetland degradation include:

- Excessive grazing;
- Burning;
- Ploughing for agriculture;
- Overexploitation of natural resources (e.g. fish, plants);
- Reclamation; and
- Reduction in freshwater flows (Figure 2).

Each of these occurs because of a combination of causal factors acting synergistically or antagonistically. An analysis of the above-illustrated threats to wetland integrity reveals that many threats have their basis in economic incentives and disincentives. This is evident when one identifies the ultimate causes behind the proximate threats to wetlands.

Local-level causes

The first four proximate causes are direct actions of user populations. Most of the causes of excessive grazing, excessive ploughing and overharvesting of resources are the same or related, and damage caused by burning of wetland areas is a direct result of high demands for grazing. These problems are most often related to the weak control of resource use at a local level, coupled with increasing populations. Weak control of resource use may occur due to a lack of scientific understanding of how to manage resources to yield optimal, sustainable returns. However, while scientific research is often lacking in these areas, and monitoring statistics are often not readily available or interpreted, local knowledge has probably filled this gap in the past. But while indigenous knowledge systems might have been reliable in the past, there are indications that these have been undermined by factors such as lack of participation by new generations. Once wetlands are degraded, indigenous knowledge systems may no longer have the tools required to rectify the situation. Furthermore, traditional management systems have probably not had to cope with the levels of demand for resources, relative to availability, that occur today. For example, within the traditional societies occupying the wetland areas, there are often rules regarding where individuals may graze their cattle or harvest resources, and timing of use, but in none of the study areas are there any rules governing the amount of harvesting or intensity of grazing of an area.

Notwithstanding scientific or indigenous understanding, control over resource use sometimes appears to be weak. The weakening of traditional authority is widely reported in communal lands across Africa (Mogaka *et al.* 2001), and is attributed in part to the political confusion caused by dual systems of control (government and traditional), and changing attitudes of new generations. Society as a whole seems to be becoming more individualistic, and this is not always compatible with traditional ways of managing resource use. The dual systems of control may interfere with good policing of state regulations, as does the widespread problem of corruption. State-imposed licencing systems for resource use (e.g. for fishing, hunting or mangrove harvesting) are flouted in all the study areas.

Weak control of resource use is exacerbated by weak tenure, leading to a situation of open access to resources. Where property rights are weakly defined or absent, there is no incentive for managing resources sustainably (the ñtragedy of the commonsò ï Hardin 1968). If a communities or individuals perceive a lack of security over tenure of resources (e.g. nothing to stop land being allocated by government to other uses), then they are more likely to mine resource bases than to use them sustainably. Weak tenure also facilitates immigration, especially in situations of opportunity, such as the perceived availability of resources for exploitation, or the promise of new development projects. This carries the risk of contributing to the modern tendency for a breakdown in the social fabric of communities, further undermining the control of resource use.

Population increase, augmented by immigration, is probably one of the ultimate causes of wetland degradation, through its effect on the demand for natural resources, including grazing. Increasing populations in urban areas away from the wetland areas probably also contribute, in that they provide growing markets for resources harvested in wetland areas, as well as a source of immigrants that move in to harvest resources.

Excessive grazing occurs because of increasing populations and lack of controls on grazing resources, but probably also because of a persistent mindset. In all of the wetlands considered in this study, cattle are not kept for commercial purposes, but for the usual traditional reasons associated with cattle keeping in Africa: a means of storing wealth, a traditional currency for certain transactions, for ceremonial slaughter, and for draft power and manure (e.g. Ashley & LaFranchi 1997). The fact that such tradition persists into modern day society is thought to be due to a combination of factors including a strong cultural tradition, mistrust of financial institutions as an alternative means of storing wealth, a lack of access to such institutions, and probably also the status derived from a visible stock of wealth. In short, cattle are kept primarily for social, rather than economic reasons, and economic incentives designed to reduce excessive grazing would have to overcome this aspect.

Outside influences

The ecological integrity of wetland areas is also undermined by reclamation for development projects and by a reduction in freshwater flows, both of which can be traced to government-level policies and decision-making. The shortage of resources caused by these may also exacerbate the problems outlined above. Development projects have occurred, or are planned, in all of the wetland areas considered in this study. Development projects have ecological and socio-economic impacts which, cumulatively, may lead to a negative outcome even though economic outputs from a region are measurably increased (using conventional measures such as GGP) and thus deemed a political or macro-economic success.

Projects, such as rice or irrigated sugar, usually result in the loss of a large, contiguous areas of floodplain grassland. Villages are often concentrated along the boundary between the floodplain and uplands so that they have access to both floodplain resources, especially agricultural fields, dry season grazing, grass, palms and reeds, and upland resources such as firewood, wet season grazing, and medicinal plants. Households adjacent to developments can lose access to floodplain resources which make a vital contribution to their livelihoods. For example, in Caprivi, a 14 000 ha area earmarked for development is currently worth some N$6 million per year to the 1000 or so households that use it (Turpie & Egoh 2003). The construction of a network of access roads from the urban centre of Katima Mulilo will, on the one hand, facilitate better marketing of products produced in the study area, but on the other, it will facilitate the collection of resources by outsiders. Both of these factors can weaken control of resources, as will the expected influx of work seekers into the area. Continued social adjustment to a new situation in the area can be expected to take its toll on natural resources, since these provide immediate opportunities for earning income for people while they seek their fortune in the job market. Those who do not find jobs will continue to exploit the natural environment. The degradation of natural resources will impoverish those currently residing in the area, since natural resources contribute most of household income. The agricultural development may be expected to earn households in the region of N$5 ï 6000 per annum in seasonal employment (assuming one job per household), which may turn out to be very poor compensation for resource losses, and perhaps also loss of community, security, health and way of life, if great care is not taken to prevent the process described above. Undoubtedly job opportunities for locals will be welcomed in the area, but the project should only go ahead if the medium and long-term benefits to the local community are greater than the costs, since it is these households that will take the brunt of the costs.

Though some development projects may be favourable on balance, those that are not may also be implemented because of a lack of a holistic approach to decision-making. Project evaluation is usually limited to conventional cost-benefit analysis and environmental impact assessments, and the full economic consequences of the developments, including impacts due to wetland degradation and loss, are seldom taken into account in quantitative terms. At a macro-economic scale, government policies tend to be highly growth oriented, especially in the agricultural sector, and measures of economic performance such as GDP ignore environmental and socio-economic impacts in the subsistence sector (Hamilton 1999).

National economic growth and development have also led to increasing demands for water and hydropower, which in turn have altered freshwater flows and flooding in wetland systems, negatively affecting their productivity (Brown & King 2002, Turpie & van Zyl 2002). The scarcity of water resources has only recently been acknowledged in policy within eastern and southern Africa (e.g. DWAF 1997), and there are currently very few incentives-based demand or supply-management initiatives.

ACHIEVING AN OPTIMAL ECOLOGICAL-ECONOMIC BALANCE IN WETLAND UTILISATION

Assessing the sustainability of resource use

It is clear that the maintenance of ecological integrity, or the indirect use and non-use values of wetlands, tends to be degraded by the excessive pursuit of economic income, or the direct economic use values. Ecological and economic systems come into conflict when economic systems demand more ecological inputs than can be supplied on a sustainable basis, leading to diminishing supplies of ecosystem goods and services. At a local level, this situation may arise either due an increase in demand (for reasons discussed above) or due to a decrease in supply, for example due to reduction in freshwater inputs.

Understanding the causes of wetland degradation is a necessary, but not sufficient, step towards promoting the optimal and sustainable use of wetland systems. It is also necessary to understand the limitations of the system in supplying the goods and services demanded by society. This may be relatively straightforward for any single wetland resource, but is complex when multiple resources are considered together. Similarly, household demands might be highly responsive to changes in the relative availability of resources, and such adaptability of households has been demonstrated by the different ways in which natural resources are used within and between major wetland areas (Turpie *et al.* in prep).

Use of some resources impacts on the availability of others. For example, while cropping and grazing are complementary to some extent, the two activities compete for land. Excessive grazing and cropping, including burning, affect the quantities of grass available for thatching and wild animals and birds for hunting. Burning further affects reed supplies and the availability of suitable habitat for fish breeding during the flood season.

Identifying the optimal use of wetlands

The only hope for understanding the complexity of these ecological-economic systems is to model them. However, this relies on the existence of primary information on individual resources and on household production systems. A preliminary dynamic ecological-economic model of this nature was developed by Turpie *et al.* (1999), using available information on wetland system functioning and survey data on household behaviour. The model, of the Barotse floodplain in Zambia, was developed in STELLA. This package is particularly well suited for systems modelling, explicitly showing the interlinkages between components of the ecosystem, and being designed for simulating dynamic ecosystem and economic processes. The model, though preliminary, was able to demonstrate the long-term economic impacts of overexploitation of resources, and the benefits of implementing incentives to encourage the wise use of resources. The outcome of such an analysis is also heavily dependent on the discount rate used. A high discount rate, which gives low weighting to the costs and benefits of future years relative to the present, can mask the environmental impacts of increasing or easing pressures on wetland resources. Although a low discount rate is more applicable for decision-making on behalf of society as a whole, taking intergenerational equity into account, it should be borne in mind that individuals, especially in poor communities, have high private discount rates, being only concerned with the present. Discount rates used in project evaluation are typically fairly high.

Ecological-economic modelling can also be used to assess the optimal level of development and conservation within communal wetland areas. For example, Turpie *et al.* (1999) also roughly evaluated the impact of declaring part of a wetland area as a protected area, and of converting part of the area to an agricultural development scheme. Such evaluation ideally has to evaluate costs and benefits at both a local and national scale, since the distribution of these has major implications. Wetlands are frequently the preferred site for major agricultural development projects. However, their suitability for grazing and agriculture and other natural resources means that they also attract concentrated human populations. The degradation or loss of wetlands, and even the protection of wetlands, may thus have greater socio-economic implications than that of many other habitats.

Creating incentives for sustainable use

Once the causes of wetland degradation and their dynamic links to human wellbeing are understood, it is easier to identify appropriate points of intervention in order to promote the wise use of wetlands. Existing policies can be examined to see how they can be replaced or modified to optimise the values associated with wetland ecological integrity and income generation. Much theoretical and empirical evidence points to the now generally accepted contention that a major incentive for wise use is created by security of tenure and well-defined property rights. These are essential to preclude the open access problem referred to above. In this context it is invariably vital to strengthen local common property institutions, whether they are traditional or emerging. Systems of control used by common property such authorities need to be appropriate, and based on sound knowledge of ecosystem functioning and human behaviour. The latter will differ from area to area depending on the context or circumstances involved. For example, the use of licencing systems to control resource use may fail in most circumstances, but might succeed where a unique set of conditions is met. This is also true of any incentive measure, such as provision of financial institutions to reduce the need for investment in cattle as a store of value, or the provision of alternative sources of income or new technologies to reduce pressure on natural resources. Conservation agencies have commonly tended to concentrate on the latter, and also on improving socio-economic conditions, such as through provision of schools and wells. Others have tended to concentrate on the intensification and adding value to existing production processes such as resource harvesting and agriculture. Improving incomes through improved technology or new sources, or indeed, improvement of services such as schools and water delivery, may not necessarily end up benefiting wetland areas, since they tend to attract new resource users into the community, especially in areas where common property management is weak. It is also important to realise that reducing peoplesô ónеedsô does not necessarily affect their ówantsö. The latter problem is better addressed through stronger property rights and control systems, as well as increasing awareness and empowerment. Barnes *et al*. (2002) in Namibia, provided economic evidence to show how development of common property rights can significantly enhance income, while maintaining or enhancing ecological integrity on communal land. Selecting the most appropriate policies depends on a thorough understanding of the relative values involved and their dynamics and the economic and social forces at play.

At the national scale, decision-making based on existing economic incentives would change if the perceived costs and benefits changed, as would happen if the environmental and subsistence level socio-economic impacts were taken into account. In many southern African countries, policy provides for subsidies to enhance the incentives for rural households to invest in agricultural production. Analysis of subsidies or livestock in Botswana (Barnes *et al.* 2001) has shown that some of these are economically efficient while others are not. Their effects on habitat ecological integrity will tend to differ with the production systems involved. Again this points to the need for thorough study of all the values and forces involved. Presently in southern Africa, there are few policies in place that create incentives for wise use of wetlands. Of all the countries in eastern and southern Africa, only Uganda has an established wetlands policy, and Zambia has recently developed one. The value of wetlands at a local and national scale needs to be articulated to policy makers and decision makers.

CONCLUSION: BALANCING ECOLOGY AND ECONOMICS

Wetland systems in eastern and southern Africa face an uncertain future in the face of increasing population pressures and spiralling poverty. These factors underlie the excessive grazing and general overexploitation of wetlands which further reduces the levels of goods and services that they can supply. Wetlands tend to attract rural populations and also attract development projects which affect their functioning. At present, floodplain and wetland systems make a major contribution to the livelihoods of large numbers of people, and their further degradation will have serious economic implications. Grazing, and the burning practices that accompany it, are a major concern in maintaining wetland ecosystem integrity in some areas. Yet the cattle involved are kept for reasons which might be replaced by other institutions, given appropriate policies. Societies in some wetland systems, with otherwise similar livelihood strategies, survive equally well without cattle.

Achieving a balance between wetland ecosystems and the economic systems into which they provide inputs will be possible through a more multidisciplinary, multi-resource, dynamic ecological-economic approach to research, through the recognition of the ecological and economic value of natural wetlands in policy, particularly agricultural policy, and through the implementation of appropriate incentive mechanisms. We have concentrated on wetlands as part of a particular category of rangeland system, but many of the principles found in this study apply to other types of rangeland systems in communal areas.

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