Environmental Management (2011) 47:218–229
DOI 10.1007/s00267-010-9592-1

A Review of the Relative Merits of Conserving, Using, or Draining Papyrus Swamps

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Received: 9 September 2009 / Accepted: 17 November 2010 / Published online: 30 December 2010

Abstract Wetlands are a vital resource, particularly in Africa where livelihoods are closely linked to natural capital. In recent years, extensive drainage has occurred to make way for agriculture. To gain insight into whether drainage is justified, we review the value of African wetlands dominated by *Cyperus papyrus* in relation to use, conservation and conversion. Evidence suggests that the value derived from low-intensity, multifunctional wetland use far exceeds the value derived from swamp reclamation and generally exceeds that of conservation. At a local level, the main driver of wetland misuse appear to be a breakdown in collaborative management regimes and the main constraint on wetland use, the value of labor and selling-times. Local drivers are linked to regional factors such as the lack of coordinated wetland policies and difficulties in ensuring that legislation is absorbed by all sectors of society. We highlight opportunities for ensuring more effective collaborative management and legislation communication, which capitalize on existing governance structures. In contrast to predictions by Hardin's Tragedy of the Commons model, we argue that effective wetland management is best achieved by preventing privatization and promoting common property management regimes. We also argue that poverty and income inequity are more important drivers of unsustainable resource use than environmental managers commonly acknowledge.

Keywords Valuation · Tropical · Wetland · Biodiversity · Habitat loss · Sustainable management

Introduction

Freshwater wetlands cover as much as 10% of East and Central Africa and are an extremely important resource for the people who live near them. However, in common with the trend globally, wetlands are fast becoming the most threatened of all ecosystems in the region (Millennium Ecosystem Assessment 2005; NEMA 2005). The view that alternative land uses have a greater economic value has lead to several large government-backed agricultural schemes, which have resulted in the drainage of several extensive swamp networks (Crisman and others 1996; Wetlands Inspectorate Division 2001; Boar 2006). At a more local level, numerous smaller wetlands have been dredged, drained or encroached upon (Crisman and others 1996; Mafabi 2000). Analyses of a time-series of remotely-sensed satellite imagery shows that more than 70% of upland swamps in the upper Nile and Congo basins have been lost in less than 20 years (Maclean 2004).

Nevertheless, increasing evidence suggests that wetland conservation or sustainable use of their resources may generate marked economic benefits, exceeding those obtained from their conversion or degradation (Balmford and others 2002; Millennium Ecosystem Assessment 2005). The need to capitalize on such potential benefits and the costs of not doing so are of particularly high-priority in developing countries, where livelihoods are likely to be linked closely to natural resources and there are high levels

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of poverty. Central and East Africa supports one of the densest, most rapidly growing and poorest human populations in the world (Lindblade and others 1998).

Papyrus-dominated swamps are the most common type of freshwater wetland in East and Central Africa, occurring around lakes, as headwater swamps, in valley bottoms or as large floodplain wetlands (Beadle 1981). The swamps provide many important services (Chale 1985; Crisman and others 1996; Emerton and others 1999; Wetlands Inspectorate Division 2001) and also support unique and important biota including commercially important fish species (Beadle 1981; Hickley and others 2004; Britton 1978). They are regularly used to supply material for building and handcrafted goods and are an important source of fuel to those without land (Turyagyenda 1964; Maclean and others 2003a). However, if drained, swamps may provide benefit in terms of revenue from crops and provision of land for settlement. In this article, we adopt a closely-linked ecological and socio-economic approach to review relevant information to determine the relative merits of using, conserving or reclaiming papyrus swamps. Adopting this interdisciplinary approach and incorporating a socio-political perspective, we discuss the primary reasons for wetland loss in the region and suggest a number of ways forward.

We discuss the value of papyrus swamps, using a framework broadly divided into two main categories: economic values (direct, indirect and non-use) and intrinsic values. We then review the relative merits of conserving, utilizing or draining papyrus swamps. Lastly we review the general causes of wetland misuse and explore the extent to which these misuses are being addressed by regional and national wetland governance and institutional systems. We conclude by proposing future governance interventions that would lead to management that offers more benefit to society. Although we focus on papyrus swamps, many of the issues and principles discussed have wider application.

Methods

A Framework for Assessing Wetland Values

A major stumbling block in understanding and interpreting the value of wetlands has been a lack of common terminology, particularly when referring to the benefits of ecosystem attributes. Authors use a confusing mix of terms (Turner and others 2000). In this study, we adopt the terminology used by Turner and others (2000) in which 'ecosystem processes' refer to the dynamics of transformation of matter and energy through processes such as primary production and biogeochemical cycling of, for example, nutrients. Ecosystem functions are a composite function of several processes. For example, Janssen and others (2005) give 'export of nitrogen' as an example of a wetland function that arises from four biogeochemical processes: denitrification; ammonia volatilization; removal of vegetation and physical losses via erosion. Functions are also dependent upon biological structure (Maltby and others 1996). This in turn is key to the continuing provision of goods and biological services. Biological goods are products such as fish and timber that are used by people. Biological services are often provided by ecosystems as a result of their physical or biological function. These functions may include retention of nutrients or eroded soil (Boar and others 1999) serving to enhance agricultural productivity. Functions in themselves are not necessarily of economic value; such values derive from the existence and demand for biological goods and services (Millennium Ecosystem Assessment 2005).

The value of wetlands can essentially be divided into two categories: economic value (in its broadest sense encompassing non-use values) and intrinsic value (Turner and others 2000). Intrinsic value (Næss 1989; Nunes and van den Bergh 2001) is defined as a 'value unto itself', completely divorced from anthropogenic values. Thus, by definition, it cannot be valued using expressed or revealed patterns of human behavior and can only be integrated into policy by adopting rights and interest-based arguments on behalf of non-human entities. We recognize that environmental decision-making is often subjective rather than quantitative and intrinsic value could be used as a qualitative tool to readdress current disparities more in favor of conservation and sustainability. Nevertheless, policies, particularly those based on utilitarian principles, are likely to be highly controversial if the needs and wants of all intrinsically valuable components of biodiversity are incorporated into decision-making processes. Consequently, we chose to focus primarily on the economic trade-offs of using, conserving or reclaiming papyrus swamps.

The economic values associated with different types of wetland use can be divided into three categories: those that result in direct use values, those that result in indirect-use values and those that result in non-use values. *Direct use value* is gained from direct utilization of an ecosystem. *Indirect use-values* are defined as those non-monetary goods and services derived from the functioning and existence of the ecosystem. *Non-use value* is gained from the satisfaction people may derive from simply knowing that a resource, such as an individual species or a particular wetland exists, i.e., from the existence value of wetland.

In this article, we define wetland use as human actions taken to derive value from wetlands. It thus refers primarily

to direct use value, although we discuss indirect values that do not require action in detail. Wetland conservation is defined as leaving a wetland intact and undisturbed, but we do discuss the extent to which wetland use and wildlife conservation is compatible and discuss the implications of alternative definitions. Drainage is defined as the conversion of wetlands to other land-use, which can be either permanent or temporary. Where wetlands are significantly altered, but not actually drained, such as when they are dredged or converted to fish ponds, this is made clear.

The Review Process

To specifically find studies in which the relative merits of using, conserving or draining papyrus swamps were valuated, we made use of the Web of Knowledge (http://isiknowledge.com 2009) to search for English language, peer-reviewed publications published between 1950 and 2008. We also used Google Scholar (http://scholar.google.co.uk/ 2009) to search for additional information published in technical reports and others "grey literature". Using Web of Knowledge the following combination of phrases were used: "wetland/wetlands and value/valuation and Africa/Uganda/Kenya", searching the title, key words and abstract. Using Google Scholar, the following combination of phrases were used: "wetland/wetlands value/valuation and Africa/Uganda/Kenya", searching any part of the article. The abstracts of all studies found were read to select those that were relevant. To find other studies, of relevance to papyrus swamp goods and services, we examined all studies in which the term "Cyperus papyrus" was included in the title, key words and abstract using Web of Knowledge and in the title using Google Scholar. We identified a total of 311 studies using the first set of search terms and 235 using the term "Cyperus papyrus".

Results and Discussion

Literature Review

After rejecting irrelevant studies, we found only three that economically valued the relative merits of using, conserving or draining papyrus swamp, but numerous studies in which the goods and services associated with papyrus swamps were described in the context of conservation, use or conversion. To enhance the robustness of our conclusions, we draw on these other studies to review the full spectrum of direct-, indirect and non-use values. We also use information in these studies to qualitatively assess the likely impacts of conserving, using or draining papyrus swamps on value.

Wetland Values

Economic Valuation

The three studies in which swamp goods and/or services were valuated were Emerton and others (1999), Abila (2002) and Maclean and others (2003b). Emerton and others (1999) assessed the present *per annum* value of domestic waste water-treatment and goods derived from Nakivubo wetland near Kampala, Uganda. They also present information on the gross value derived from different use types including conversion to agriculture. Abila (2002) assessed the net benefits of commercial products in Yala Swamp in Kenya. Maclean and others (2003b) assessed the value of harvested papyrus, crops and fish derived from papyrus swamps surrounding Lake Bunyonyi in south-west Uganda. A comparison of values derived from each study is presented in Table 1.

The three studies used different valuation approaches. The Maclean and others (2003b) study employed an empirically justified production function approach to determine the benefits of goods derived under four different demand scenarios. The net present value of swamps was estimated for different ratios of conservation, drainage and use over 100 years using a discount rate of 5%, although it is also possible to deduce the *per annum* values. The Abila (2002) study used open-ended questionnaires to estimate the consumer and producer surplus of commercial goods. The value of non-commercial goods was estimated by examining replacement costs, but these are only compared anecdotally to opportunity costs and benefits. The study by Emerton and others (1999), calculated the avoidance costs of replacing natural wetland functions with human-made alternatives and the foregone expenditures of mitigating or off-setting the effects of losing wetland services, in particular waste-water treatment. Additionally, the value of goods derived from Nakivubo was determined from the amount of income generated through utilizing these resources, but it is assumed that labor costs are zero. Whereas the studies employ rather different evaluation methods and value different components of wetlands, the results of all three studies reveal that the economic value of low-intensity wetland use greatly exceeds the value of wetland conversion and generally exceeds that of conservation (Table 1).

Emerton and others (1999) show that the *per annum* present value of waste water treatment alone lies within is c. US $2,440 per ha, which contrasts with US $1,393 per ha when the swamp is dredged for brick-making clay or US $178–1,042 per ha when converted to fish farming. Abila (2002) also showed that the replacement values of substitution activities far exceed the benefits that would be gained from converting the wetland. For example, the

Table 1 Overview of characteristics and monetary values derived from three studies that have carried-out quantitative analyses of the economic value associated with papyrus swamp goods and/or services

Study	Abila (2002)	Emerton and others (1999)	Maclean and others (2003b)
Area of wetland (ha)	17,500	529	21.25
Location	Kenya	Uganda	Uganda
	34° 16′ E, 0° 06′ S	32° 41′ E, 0° 19′ N	30° 00′ E, 1° 09′ S
Number of households using wetland	?	23,422	2,600
Total surrounding	?		
Total directly bordering	?	7,807	1,200
Per hectare surrounding	?	44.28	122.35
Per hectare directly bordering	?	14.76	56.47
Value (US $ ha^{-1} year^{-1})			
Crops	176[a,b]	340[a,c]	21–181[c]
Harvested papyrus	124[a,b]	635–2,390[a,c]	466–520[c]
Brick-making	17[a,b]	1,393[a,c]	0[d]
Fish-farming	0[d]	178–1,042[a,c]	0[d]
Subsistence fishing	630[a,b]	1,315–2,440[a,c]	760–1,095[c]
Grazing	23[a,b]	Not evaluated	0[d]
Hunting	3[a,b]	Not evaluated	Not evaluated
Waste-water treatment	Not evaluated	2,440	Not evaluated
Value (US $ ha^{-1} year^{-1})			
Conservation	0	2,440	0
Low-intensity use (harvesting, fishing, grazing and hunting)[e]	780	1,950–4,830	1,226–1,615
Conversion (cultivation, brick-making or fish farming)[f]	17–176	178–1,393	21–181

[a] Excludes labor costs, [b] values are mean monthly household income (KSh). However one household per hectare of wetland is a population density typical of western Kenya (Swinkels and others 1997), [c] assumes exchange rate of US $1 = USh 1795, [d] activity not carried out in study area, [e] only papyrus burnt as fuel and included in harvested papyrus value, [f] these uses are not mutually exclusive

resources obtained from papyrus swamps had a commercial value of KSh 7,867 (US $102) to each household, compared to KSh 2,049 (US $27) when converted to subsistence crops and just KSh 1,432 (US $19) when converted to commercial crops. Maclean and others (2003b) reveal that the net per annum present value of harvested papyrus and fish derived from swamps exceeds the net per annum present value of crops when swamps are drained (US $1,226–1,615 per ha compared to just US $21–181 per ha). The study demonstrates that the summed net present value over a 100 year period can be as much as US $11,200–24,000 per ha with a 5% discount rate and is maximized when 27–33% of a swamp is utilized for harvesting, but less than 2% is reclaimed for subsistence cultivation. A higher ratio of use to drainage net benefit when considering net present value as opposed to *per annum* value results because agricultural production is often short-lived. Soils from drained wetland are often exposed conditions that enhance decomposition of organic matter and nutrient mineralization (Crisman and others 1996).

Although, the Maclean and others study made assumptions about the population dynamics of swamp goods, sensitivity analysis revealed that it is the perceived value and amount of time invested in labor and selling goods that most affect the degree to which cultivation or use affect net present value. As markets expand in response to population growth and transport network improvements, the time taken to sell goods will decline. The findings also highlight that increased poverty is likely to result in increased levels of cultivation and use. All three of the studies represent a conservative estimate of the true total economic value of papyrus swamps because their non-use value and many of their services were not considered. No formal quantification of the full spectrum of values has been undertaken. In particular, none of these studies specifically examine the value of conserving wetlands. This is primarily because this in itself is a subjective concept. On the one hand, a "conserved wetland" could be one which is not used by humans and its value stems primarily from the services it provides. On the other hand, a "conserved wetland" could refer to one in which wildlife conservation is the primary objective. Its value would depend on the extent to which various uses are compatible with wildlife and it would owe a degree of its value to the existence value of animals and plants found therein. In order to explore this concept in

more detail and also to capitalize on information presented in the numerous studies in which goods and services associated with papyrus swamp conservation, use or reclamation are described but not formally quantified, the following section reviews these goods and services. The likely compatibility among different types of wetland use is also described so that a qualitative assessment of the relative merits of conservation, use or drainage can be made.

Direct-Use Values

Rural inhabitants living near swamps in most parts of East and Central Africa harvest papyrus, which is used to handcraft goods that are sold or used by makers themselves. Examples include baskets, hats, fish traps, trays or winnowing mats and floor mats. Papyrus is also used to make roofs, ceilings, rope and fences, or as fuel (Maclean and others 2003c). Although alternative fuel sources such as eucalyptus *Eucalyptus* spp. are available, papyrus is still used as fuel by a minority of residents, particularly brewers or those without land (Turyagyenda 1964; Maclean and others 2003b). In western Kenya, other wetland plants associated with papyrus swamps are used as condiments or have medicinal purposes (Odongo 1996; Abila 2002). Several fish are also extracted directly from papyrus swamps, particularly catfish (*Clarius* spp.), lungfish *Protopterus aethiopicus* and in some areas, introduced Louisiana crayfish *Procambarus clarkii* (Crisman and others 1996; Maclean and others 2003c). Game such as sitatunga *Tragelaphus speckii* are also occasionally captured in swamps (Maclean 2004; Maclean and others 2003b). Swamps are also a source of brick-making clay, an increasingly important resource given rapid population growth, urbanization and desire for better housing (Crisman and others 1996).

Reclamation of swamps provides goods in the form of crops. These fall into two categories: subsistence or commercial. Throughout East and Central Africa, but particularly in upland areas where rural population densities are highest, many swamps have been encroached or drained to grow vegetables, particularly Irish potatoes *Solunum tuberosum*, sweet potatoes *Ipomoea batatas* and cabbages *Brassica oleracea.* Tomatoes *Lycopersicon esculentum*, beans *Phaseolus vulgaris*, carrots *Daucus carota*, cauliflower *Brassica oleracea* and sorghum *Sorghum bicolour* are also occasionally grown (Maclean and others 2003c). In some places, such as around Lake Kyoga in Uganda and Yala swamp in western Kenya, papyrus swamps have been cleared in favor of commercial rice *Oryza sativa* and sugarcane *Saccharum officinarum* schemes. In Kigezi region in south-west Uganda, several large papyrus swamps have been drained for dairy farming (Mafabi 2000). Water availability and the fertility of swamp sediments often allow three crops per year to be grown, making a significant contribution to food security (Wetlands Inspectorate Division 2001).

Indirect Use-Values

Some goods are dependent indirectly on papyrus swamps, and thus fall under the category of *indirect-use value*. These include the habitat values of wetland such as providing nesting grounds and cover for fauna that are valued for other reasons. For example, papyrus swamps are instrumental in the upkeep of open-water fisheries. Tilapia (*Oreochromis* and *Tilapia* spp.) use water proximal to papyrus swamps for feeding or for structural refugia from Nile Perch *Lates niloticus* (Chapman and others 2002; Hickley and others 2004). Swamps may also buffer against sedimentation and eutrophication of open water (Boar and others 1999; Chapman and others 2002; Hickley and others 2004; Kyambadde and others 2004), thus benefiting fisheries by ensuring suitable conditions for aquatic macrophytes and the invertebrates upon which many fish depend (Hickley and others 2004).

Important also is the ability of papyrus swamps to improve drinking water quality via the retention of fecal coliforms and their associated pathogens (Kansiime and van Bruggen 2001). Retention is largely due to adherences to particles suspended in the water column originating from the floating mat of detritus surrounding papyrus rhizomes (Kansiime and van Bruggen 2001). In 1996, Africa reported more than three times the number of cholera cases than in the rest of the world combined. Between June 1997 and March 1998, in the Nyanza District of western Kenya alone, there were 14,275 cholera admissions to hospitals and 547 deaths (Shapiro and others 1999). Most cases occurred as a consequence of drinking contaminated lake water and lacustrine fringes of papyrus could thus be instrumental in reducing the scale of the problem.

Climate may be regulated at a local scale by papyrus swamps. In Kigezi district in south-west Uganda, large-scale drainage has been linked to a decline in the persistence of mist and a concomitant reduction in precipitation (Turyagyenda 1964). Additionally, swamps provide water storage and evapo-transpiration from papyrus is considerably less than evaporation from open water. Papyrus swamps are thus instrumental in conserving water during periods of drought (Jones and Muthuri 1984, 1985). Water retention characteristics may also prevent flooding during periods of high rainfall (Dixon and Wood 2003). Papyrus culms act as a physical barrier to flow, which prevents storm-surges after periods of high rainfall (Kansiime and others 2005).

Papyrus swamps are a significant carbon sink, although their ability to sequester carbon is not known with certainty

(Jones and Humphries 2002; Jones and Muthuri 1997). Papyrus is a highly productive system and several meters of plant detritus can accumulate below the living mats of rhizomes and roots, in some cases over thousands of years, thus storing over 70 kg m^{-2} (Lind 1956; Hillaire-Marcel and others 1989). Although efforts to value carbon vary considerably, some estimates exceed $250 per tonne (Creedy and Wurzbacher 2001). To put these figures in perspective, given estimates of 3,500 km^2 of papyrus in Uganda for example (Maclean 2004), and conservatively assuming just 10 kg of carbon per m^2 at just US $5 per ton, the value of carbon stored in papyrus swamps alone is more than eight times the country's estimated GDP of US$ 43.22 billion (CIA 2010).

Nature-based tourism is also a value arising from indirect-use. This form of tourism has been identified as the fastest growing industry in the world. Revenue from eco-tourism contributes considerably to the national economies of East and Central Africa. In Kenya, for example, 70% of tourists are attracted to the country by unique opportunities to view wildlife and receipts from tourism are the largest source of foreign exchange (Weaver 1999). Both visitors and residents may benefit from employment and local economies gain as a consequence of the presence of wildlife, albeit that benefit accrue to local residents is a contested claim (Infield and Namara 2001). The scope for wildlife-based tourism in papyrus swamps, however, is limited by finite tourist numbers, limited interest in papyrus wildlife and the large number of papyrus swamps in the region. At Lake Bunyonyi, one of the more visited wetlands in Uganda, revenues from eco-tourism are less than 2% of those obtained from swamp goods (Maclean and others 2003b).

Non-Use Values

Whereas use values potentially provide the means for credible environmental decision making in developing countries, the *non-use value* of wetlands should not be ignored. People may derive satisfaction from simply knowing that a resource, such as an individual species or a particular wetland exists i.e. from the existence value of wetland. The biotic communities associated with papyrus swamps have two characteristics: they have low diversity, but support species restricted to this habitat type. Thus, although the number of species present is low (Britton 1978; Beadle 1981; Sutton and Hudson 1981), those that are present contribute to diversity at a regional and global scale.

The satisfaction that wetlands or their biota exist is philanthropic in the sense that people recognize that others could benefit. The distinction between existence and intrinsic value is often blurred and some authors (Ghilarov 2000) adopt the term intrinsic value to describe what we refer to as existence value. We draw a clear distinction between the two: pure existence value is a measure of an individual's or societal acceptance of intrinsic value and is thus quantifiable through expressed or revealed human preferences. Intrinsic value is the value of components that nature might have regardless of whether they are valued by humans.

Difficulties in incorporating non-use values in decision-making may result from different perceptions of the notion of value since non-use value is especially likely to be culture or region specific. Some communities hold spiritual and customary values for papyrus swamps that may well be imperceptible to policy-makers (Gichuki and others 2001). Conversely, the existence value assigned to 'charismatic megafauna' by those in developed countries often conflicts with the needs and wants of local people (Infield and Namara 2001).

Qualitative Assessment of Value in Relation to Use

Intensive harvesting of papyrus could damage fisheries and wildlife. However, previous work suggests that birds, even papyrus specialists, tolerate low intensity harvesting (Maclean 2004) and that fisheries do not decline substantially (Maclean and others 2003b). Harvesting stimulates rapid re-growth thus ensuring continual removal of nutrients and carbon (Jones and Humphries 2002). Retention of fecal coliformes and associated pathogens is also likely to be enhanced by cutting since trampling by harvesters disturbs detrital mats and increases the density of suspended particles onto which pathogens may attach. Conversely, dredging or reclamation is likely to impair these functions and derived services. Although agricultural landscapes also sequester carbon to some degree, reclamation of papyrus is likely to lead to rapid oxidation of peaty sediment and a reduction in carbon storage (Lind 1956), although as oxidation is partially dependent on flooding regimes and soil use strategies, there may be scope to increase carbon storage with appropriate management (Komatsuzaki and Ohta 2007). Whereas areas reclaimed for agriculture could potentially remove nutrients from water, health issues would prohibit their use for tertiary treatment of sewage. Thus, extracting goods from papyrus swamps, particularly harvesting raw material, could in many instances increase the provision of ecosystem services. Similarly, the extraction of goods, unless resulting in severe disturbance, does not damage swamp biota unduly.

Although the net benefits of swamp resource use or cultivation are likely to vary substantially in different locations due to differences in labor costs in swamps of different topographies, gross values vary less. Consequently, unless the demand for crops is substantially

greater than the demand for swamp goods, or unless the labor cost involved in extracting swamp resources is considerably greater than the cost of cultivation, low-intensity multi-functional swamp resource use will always be more profitable than swamp reclamation. Establishing the level of resource use that maximizes societal benefits is complex and is likely to depend primarily on labor costs, demand for swamp goods, the sustainability of harvests and the extent to which harvesting affects fisheries. All of these could vary spatially and temporally, and particularly the last issue has received little attention from researchers. In light of these uncertainties, we recommend a precautionary attitude in which resources are extracted far below their suspected maximum sustainable yield. The functional relationship between net present value and resource use is likely to be asymmetric: the marginal decline in net present value of overuse is likely to exceed that of under-use (Maclean and others 2003b).

Causes of Wetland Overuse and Misuse

Since many papyrus swamps are used heavily or converted to agricultural land, and available evidence suggests that low-intensity use maximizes the benefit, it is evident that papyrus swamps are being misused. In following sections we draw on information presented in the reviewed studies to elucidate why this may be the case. We first examine causes of misuse from the point of view of individual householders. We then examine how and why governance structures and institutional frameworks have failed to ensure that householder activity is regulated in manner that ensures greater benefit to society.

Householder Use and Misuse

One of the prominent factors underlying wetland misuse in East and Central Africa is claimed to be lack of, or insufficient, awareness of the functions and benefits of wetlands (e.g., NBSAP 2000; Wetlands Inspectorate Division 2001). The results of our review suggest, however, that this is not case. Numerous studies have demonstrated that rural householders, the primary users of swamp resources, are very aware of the benefits of wetland goods and services and have good understanding of such issues, despite low levels of education (Odongo 1996; Gichuki 2000; Gichuki and others 2001; Maclean and others 2003b; Abila 2002, 2005; R. Boar, unpublished data). Indeed, although education has often been considered an important means of mitigating problems associated with information failure, research indicates that demand for education itself (in terms of school fees), often causes over-use of wetland resources (Maclean and others 2003b).

Three root causes appear responsible for the misuse of papyrus swamps (1) poverty and income inequity (2) wetland privatization and (3) breakdown in collaborative management. Income obtained from papyrus swamp goods prior to drainage, reduces household income inequalities (Maclean and others 2003c). Thus, not only do swamps provide an important source of income to many, it is the poorest members of society that receive most benefit. Furthermore, where tested (e.g., Maclean and others 2003b), it appears that the single most important factor affecting the balance between conservation, use and reclamation that affects the value derived from swamps, is perceived value of labor and selling time. Assuming an average income the net present value of wetlands is maximized when only a small proportion (<0.1%) of a swamp is drained and 25–35% is harvested annually. When the perceived value of labor and selling time is reduced by 50% (as would be the case if a society was poorer), net present value is maximized when a much higher proportion of the swamp is drained (5–15%) or harvested annually (55–95%). If average incomes are reduced by 80%, complete drainage of the swamps yield the highest net present value. Thus, a society in which income equality is low, even if average income is high, will always contain a few people willing to drain wetlands or use their resources intensely. Moreover, the problem is likely to be self-perpetuating in that drainage could lead to further income inequity and over-use of resources leading to a reduction in future societal benefits. Income inequity thus imposes a double jeopardy.

Evidence suggests that most large scale, permanent reclamation schemes are usually government-backed ventures or carried out by rich and powerful individuals (Crisman and others 1996; Bennun and Njoroge 1997; Lindblade and others 1998). An alternative driver of wetland drainage, but linked to the same process, occurs when wetlands are privatized by the rich and powerful. In such instances, labor costs are reduced by technological means and sellers have access to global markets reducing selling costs (Bennun and Njoroge 1997; Lindblade and others 1998). Often local residents have been offered benefits in terms of employment, food, housing and education in order to secure backing, but often these benefits do not materialize and agricultural production is short-lived (Carswell 2002). Overall, the value of commercial crops is usually substantially less than the value of subsistence crops (e.g., Abila 2002) and the poorest sectors of society who are the most dependent on swamp resources lose their access to a valuable source of income. Thus, in contrast to the predictions of the Tragedy of the Commons model (Hardin 1968), privatization of papyrus swamps appears to lead to Pareto inefficiency.

In further contrast to the predictions of the Tragedy of the Commons model, there is also evidence to suggest that resource users can establish rules among themselves for sustainable use. Although Hardin's "free-rider" assertion attributes degradation to the overuse of common property resources (Hardin 1968), the open-access nature of papyrus swamps does not necessarily result in rival consumption. For example, in Kenya and Uganda, although drainage and resource use are restricted legally, most rural inhabitants experience no or little resistance to swamp access, yet often co-operate with one another rather than pursuing individualistic strategies (Lindblade and others 1998; Gichuki 2000; Maclean and others 2003c). Nevertheless, there is evidence that breakdowns in such collaborative management regimes are an important driver of wetland misuse. Effective collaborative resource management relies on trusting all users. If benefits accrue to the untrusted, individual users lack the incentive to curtail their activities, resulting in overuse. Growing evidence suggest that trust is being eroded by rapid population growth as establishing trust is easier when people know each other well. Overpopulation has in part been caused by and in part results in, the migration of people. For example, high population densities and resulting land pressures in Kigezi district in south-west of Uganda, led to the organized resettlement of around 56 thousand people between 1946 and 1962 (Lindblade and others 1998). A study designed to find the causes of wetland degradation in south-west Uganda (Maclean and others 2003c), revealed that many people, particularly older people, are increasingly reluctant to trust strangers and to exploit wetland resources sustainably. Rapid population growth leads not only to the direct depletion of swamp resources but also promotes mistrust and consequentially, the collapse of effective common property regimes.

Weak Governance and Institutional Frameworks?

Local drivers of papyrus swamp use are in part determined by governance and institutional frameworks and the local drivers of misuse can be linked to two broad regional factors. Firstly, appropriate polices regulating the use of wetlands have not always been formulated and secondly, where they do exist, they are often not enforced.

With regards to lack of appropriate policies, the majority of countries hosting major tracts of papyrus swamp have government departments and organizations with partially overlapping responsibilities for planning, co-coordinating, implementing and monitoring wetland policies and legislation on the environment (Table 2). Consequently, legislation is often contradictory and lacks cohesion (Bennun and Njoroge 1997). Divisional approaches to wetland management have many disadvantages: policy co-ordination is complex, legislation can be contradictory, bureaucratic processes are slow and wetlands are not treated as functional entireties (Ramsar Convention Secretariat 2007). Consequently, the implementation and execution of various Acts and policies in relation to the management of papyrus swamps has been slow and without legal base. With regards to enforcing appropriate policies, one of the problems is that legislation has yet to be absorbed by all sectors of society. Thus, the use of swamps has not been determined fully by government policy and is usually more influenced by local decisions (Abila 2005; Gichuki 2000). This is particularly the case in the Democratic Republic of the Congo and in Burundi, where although weak wetland legislation is in place, policies are almost universally ignored (Table 2). The lack of effective implementation of government policy becomes problematic when the costs and benefits associated with a particular use of wetlands are not received or incurred by those responsible for that use. For example, wetland drainage may incur costs in the form of reduced flood regulation or increased pollution, but predominantly to those downstream of the wetland drained (Kansiime and others 2005). Similarly, the benefits of carbon sequestration (Jones and Humphries 2002; Jones and Muthuri 1997) may be very small to people in a position to prevent such sequestration, but much larger when summed across society as a whole. Pareto optimality across society as a whole is more likely to be achieved through the implementation of effective national, regional or international policies.

Nevertheless, there are indications that coordinated wetland governance arrangements are emerging in some countries. In Kenya, the National Wetland Standing Committee and in Tanzania, the National Wetland Technical Committee, draw membership from both government and non-governmental organizations. These organizations provide a mandate for awareness creation, inventory, policy formulation and technical advice and provide a means for promoting sustainable resource use (Masija 1991; Kairu 2001). In Uganda, wetland management policy is even more coordinated. Most wetland conservation monitoring, planning and coordination is carried out by a single body. One of the key actions proposed in the national wetlands sector strategic plan (Wetlands Inspectorate Division 2001) is to ensure that decisions concerning the management and use of wetlands are informed by an understanding of the value of goods and services.

There are also efforts to ensure that policies are more effectively enforced. For example, in the wetlands sector strategic plan for Uganda (Wetlands Inspectorate Division 2001), it is recognized that day-to-day use of wetland is a decentralised function, meaning that governance is primarily carried-out at the level of villages and parishes. In the last two decades, decentralized governance has gained

Table 2 Overview of governance and institutional frameworks of relevance to wetland policy in East and Central Africa

	Burundi	Democratic Republic of the Congo	Kenya	Rwanda	Tanzania	Uganda
International						
Signatory of Ramsar convention (date)[a]	15/10/02	18/05/96	05/10/90	01/04/06	13/08/00	04/07/88
Number of Ramsar sites[a]	1	3	5	1	4	7
CBD ratification (date)[b]	15/04/1997	03/12/1994	26/07/1994	29/05/1996	08/03/1996	08/09/1993
Member of East Africa community treaty[c]	Yes	No	Yes	Yes	Yes	Yes
National wetland policies[a]						
Status of national wetland inventory	Very incomplete	Incomplete	Incomplete	Near completion	Complete	Complete
Cohesion of policies and legislation	Low	Low	Low	Moderate	Moderate	High
Strength of national policies and legislation	Very weak	Very weak	Weak	Weak	Weak	Moderate
Local governance[a]						
Political decentralization	Low	Low	High	Moderate	Moderate	High
Administrative decentralization	Low	Low	Moderate	Moderate	Moderate	High
Fiscal decentralization	Moderate	Moderate	High	Moderate	Moderate	High

Sources of information: [a] Ramsar Convention Secretariat (2010); [b] CBD (2010); [c] (EACT 1999), Ndegwa (2002)

prominence throughout East and Central Africa (Raussen and others 2001; Ndegwa 2002; Ribot 2003). For example, in Uganda a hierarchy of Councils and committees has been introduced at five administrative levels ranging from districts to villages. In terms of enforcing wetland policy, this system provides a forum for local decision-making. Elected Chairpersons of the Council form executive committees at respective levels, and propose policies for their legislative bodies, which are formed by the representatives of the people (Saito 2003). This decentralized structure has been used as a vehicle to train and equip District Environment Officers to carry out wetland management functions and to ensure allocations of recurrent budgets at a local level to achieve this (Wetlands Inspectorate Division 2001). Although countries differ in terms of their decentralization (Table 2), there are indications that such devolved power structures, if properly accountable, can provide an effective means of, not only governing resource use at a local level, but also of ensuring government policies are implemented locally (Abila 2005; Gichuki 2000; Ribot 2003).

Conclusions and Policy Recommendations

Evidence from the studies reviewed in this article suggests that conversion of wetlands almost always serves to reduce the overall value of wetlands, even though it may enhance the welfare of a small number of individuals. With regards to use, economic value is a function of supply and human demand for goods and services. Consequently, in the short-term, the value of papyrus swamp-derived goods is maximized in two ways. Firstly, when there is a high supply and demand for goods and secondly when more types of good are extracted, provided that the extraction of one type of good does not impinge on the availability of another. However, the high use of any one good often leads to unsustainable yields and impaired services and as a result, the value of papyrus swamps is likely to be greater when resources are used less-intensely (Wetlands Inspectorate Division 2001). In contrast, the extraction of one type of good rarely affects the availability of others: for example papyrus harvest does not affect the availability of medicinal plants and vis-versa (Odongo 1996). The extraction of a diverse range of goods will thus generally increase the value of wetlands. In terms of conservation, valuation is blurred by the subjective nature of this term. If a "conserved swamps" is one in which wildlife conservation the primary objective, then current evidence suggests that low-intensity extraction of papyrus swamp resources need not be prevented (e.g., Maclean and others 2006). However, more work is needed to determine the impacts of papyrus harvesting on fish, particular on the extent to which this impairs a swamps capacity to act as structural refugia for native fish species from introduced predators. Additionally, the importance of papyrus swamps in terms of reducing poverty and income inequity and in turn, the effects this has on levels of resource use, should be considered when balancing the value of wildlife conservation against the needs and wants of local people. On the other hand, if a "conserved swamp" is one that is not used by humans, then

the value stems primarily from the services it provides. The overall value will be less, because no value is derived from goods and the services are in many instances enhanced by low-intensity use (Kansiime and van Bruggen 2001).

There is some evidence that in areas of high rural population density, resources are being used more intensely than is optimal in terms of societal benefit (e.g., Maclean and others 2003b, c). Of greater concern however, is the degree of drainage taking place. Numerous smaller wetlands, particularly in upland areas have been drained for subsistence farming and in some places extensive swamp networks have been drained for commercial crops (Mafabi 2000; Maclean 2004). Since there is clear evidence that drainage serves to reduce benefit to society, there is a need to ensure that polices clearly and unequivocally reflect this. Even if large-scale schemes backed by government or multi-national companies provide employment and others benefits, these generally fall a long way short of compensating the costs incurred across the wider community (Carswell 2002). In order to achieve this, a less divisional approach to wetland management is required. By following the model in Uganda, it is likely that other countries would be able to implement a more strategic approach to wetland management and convey more clearly that wetland drainage is not economically justifiable.

At a local level, there is a need to re-establish cooperative management regimes and to ensure that region-wide legislation and policies are communicated to those most responsible for using wetland resources. Both these objectives could be achieved by capitalizing on the hierarchical decentralized governance structures that are already in place to varying degrees in each of the countries hosting major tracts of papyrus swamp. Additionally, evidence amassed in this study suggests that poverty and income inequity are significant drivers of wetland drainage and overuse. In practical terms, a solution to this problem would be to promote a variety of potential income sources. This would reduce the dependence of the poor on wetland resources, thus weakening the detrimental feedback cycle between poverty and resource use.

In order to achieve this, it would be helpful if there was a paradigm shift in what is seen as the root cause of wetland drainage and unsustainable resource use. This would allow income diversification schemes to be incorporated into national wetland management strategies. At present, lack of knowledge and awareness of the value of wetlands is thought to be the root cause of wetland misuse. However, our review suggests that local communities have a good understanding of the benefits wetlands provide and it is more likely that poverty and income inequity drive unsustainable natural resource use. It is well established that the per-unit production costs of natural resource harvest increases with quantity (Gorden 1991). Thus, provided marginal benefits do not increase at a rate sufficient to counteract this, then this increase in marginal costs must be a fundamental factor constraining the quantity of resource use. As there is no reason to suppose that marginal benefits do increase substantially with quantity, it is likely that this constraint is universal. Since the marginal costs of natural resource extraction are at least partially determined by labor costs, and since it is a fundamental tenet of labor economic theory that poorer people work for less (e.g., Ashenfelter and Layard 1986), then poorer people must, on the whole, be willing to extract more resources.

Although links between poverty and natural resource use have received attention from environmental managers, poverty is generally thought to increase pressure on the environment due to high population growth rates and limited access to high quality land (Scherr 2000). The importance of poverty in terms of reduced production costs has received surprisingly little attention. Sustainable resource use and poverty reduction are not only separate moral obligations. They are inextricably linked with one another and should be considered simultaneously.

Acknowledgments Aspects of this work were funded by British Airways and the Royal Geographical Society. We thank Virginia Dale and anonymous referees for helpful comments on aspects of this manuscript.

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