Author's personal copy

Journal of Environmental Management 93 (2012) 71–84

Contents lists available at SciVerse ScienceDirect

Journal of Environmental Management

journal homepage: www.elsevier.com/locate/jenvman

Integrating local ecological knowledge and management practices of an isolated semi-arid papyrus swamp (Loboi, Kenya) into a wider conservation framework

Taita Terer [a,b,*], A. Muthama Muasya [c], Farid Dahdouh-Guebas [b,d], George G. Ndiritu [a], Ludwig Triest [b]

[a] Wetland and Marine Section, Centre for Biodiversity, National Museums of Kenya, P.O. Box 40658-00100, Nairobi, Kenya
[b] Laboratory of Plant Sciences and Nature Management, Vrije Universiteit Brussel (VUB), Pleinlaan 2, B-1050 Brussels, Belgium
[c] Department of Botany, University of Cape Town, Private Bag X3, Rondebosch 7701, South Africa
[d] Laboratory of Complexity and Dynamics of Tropical Systems, Université Libre de Bruxelles (ULB), Av. F.D. Roosevelt 50, B-1050 Brussels, Belgium

ARTICLE INFO

Article history:
Received 13 August 2010
Received in revised form
5 July 2011
Accepted 5 August 2011
Available online

Keywords:
Cyperus papyrus
Wetland
Sustainable utilization
Ethnobiology
Great rift valley
Kenya

ABSTRACT

The current study documented local utilization of *Cyperus papyrus* L. (papyrus), harvesting patterns, threats, and local management practices among the Endorois community living around Loboi swamp (Kenya). Papyrus is a highly productive freshwater macrophyte that is widely utilized throughout tropical Africa. However, increased human population and poverty, has led to over exploitation and conversion of papyrus wetlands to agricultural fields. Nonetheless, users of papyrus hold important local ecological knowledge (LEK) and practices. We show that Endorois practices on papyrus uses are compatible with the management priorities of the swamp and a wider conservation framework using data obtained from three focus group discussions (FGD), interviews of 34 households and 15 key informants. The study revealed that papyrus support local livelihood notably as a source of income (papyrus mats are sold), cattle fodder, roofing materials (shelter), and cooking fuel. The study further revealed important LEK relating to harvesting patterns, recovery after harvesting and traditional management practices. Correlation and principal component analyses showed that experienced old harvesters (EXPERT) avoided harvesting repeatedly at the same location (REVISIT), thereby allowing recovery of papyrus when compared to younger harvesters ($r = 0.63$, $p < 0.01$). However, over 70% of harvesters predicted a decrease in papyrus coverage in the future due to the current diversion of water from the swamp, and frequent droughts, despite the instituted traditional management strategies (e.g. rotational harvesting) to curb overharvesting. The study concluded that the documentation of site-scale papyrus users' profile, LEK, and traditional practices are vital for the conservation and management of Loboi swamp.
© 2011 Elsevier Ltd. All rights reserved.

1. Introduction

Wetlands have been referred to as the cradle of human civilization, mainly because they provided grazing areas, food (e.g. macrophytes use as vegetables, fish), rich fertile soil and supplied water for domestic use and irrigation. For example, between 4000 and 5000 years ago, the flood plains of the Nile, Euphrates, Tigris, and Indus Rivers were the economic basis for the advanced cultures of the Egyptians, Sumerians and Harappas (Kramer, 1969; Hammerton, 1972; Boulé, 1994). The uses of macrophytes (and aforementioned uses) have continued to this century and still play an important role in supporting community livelihood (Silvius et al., 2000; Mmopelwa, 2006). However, increasing human population density coupled with worldwide changes in life styles are creating mounting pressures to convert wetlands into land uses such as agriculture, pasture land in addition to climate change and over exploitation of wetland resources (Junk et al., 2000; Owino and Ryan, 2007). As a result, there is an increased risk of losing wetlands as well as the associated traditional uses and practices. The degradation of wetlands resources is happening when we have little information on resource users' perceptions and understanding on sustainable extraction and threats, especially on community utilization of macrophytes (Gichuki et al., 2001; Mmopelwa, 2006). Thus, there is an urgent need to carry out site-specific studies on sustainable community utilization of macrophytes and other wetland resources like those undertaken for fauna such as fish.

Papyrus (*Cyperus papyrus* L.) is one of the most important and popularly used macrophytes in tropics. Papyrus is a highly productive plant with an average aerial dry weight biomass

* Corresponding author. Wetland and Marine Section, Centre for Biodiversity, National Museums of Kenya, P.O. Box 40658-00100, Nairobi, Kenya. Tel.: +254 20 3742131; fax: +254 20 3741424.
E-mail addresses: taaita@yahoo.com (T. Terer), Muthama.Muasya@uct.ac.za (A.M. Muasya), fdahdouh@ulb.ac.be (F. Dahdouh-Guebas), gatereg@yahoo.com (G.G. Ndiritu), ltriest@vub.ac.be (L. Triest).

0301-4797/$ – see front matter © 2011 Elsevier Ltd. All rights reserved.
doi:10.1016/j.jenvman.2011.08.005

Author's personal copy

regeneration of 6.28 kgm^{-2} y^{-1} similar to sugarcane crop (Muthuri et al., 1989). The high productivity of papyrus plays a vital role in ecological functioning and is harnessed for socio-economic purposes. From an ecological perspective, papyrus swamps trap sediments and pollutants entering water bodies (Boar et al., 1999; Kipkemboi et al., 2002) and act as net carbon sinks (Jones and Humphries, 2002). They offer important biodiversity services such as breeding grounds for fish (Mnaya and Wolanski, 2002), grazing fields for wild herbivores during dry seasons (Morrison and Harper, 2009), and habitat for birds such as Papyrus yellow warbler *Chloropeta glacilirostris* O-G. and Papyrus gonolek *Laniarus mufumbiri* O-G. (Owino and Ryan, 2006) both listed as (near) threatened (Bird Life International, 2004; IUCN, 2010). The range of functions and values attributed to papyrus ecosystems are analogous to those attributed to mangroves in tropical coastal areas (Mumby et al., 2004; Dahdouh-Guebas et al., 2006; Nagelkerken et al., 2008; Walters et al., 2008). The socio-economic uses of papyrus are enormous. For example, the ancient Egyptians utilized it to make paper and other products such as boats, mattresses, mats, rope, sandals, and baskets (Sculthorpe, 1967; Bridget and Tait, 2000). Examples of contemporary uses of papyrus include: materials for building houses, fire fuel, and medicine (Jones, 1983; Gichuki et al., 2001; Simpson and Inglis, 2001). In Kenya, papyrus occurs in unique, isolated freshwater swamps and springs of Loboi, Moi-Chepkoilel, Amboseli, Ruiru, Nakuru-Mbaruk river, Londiani-Simboiyot and in large river deltas and shores of Lakes Victoria, Jipe and Naivasha (Boar et al., 1999; Muasya et al., 2004; Terer, 2011). In most of these swamps especially in Lake Victoria, Ruiru and Loboi, there has been significant local exploitation of this species. Notably, there has been a tremendous increase in the use of papyrus to meet subsistence needs of local communities living adjacent to these wetlands, yet available information are skewed to ecological studies (e.g. Muthuri et al., 1989; Mnaya and Wolanski, 2002) and little is known on its sustainable utilization, local ecological knowledge and management practices.

It is apparent among many cultures that inextricable links exist between wetlands and surrounding communities. These links evolved over many centuries (Posey, 1999) and are reflected in various practices adopted to utilize these wetland resources (Terer et al., 2004; Stave et al., 2007). These assemblages of indigenous practices are generally referred to as Traditional (or Local) Ecological Knowledge (TEK/LEK) and are not simply a compilation of facts (Gadgil et al., 1993) but rather a basis for local-level decision-making in forums of contemporary life (Warren et al., 1995). This has been described in detail by several authors (e.g. Olsson and Folke, 2001; Robertson and McGee, 2003; Stave et al., 2007; Brook and McLachlan, 2008; Raymond et al., 2010). The role of LEK in biodiversity conservation, including wetland ecosystems, has been recognized by the Convention on Biological Diversity (CBD) and the Ramsar Convention on Wetlands (Posey, 1999; Ramsar Convention Bureau, 2000). Both treaties acknowledge the complex interactions between humans and nature in the formation and evolution of landscapes. Specifically, CBD and Ramsar recognize the importance of customary practices in biodiversity conservation and advocate for their improvement to make them vibrant and adaptive to holistic systems of environmental management.

In the light of the above, ecological information and socio-economic understanding of local communities must be integrated in order to develop ecologically resilient and sustainable community-based management programs (Berkes and Folke, 1998; Becker and Ghimire, 2003; Terer et al., 2004; Giordano et al., 2010). By using LEK, these communities can both assess and monitor extraction pressures exerted on their resources. Furthermore, LEK often represents less expensive methodologies that can be employed in addition to conventional monitoring methods which tend to be less sustainable as well as unpopular among local communities (Topp-Jørgensen et al., 2005). For example, Dahdouh-Guebas et al. (2006) demonstrated that ethnobotanical surveys and local community perception on the uses of mangrove fisheries related activities is important information that can be used to improve management plans and policies. Biological resources can only be sustainably managed when scientific knowledge of ecosystems are integrated with the LEK of the local people who use and manage these resources (Berkes et al., 1998; Mackinson and Nottestad, 1998; Turner et al., 2000; Armitage, 2003; Brown, 2003; Moller et al., 2004; Terer et al., 2004; Rist and Dahdouh-Guebas, 2006). Most research and monitoring in African wetlands has been biased toward academic knowledge, with little emphasis placed toward management aspects. There are; however, a few examples of management centered research geared toward conservation of some wetlands including Lake Naivasha (Morrison and Harper, 2009), Lake Victoria region (Owino and Ryan, 2007), highland wetlands (Macharia et al., 2010) and mangroves (Kairo et al., 2001). Ethnobotanical and LEK are crucial in the development of particular wetland management plans; however, such data seldom exist on papyrus wetlands in spite of the serious threats these ecosystems face with respect to over-utilization and habitat loss (Crisman et al., 1996; Owino and Ryan, 2007).

The current study was carried out in the Loboi swamp, an isolated freshwater wetland where local people harvest papyrus as an alternative source of income to support livelihood. Sustainable utilization of papyrus swamp has been incorporated in the newly developed integrated management plan for Lake Bogoria National Reserve (LBNR) and its environs, including Loboi swamp which is just 1.5 km away from the LBNR (JMBNR, 2007). Developed under the auspices of World Wide Fund for Nature-East Africa Regional Program Office (WWF-EARPO) through Lake Bogoria Community Based Project, the management plan is a collaboration of all local stakeholders, including the county councils of Baringo and Koibatek, local people, government agencies and nongovernmental organization dealing with environmental issues. The integrated management plan recognizes the significance of LBNR as a Ramsar site that harbors regionally and nationally endangered species of birds (e.g. Lesser flamingos *Phoenicopterus minor* S-H.) and a mammal (Greater Kudu *Tragelaphus strepsiceros* P.). In addition Lake Bogoria together with Lakes Nakuru and Elementaita which form the Lakes System of the Great Rift Valley were inscribed into the UNESCO World Heritage List during its 35th Session (year 2011) in Paris, France; where they were classified as important natural ecological properties in the world. Similarly, the plan acknowledges the strong interconnectedness between ecological components and socio-economic activities within the area. This area is currently threatened by unsustainable human activities and inadequate data on the swamp and the surrounding water catchment areas.

The overall objective of the study described herein was to document and summarize the ethnobiological information and LEK relating to Loboi papyrus swamp. Specifically we sought to: (a) assess the uses of papyrus and its ethnobiological knowledge base, (b) obtain the local people's ecological knowledge and perceptions on harvesting practices in relation to changes in papyrus availability, local harvesting sustainability and regeneration time for papyrus, (c) investigate and document the local management practices that could be incorporated into the integrated management plan of the LBNR, and (d) describe how local practices could be included in LBNR integrated management plan and policy implementations.

Author's personal copy

2. Methods

2.1. Description of the study area

Loboi swamp is situated between Lakes Baringo and Bogoria in the East Africa Rift Valley just 20 km north of the equator at 00°21′N 036°02′E (Fig. 1). It is a freshwater wetland that developed about 700 years BP (before present) on a low relief alluvial plain on the Rift Valley floor (Ashley et al., 2004). LBNR is situated just 1.5 km south of Loboi swamp. The swamp has a surface area of about 2 km^2, ground-water fed by two major springs: Lake Bogoria Hotel spring locally called the spring of men "*Kong'ta|Oine kap murenik*" (Fig. 1a, numbered 1) and Chelaba spring, the spring of women "*Kong'ta|Oine kap kapchepyosoik*" (Fig. 1a, numbered 2). At the southern part of the papyrus swamp is a third smaller spring called the Turtle spring (Fig. 1a, numbered 3), as well as a series of artesian blister bogs (Ashley et al., 2002), which discharge water into the swamp. The swamp supports more than 32 vascular plant species with *Typha domingensis* Pers. occupying 80% and *C. papyrus* L. 20% of the swamp area (Muasya et al., 2004). *C. papyrus* which is the focus of this study occupies the south western part of the swamp and is surrounded by *T. domingensis* except at an accessible western side bordering the fault (Fig. 1a and b).

The climate in Loboi is semi-arid characterized by erratic annual rainfall of about 700 mm in the Rift Valley floor and 1200 mm in the adjacent highlands with potential evapotranspiration estimated at 2500 mm yr^{-1} (Ashley et al., 2004). The rainfall has a bimodal pattern with a short rainy period occurring from October to November and longer rainy period from April to August. The longer rainy period consist of two major peaks, in April to May and in July to August (Johansson and Svensson, 2002).

2.2. Description of Endorois community living around Loboi swamp

The people living around Loboi swamp belong to the Endorois community, a distinct minority group in Kenya included in the larger Kalenjin community. They make their livelihood through a pastoral lifestyle of keeping livestock (mainly cattle, sheep and goats) and subsistence agriculture in the Loboi and Sandai flood plains. For many decades the Endoroi community lived at the shores of Lake Bogoria and the Mochongoi forest. Normally the life of the Endorois people alternated between the Mochongoi forest during the dry seasons and the fertile shores of Lake Bogoria during the rainy seasons. But in 1973 they were evicted from their ancestral land by the government to pave way for the creation of Lake Bogoria National Reserve (LBNR) that consequently gave them limited access to their ancestral land (Key Informants, per. comm.; FGD). As a result, they were displaced into semi-arid lands and denied access to the Mochongoi forest, and the fertile pasture land of Lake Bogoria. The Endorois people had inadequate knowledge of how to cope with the frequent droughts and as a result many of their livestock died and many families became extremely poor (Key Informants, per. comm.). However, in February 2010 the African Commission on Peoples' Rights international court ruled in favor of the Endorois community and instructed the government of Kenya to compensate and return their ancestral land (Kiprotich, 2010a). The court stated that the Endorois had a rich culture as well as a strong attachment to Lake Bogoria and its environs and that should be preserved. Though disrupted by their displacement, there are efforts by LBNR through an integrated management plan to revive as well as document some of their environmentally sustainable practices. The Endorois community has an estimated population of approximately 60,000 people (Morel, 2004;

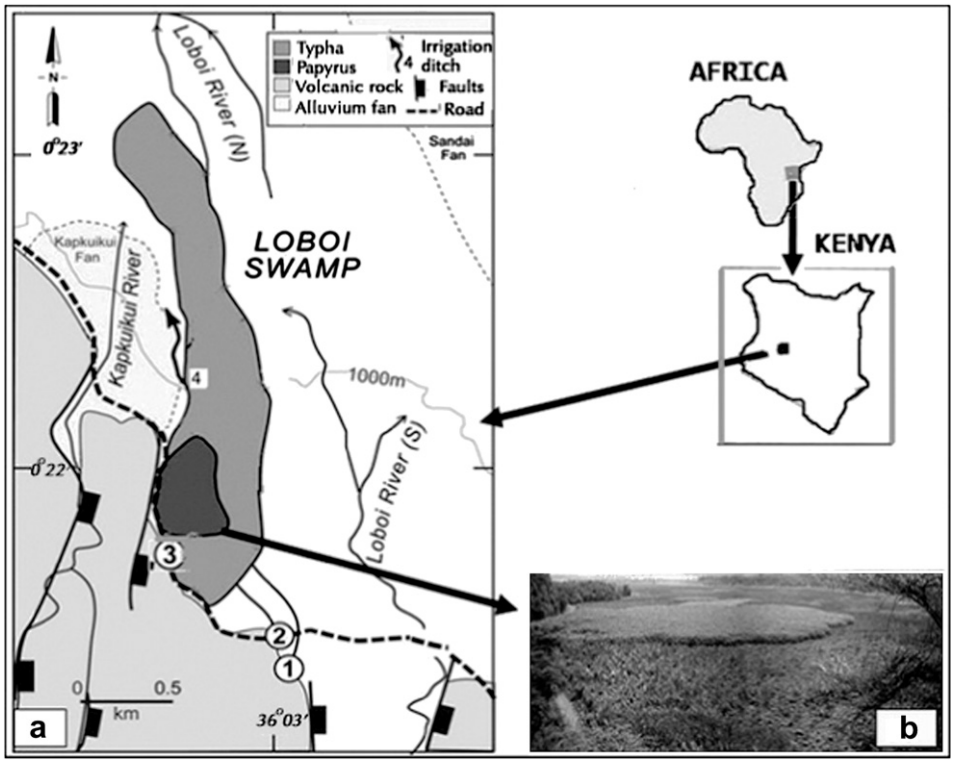

Fig. 1. Inset is a map of Kenya showing the location of Loboi swamp. On the right is a picture of the swamp showing *Cyperus papyrus* swamp (circular patch of vegetation) surrounded by *Typha domingensis* (map modified from Muasya et al. (2004), Photo taken further south of spring 3). The three springs feeding the swamp are numbered 1, 2 and 3 and originate from volcanic faults. Note an irrigation ditch numbered 4, dug in 1970 to channel swamp water for irrigation at Kapkuikui area.

Author's personal copy

Kiprotich, 2010b). Some families live around Loboi swamp, while others were forced to migrate to faraway places in the Baringo and Koibatek districts in search of water and pastures (Kiprotich, 2010b).

2.3. Data collection and analysis

Data concerning papyrus utilization, local perceptions on regeneration, and sustainable harvesting were gathered through semi-directed questionnaires consisting of both multiple and open-ended questions, focus group discussions, and field observations in Loboi swamp. Local harvesters of papyrus (all women) were interviewed in the field as they carried out harvesting or weaving of various handicrafts. Handicraft making has traditionally been viewed as feminine work in the Endorois community except when harvesting for socio-cultural purposes where both sexes have been involved. Some harvesters have organized a local group, the Chelaba Women Group, while others harvest individually. The socio-economic surveys were carried out in September 2008 and February 2009 to coincide with the short rain and dry seasons when most harvesting occurs. Thirty four harvesters were interviewed which consisted of younger (<40 years of age) and older (>40 yrs) members of the community. The study was not designed to test the role of age differences in harvesting practices, but this turned out to be the most significant variable explaining differences among the respondents' answers.

Because many of the respondents were illiterate, semi-structured questionnaires containing multiple choice and open-ended questions were preferred and precautions were taken as outlined by Cohen and Manion (1994) and Huntington (2000). The interviews were conducted in Kiswahili and Kalenjin languages. Local guides were hired and trained to properly administer semi-directed interviews and also served as local translators. Interviews with semi-structured questionnaires were administered to obtain information on utilization of papyrus, perceptions on regeneration, current harvesting sustainability, and management practices by the locals including the harvesters. An important aspect of each interview was to gauge the level of the local harvesters' knowledge about the regeneration rate of papyrus plants and sustainable utilization. Special emphasis was placed on the utilization of the papyrus plant and observations about the changes of its areal coverage over time. In the semi-structured questionnaire we asked for quantitative assessments of harvesting practices and perceived changes in papyrus resource availability in terms of accessibility of the right sizes (height) to harvest over time (Table 1). Questions relating to the number of mats made per day and papyrus stems used were sought from the harvesters. Focused group discussions (FGD) and interviews of key informants were used to get more information, in-depth knowledge, and verification of information not clear from individual-harvesters. Specifically FGD were useful in understanding the community history, isolating the existing traditional, and emerging local practices in relation to use of papyrus and LEK relevant for conservation. This complemented the use of semi-structured questionnaires interviews. Three FGD were held and 15 key informants consulted. Two FGD were conducted with papyrus harvesters and one with other community members around the swamp. In addition, more information was sought from the existing policy documents especially the LBNR integrated management plan 2007–2012 (JMBNR, 2007), Baringo District Development Plan 2002–2008 (G.o.K, 2002) and a draft of Kenya National Wetland Policy (G.o.K, 2008) in order to understand the policy issues, management options, and research gaps.

Descriptive statistics were used to explore harvesters' characteristics otherwise presented as percentages. Spearman's rank correlations analysis using STATISTICA (StatSoft, 1996) was carried out to determine associations between respondents' variables relating to utilization of papyrus. Multivariate analysis based on a matrix of standardized variables, appropriate for mixed sets of ordinal and continuous variables (ter Braak, 1987) was used to analyze the data with CANOCO Version 4.5 (ter Braak and Smilauer, 2002). Only eigenvectors with eigenvalues of more than one were considered and Principal Component Analysis was preferred because the gradient of all axes was less than two.

3. Results

Data obtained by this study showed that a strong relationship existed between Endorois community and Loboi swamp. The swamp was a major source of livelihood for many families, mainly through utilization of papyrus for various uses, farming and livestock grazing. Three factors (age, experience of papyrus harvesters and individual vs group-harvesters) determined the degree of utilization of papyrus and resource availability in the swamp. A significant percentage of the papyrus harvesters felt that the swamp was threatened; mainly by water abstraction for irrigation purposes. Information gathered during FGD shows that the Endorois community are endowed with immense local/traditional ecological knowledge and was very essential in determining their utilization strategies in Loboi swamp and the surrounding ecosystems. Details and analyses of the key results of this study are described below under (a) local people means of livelihood, (b) utilization of papyrus, (c) perceptions on sustainability, (d) threats and (e) local management practices.

3.1. Harvesters' characteristics and means of livelihood

The information collected from papyrus harvesters revealed that their ages ranged from 20 to 67 years, distributed as 58.8% young (<40 years) and 41.2% old (>40 years). Harvesters' average residence time (years lived in the area) was 24 ± 12.2 (±std). The households main source of income were farming (38.2%), livestock keeping (11.8%), and to a lesser extent bee keeping. All households practiced subsistence farming while commercial farming was only done by a few families who were contracted by the Kenya Seed

Table 1
Description of the five semi-structured questionnaire variables used in the principal component analysis (PCA).

Variables	Abbreviation	Questions/description	Type of variable
Difficulty	DIFCULT	Has the difficulty of finding papyrus stems suitable for harvesting increased (3), remained the same (2), or decreased (1) over time?	Ordinal
Trend in average daily harvest	TREND HD	Have average daily harvests increased (3), decreased (1) or stayed the same (2) over time?	Ordinal
Return	REVISIT	Number of months waited before returning to harvest at the same location/point	Continuous (Log)
Average daily harvest (number of stems)	ADH	Present day daily harvest	Continuous (Log)
Experience	EXPERT	Years of harvesting papyrus	Continuous (Log)

Author's personal copy

Company to produce hybrid maize seeds. Farming was practiced in the Kapkuikui plains with irrigation water derived from Loboi swamp (Fig. 1a). This represented a profitable venture that has substantially increased the farmer's income. Frequent droughts and continuous loss of livestock have forced most locals to shift to farming activities. Bee keeping, with households having an average of five beehives, is gaining popularity in the area; however, it does not represent a major source of income. Monthly households' income during the month of September 2008 (1 EUR = 100 KES) ranged from 8 to 120 EUR (with 14.7% of households earning less than 10 EUR; 67.6% [10 to 50], 14.7% [51 to 100] and 2.9% earned more than 100 EUR). The low income earned from subsistence farming has forced some locals to engage in papyrus harvesting to make mats and handicrafts as an alternative source of income. This occurs mainly during the dry seasons and can contribute to yearly average of 50 EUR per household. The distance traveled by harvesters to the swamp ranges from 1 to 10 km (mean: 3.5 ± 1.8 (±std)). The number of years that respondents were involved in harvesting papyrus (proxy of experience) for both socio-cultural and economic purposes ranged from 2 to 29 years with a mean of 11.7 ± 5.8 (±std). Each harvester cut an average of 92 ± 48 (±std) stems of papyrus per day which corresponds to removing stems in an area of 2 m^2 (50 stems/m^2). This amount of stems can make one mat measuring 6 ft by 3 ft. The process of making one mat (harvesting, splitting into strips, drying in the sun and weaving) take a minimum of 5 days for an experienced harvester i.e. over 10 years of harvesting.

3.2. Ethnobiology and local uses of papyrus

The species *C. papyrus* was unambiguously identified and was not confused with other Cyperaceae plant species in Loboi swamp. The local (or Endorois) name for papyrus is "*Kutwee*" which according to key informants means "crown or majesty". This is a term given to honor triumphant individuals in the community. This is signified by the umbel inflorescence of the papyrus plant. The respondents gave three descriptions of papyrus based on the uses and habitat when asked to 'say more' about the plant. The majority of respondents (50%) described it as a plant associated with blessing rituals and traditional ceremonies, 38.2% as a water plant, and the remaining 11.8% perceived it as a plant for making mats.

The utilization of papyrus in Loboi swamp was primarily for local livelihood. Respondents identified five major uses of papyrus (Fig. 2a–f) as socio-cultural uses (60% of the respondents), making of mats (52%), fodder (47.1%), roofing (23%) and fuel (2.8%). Socio-cultural utilization consisted of traditional dances (use of the umbel) and rituals (use of both umbel and rhizome) for cleansing and blessing ceremonies to avert drought calamities and outbreak of diseases in Endorois's land. Most papyrus mats were for sale although locals also used them in their homes as bedding or sleeping mats as well as ceilings in their houses. In-depth investigation into the use of papyrus as sleeping mats revealed that they were preferred by the locals over traditional sleeping material (i.e., cow's skin) and conventional mattresses. Sleeping mats were

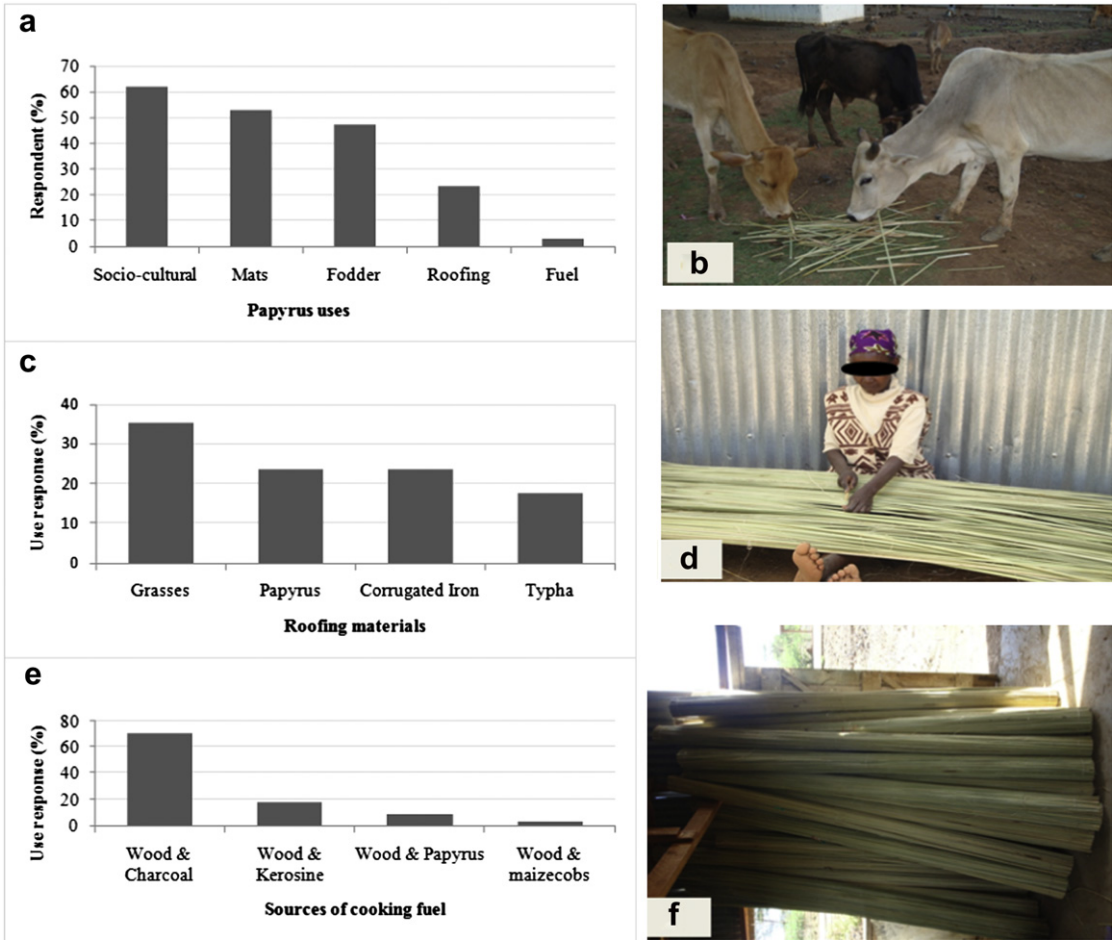

Fig. 2. Local utilization of *Cyperus papyrus* in Loboi swamp (a), cattle feeding on dry papyrus culm/stems cut from finished mat (b), the main sources of roofing materials (c) and cooking fuel for Loboi community (e), papyrus harvester making mats (d) and finished mat products (f). Photos taken by Terer, T.

Author's personal copy

considered superior to traditional cow skins and mattresses because they do not retain urine (especially in the case of bed-wetting with young children), do not require washing (only drying in the sun), and are inexpensive and readily available. When used underneath conventional mattresses, they are known to prevent wear and tear, thus increasing their longevity and were highly valued by the local people. Investigations into the sources of roofing materials and fuel wood showed that most locals obtained their roofing materials from graminoids or grasses (35.5%), followed by papyrus (23.5%), corrugated iron (23.5%) and *Typha* species (17.6%). The use of corrugated iron sheets to build houses is gaining prominence in the area as they were perceived as a sign of affluence, durability and saved time (otherwise spent looking for grasses). One respondent when explaining the advantages of using corrugated iron said "*they save the time, which can be used to do other work, minimize unnecessary quarrels among neighbors when cattle destroys or eat someone else and your roof*". This was mainly in reference to instances where cattle destroyed their houses by feeding on the dry roofing materials such as grass and papyrus which frequently leads to complaints by the affected family. It was also noted that corrugated iron sheets can have disadvantages. For example, foods such as milk spoiled more quickly under corrugate iron roofs because the structures became extremely hot inside as opposed to macrophyte and grass- thatched houses. Secondly, iron sheets are relatively expensive and cannot be afforded by many local people. Fig. 2(e) shows that wood and charcoal (70.6%) were the main sources of cooking fuel, followed by combinations of wood and kerosene (17.6%), wood and papyrus (8.8%) and wood and maize cobs (2.9%).

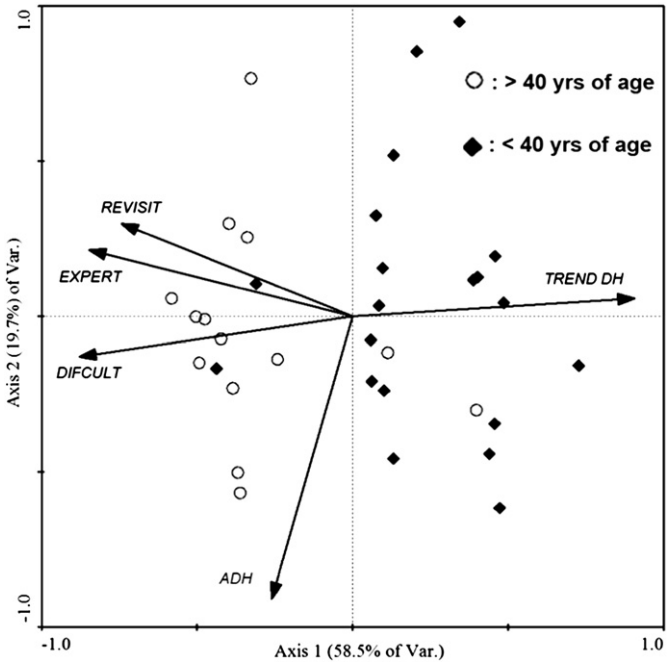

Fig. 3. A PCA biplot showing the correlation between papyrus resources availability and harvesters' perceptions. Variations explained by the first and second axis are 58.5 and 19.7%, respectively. Full names of abbreviated perception factors are given in Table 1. The labels indicate whether the respondent was younger (◆) or older (○) than 40 years of age.

3.3. Perception on papyrus resource harvesting, sustainability and regeneration

The local people's perceptions of harvesting practices and the changes in papyrus resource availability over time, were explored using multivariate analysis. PCA axis 1 accounted for 58.5% of the total variance and correlated with four questionnaire variables, while the remaining one variable correlated with PCA axis 2 which accounted for 19.7% variance (Table 1, Fig. 3). PCA axis 1 relates to papyrus harvesting practices (REVISIT), harvesting experience (EXPERT), availability of suitable stem sizes (DIFCULT), and intensity of harvesting (TREND DH) by group-harvesters, while axis 2 is related to the amount of harvested papyrus (ADH) in regard to group-harvesters vs individual-harvesters. The PCA biplot revealed two major groups of group-harvesters based on age: the older (over 40 years) and younger (below 40 years). The older group consisted of experienced harvesters, who took longer times to return to harvest in a given location (or point) and reported having difficulties obtaining stems of suitable height to harvest. In contrast, the group of young harvesters did not perceive changes in resource availability such as decreasing trends in daily harvests suggesting that they were not keen in detecting change in the resource perhaps because they are inexperience, strong and can easily penetrate into the swamp. Both groups; however, seemed to cut the same number of stems when they visited the swamp as suggested by PCA axis 2 (Fig. 3). Further exploration of PCA (Fig. 3, upper parts of axis 2) showed that individual-harvesters harvest more on average than group-harvesters irrespective of their age and experiences. Further analyses showed a high degree of association between age and perceptions of papyrus resource availability (Table 2), which was consistent with results obtained using PCA (Fig. 3). Age significantly and positively correlated with (a) the elapsed between a harvesters' return (REVISIT) to harvest papyrus at the same locations (or points) in the swamp, (b) experience of harvesting (EXPERT), (c) residence time (LIVETIME), (d) the distance penetrated inside the swamp (DISWAMP) to search for suitable stems, but negatively correlated with trends in daily harvesting (TREND DH) ($p < 0.05$).

With respect to resource sustainability, 87% of all the respondents considered the current harvesting of papyrus in Loboi swamp to be sustainable and gave a variety of answers explaining why papyrus could not be exhausted. Over 60% reported that papyrus regenerates fast enough to recover from harvesting, while 29% attribute it to availability of enough water in the swamp. The harvesters used varied expressions when referring to regeneration such as "*grow rapidly*; *grow in large numbers*; *grow quickly*; *multiply fast* and *mature rapidly*". The harvesters were fully aware that papyrus was a water dependent plant that could not survive without water in the swamp, thus represented key local ecological knowledge together with the understanding of regeneration characteristics of papyrus. Nineteen percent of the respondents maintained that there were low levels of exploitation of papyrus because only a few people were involved in the harvesting. This low level of exploitation was attributed to lack of modern harvesting equipment and markets for papyrus products. Young women reported that they would harvest more if the area covered by papyrus were to be increased from its current coverage. At the moment, the relatively small area of papyrus coverage is preventing large-scale harvesting. According to them, an increase in papyrus area would be favorable because it would allow large-scale harvesting to be carried out in the future. Meanwhile 13% of the respondents agreed that the strategies adopted by harvesters had assisted in minimizing the depletion of papyrus; whereas, 10% believed that since the swamp was protected so was the papyrus. For instance, local harvesters reported having adopted best harvesting practices such as rotational harvesting. Six percent of the respondents mentioned inaccessibility during wet seasons and informal harvesting (part-time job) as reasons that will ensure that papyrus will not be depleted. The reasons given for inaccessibility during the wet

Author's personal copy

Table 2
Spearman's correlation between harvesters' age, perceptions of papyrus resource availability and utilization. Asterisks (* and **) means significance level accepted at $p \leq 0.05$ and $p \leq 0.01$ respectively. Variables are abbreviated as follows: AGE-respondent age, LIVETIME-residence time, EXPERT-experience in harvesting, REVISIT-return time in months to harvest from the same point, DISWAMP-distance penetrated into the swamp in search of papyrus of suitable height, DIHOME-distance to the swamp from their homes, DIFCULT-difficult in finding payrus of suitable height to harvest, ADH-avarage daily harvest, TREND DH-trends in daily harvest, IND HARV-individual-harvesters, GR HARV-group-harvesters.

	AGE	LIVETIME	EXPERT	REVISIT	DISWAMP	DIHOME	DIFCULT	ADH	TREND HD	IND HARV
LIVETIME	0.57*									
EXPERT	0.75**	0.80**								
REVISIT	0.49*	0.48*	0.63**							
DISWAMP	0.66**	0.42*	0.59*	0.41*						
DIHOME	−0.32	−0.27	−0.33	−0.34	−0.18					
DIFCULT	0.66*	0.42	0.59*	0.41*	1*	−0.18				
ADH	0.15	0.14	0.15	0.08	0.22	−0.25	0.22			
TREND HD	−0.70**	−0.50*	−0.65**	−0.47*	−0.94**	0.16	−0.94**	−0.17		
IND HARV	−0.27	−0.29	−0.26	−0.21	−0.13	−0.03	−0.13	0.43*	0.19	
GR HARV	0.27	0.29	0.26	0.21	0.13	0.03	0.13	−0.43*	−0.19	−1

seasons were that the swamp depth increases as you get inside and the harvester risks drowning, as well as a fear of animals such as crocodiles and snakes. Indeed harvesters reported seeing crocodiles move downstream into the swamp during the wet seasons. For the local harvesters, papyrus harvesting was a seasonal and an informal activity that most of them undertook when they were free especially during weekends and when special demands for mat products are high. In contrast, 13% of all the respondents replied that the current harvesting of papyrus was not sustainable because all the community members wishing to harvest were free to do so. They expressed concerns that there was a great danger of overharvesting if papyrus products were to increase in demand and fetch higher prices. This fear concurs with the responses on whether or not there was restriction over who to harvest papyrus amongst community members, in which 90% said there was no restriction, with the exception that they will not allow outsiders to harvest. The notion of no restriction and fears of overharvesting was agreeable with other members when the same issue was revisited during FGD.

On whether it was good to have more papyrus or not, all the respondents except one reported that it was good to have more papyrus because it was a source of income, fodder for their cattle, and it ameliorates the dry climate of the area. The one respondent who viewed papyrus as bad claimed that it harbors' mosquitoes and tsetse flies as well as occupying land suitable for cultivation and grazing fields. The FGD confirmed the prevalence of mosquitoes and tsetse flies in the swamp but did not blame that entirely on papyrus alone but on other wetland vegetation as well. Most of the harvesters had adequate ecological knowledge about the time it takes for papyrus to recover after harvesting with 73.5% reporting a fast recovery period of 6 months while another 23.5% as less than three months, with only one harvester reporting more than a year (Fig. 4).

3.4. Threats to papyrus swamp

Perceptions on the future areal coverage and use of papyrus were also sought from the harvesters. In the foreseeable future 76% of the harvesters predicted a decrease in the coverage area of papyrus, 14.7% said no change, and 8.8% predicted an increase. Those predicting a decrease attributed it to the present diversion of water (29.4% of the respondents) from the swamp for irrigation (using irrigation ditch numbered 4 in Fig. 1a) around Kapkuikui, and other areas where they depended on the Loboi River before it changed its course. Other reasons given for a predicted decrease of the swamp included frequent droughts (23.5%) and the overharvesting of papyrus (23.5%). The main external challenge at present is the change in the course of Loboi River which was supplementing some local uses of water thus more pressure is now exerted on the available spring water. During the course of our study, it was confirmed to us that Loboi River changed its course in 2002 to the present point where it is draining directly into Lake Bogoria. However, local people who predicted an increase of the area under papyrus gave high regeneration of papyrus as the main reason. Interestingly a 67 year-old respondent who has been utilizing the papyrus for the last 29 years said "*they will increase because of their quick germination*". Those who predicted no change or constant areal coverage also attributed it to quick papyrus regrowth and constant availability of water in the swamp.

3.5. Local management practices

Focused group discussions highlighted local ecological knowledge and management practices relating particularly to the harvesting of papyrus and the swamp in general as explained in detail in Table 3. The swamp is protected from burning, with the last fire occurring in 2005. Limited entries are made into the swamp during the rainy season. There is restricted access for grazing and hunting of wildlife in the swamp, with wildlife kept away from the swamp. Papyrus harvesting is done on purpose, selectively and in rotation, allowing time for plants to grow. However, there was no evidence of synchronization in conservation management initiatives and utilization activities for individuals using swamp water to irrigate their farms.

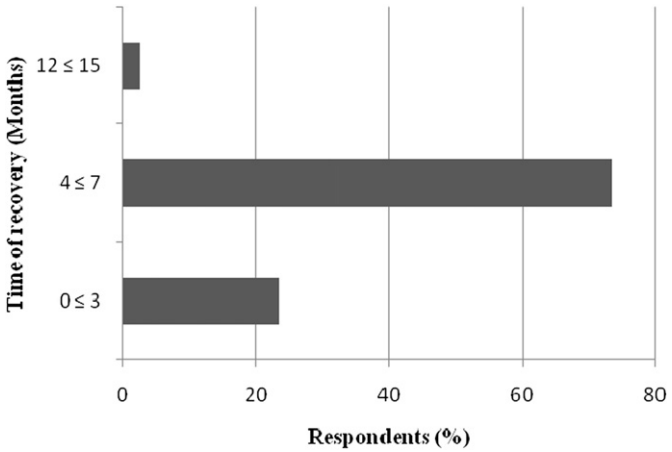

Fig. 4. Local community harvesters knowledge on the recovery of papyrus after harvesting in Loboi swamp, $N = 34$. Papyrus reaches its maturity in approximately 6 months (Muthuri et al., 1989).

Author's personal copy

Table 3
Local management practices generated from focused group discussions in Loboi swamp, Kenya.

Practice	Description of the management practice on papyrus stands
Banning of burning	In some occasions cattle herders burnt vegetation during the dry periods to remove old growth and to trigger the regeneration of fresh grass. Such burning last occurred in 2005 when the swamp was completely burnt. Since the community started utilizing the papyrus to make the new handicraft products, this practice has been banned and is punishable if any one goes against. The ban is imposed by the local elders including the area chief.
Rotation harvesting	Rotational harvesting is done in sections or "corners" to allow re-growth of the harvested sections. Though physically this was not well defined, it was intrinsically practiced among the harvesters. This practice is also called 'paddocking harvesting' or 'cutting at the selected areas at a time'.
Purposeful harvesting	Harvesting of papyrus for no intended purpose was strictly restricted by the elders. Children especially boys who are known to be involved in local games such as bird hunting are not allowed to cut papyrus as hunting sticks.
Selective harvesting	The harvesters have inculcated some form of control among themselves on the age of the stem to be harvested. Mature stems were recommended among harvesters. The local harvesters agreed that they tried as much as possible to selectively harvest mature stems. The market requirements of ceiling products also demands that they should harvest stems of a required length. The standard length of mats locally referred to as "jambi" is 1.8 m by any width starting from $\geq$ 1 m. They also harvest the papyrus stem at the above last sheathing leaf (more than 0.05 m above the ground).
Wet-closed seasons	There was limited entry of the swamp during the rainy season. During this period, local harvesters divert their attentions to subsistence farming. Limited harvesting was only done for restocking the handicraft shop when demand of the papyrus products was high. In addition, increased water levels, risk of drowning and meeting dangerous animals such as crocodiles add to this limited entry of the swamp during the wet spells. This scenario was similar to close seasons applied in fish management, with no control in strict sense.
Control of Typha expansion	In Loboi swamp two emergent macrophytes species, the *Typha domingensis* Pers. and *Cyperus papyrus* L. are the dominant plants. There is a clear boundary separating the two species (also see photograph in Fig. 1b). *Typha* occupies the outside i.e. landwards except on the side of volcanic fault rock i.e. where the road passes, while papyrus is on the inside permanent swamp (Fig. 1b). The boundary between the two species is dynamic and has been observed to shift seasonally in response to changes in water levels. The harvesters are aware of this ecological phenomenon and in order to promote the proliferation of papyrus they cut or cull the *Typha* species giving room for papyrus to grow. This is normally done during dry seasons because *Typha* tends to extend inwards following the drying land.
Practice	Description of management for the whole swamp area
Control cattle grazing in the swamp	Cattle grazing is not allowed in the swamp. This practice is aimed at protecting the papyrus and other emergent macrophytes from being trampled over and destroyed by livestock as well as to protect the entire swamp which is considered as a water fountain source by the locals.
Chasing wild animals near wetlands	This is an activity done to limit wild beasts from entering the wetlands especially the zebras. This is because they graze on the wetland plants and drink the water. Loboi swamp is about 1.5 km from Lake Bogoria National Reserve, which forms a good habitat for grazers such as zebras and antelopes. Though there are a number of freshwater springs within the reserve, there is an increased demand for watering points during the dry spells, the reason why wild animals migrate outside their ranges in search of water and fodder. Loboi swamp is one of those few alternative sources in the vicinity.
Awareness raising campaigns	There have been campaigns on the proper management of wetlands in the area spearheaded by WWF in collaboration with local community, county councils of Baringo and Koibatek who are mainly responsible with the management of Lake Bogoria National Reserve and assisted by KWS. The locals, who are responsible for the management of Loboi swamp, have agreed to manage the two important ecosystems together. Activities that go with these campaigns include local people participating in the construction of gabions and terraces to control soil erosion during floods which is quite widespread and serious in this area. At the moment the National Museums of Kenya (NMK) have targeted papyrus harvesters in a series of public awareness and educational activities on the value addition of their handicraft products and finding markets with strong wise use activities in and around the wetlands.

4. Discussion

This study gathered enough data in relations to our research questions on Loboi swamp's resources/papyrus uses, the local people's ecological knowledge on sustainability of resources, LEK/TEK that could be incorporated into the integrated management plan of the LBNR, and LEK/TEK that could be used in policy formulation and implementation. Equally information was compiled on how ethnobiological data can be used in wetland management as well as development of conservation policy at national level. Overall our results were consistent with studies done elsewhere on the uses of wetlands (e.g. Gichuki et al., 2001), threat (Owino and Ryan, 2007), sustainable use (Macharia et al., 2010) and use of LEK/TEK in management of natural resources (Terer et al., 2004; Stave et al., 2007). Moreover, wetlands resources act as lifeline and are known to support livelihood of many communities especially in regions where poverty is endemic (Silvius et al., 2000; Gichuki et al., 2001; Mmopelwa, 2006). Interesting, these areas are mostly characterized by limited sources of income to cater for community needs such as food, fuel, shelter, health and education. Thus the high reliance of macrophytes (except for socio-cultural uses) is normally driven by the need to alleviate poverty levels among the rural people living near wetlands, such as the case for this study.

4.1. Profiling and understanding papyrus uses

It is clear from this study that Loboi papyrus swamp provided important values and services that satisfied Endorois basic social human needs which revolved around shelter (thatching), energy (fuel wood), food (fodder), income (sale of mats) and social/spiritual needs (dances and ceremonies). The income obtained from sales of mats and other handicraft products though relatively small per household (about 5 Euro/month = 500 KES) was an important source of money that was used to buy household necessities (e.g. sugar, paraffin for lighting at night, salt, cloths). There are potentials to gain more profits from the use of papyrus to make small handicraft products. This is especially so, if local conservation and cultural messages are incorporated in their design and production, targeting the growing tourism industry in the area. For example, a standard mat measuring 6 ft by 3 ft (180 cm by 90 cm) which is currently sold for 1 Euro (100 KES) can make 162 small products measuring 10 cm by 10 cm which when local wildlife (e.g. threatened greater kudu *Tragelaphus strepsiceros*) and cultures are

Author's personal copy

incorporated, can fetch up to 5 Euro per item translating to 810 Euro (81000 KES). This will not only become an incentive for local conservation but also will reduce the amount of papyrus harvested since more emphasis will be placed on the design as well as local conservation messages. While this will attract more harvesters due to the accrued benefits, it will also counteract the effects of harvesting because of the time invested in value additions and designs (e.g. decorations), the high monetary value obtained, and many products produced in a small area harvest (2 m^2) which is enough to meet the market demands. Mat making using papyrus especially for sale and local use as a house ceiling is also common in other parts of Africa particularly in the Lake Victoria region (Abila, 2002), as sleeping mats in Botswana (Van Wyk and Gericke, 2000), and West Africa (Burkill, 1985).

The uses of papyrus as thatching or roofing material in the Loboi area was minimal (Fig. 2a and b) and according to the local people, households with houses roofed with papyrus alone are rare because they are less durable when compared to those made from grasses. Generally, some households had more than one house; the main house was roofed with grasses and other sedges (common in many households), the second with corrugated iron sheets, and the third with either *Typha* or papyrus. Perhaps minimal knowledge with respect to the thatching process using papyrus among the local people has contributed to its unpopularity. This is in contrast to the Luo people of the lower Sondu Miriu wetland in Lake Victoria who use it as principal source of roofing material (Gichuki et al., 2001). The corrugated iron sheets are slowly gaining prominence in the two regions even though they are considered costly by many local people.

Fuel sources are a vital necessity among all communities worldwide. In developing world, the rapid disappearance of fuel wood trees and high prices of fossilized fuel products have intensified the uses of macrophytes as an alternative sources of fuel. For example, in Lake Victoria region (Kenya) where shortages of fuel has been reported, papyrus and other macrophytes are the main sources of cooking fuel especially for the poor who cannot afford to buy charcoal (Gichuki et al., 2001). The majority of the people in Loboi area use fuel wood and charcoal as the main source of energy for cooking (G.o.K, 2008). The presence of prosopis, *Prosopis juliflora* (SW.) DC, an introduced and invasive tree species in the study area, is supplementing shortages of fuel wood and charcoal that is relatively scarce around the swamp. However, a combination of wood and dry papyrus (though at insignificant levels) represents a new source of fuel for cooking; made from leftovers of trimmed-finished mat products and pieces of dry wood. In addition, dry papyrus culms are fed to livestock during the dry season and this was common among the female papyrus harvesters who fed the cattle the unused trimmings from finished mat products (also see Fig. 2b). According to Muthuri and Kinyamario (1989), the papyrus nutritive values of crude protein and ruminal dry matter digestibility are high and comparable to those of rangeland grasses. Thus the use of papyrus plants as sources of fodder during dry season when other forms of forage are scarce was scientifically sound LEK. Importantly, livestock and their products are a main source of livelihood to the locals and the presence of the swamp resources contribute to their survival in this dry landscape.

It is well known that uses of natural resources (e.g. plants) that are embedded in the traditions of people serve as an important premise for their conservation and protection (e.g. Terer et al., 2004; Stave et al., 2007). People living around Loboi swamp used papyrus during socio-cultural activities, such as rituals and traditional dances. This use has resulted in an intrinsic attachment between the people and papyrus. As such, the plant is associated with honor, respect, and majesty. A 60 year-old elder of the community explained that as part of performing important rituals such as cleansing the Endorois lands against hard periods such as droughts and outbreaks of diseases, papyrus rhizomes are cut into pieces and given to ritual participants as a sign of unification against the bad events. Part of the ceremony also required ritual participants to put some pieces of the rhizome into traditional water pots they use at home to store water (P. Chepkirwok, pers. comm.). To the best of our knowledge nowhere else in Kenya, is papyrus used for socio-cultural purposes; however, in Gabon, West Central Africa papyrus is used for religious purposes, where dried rhizomes are chewed in order to ward off evil spirits (Burkill, 1985).

The above socio-cultural (traditional uses) and livelihood support values (emerging uses) form important pillars for sustainable utilization of papyrus in Loboi swamp. Thus by providing papyrus users' profile, this study would helped in understanding the needs of local people in relations to the rising poverty levels and in addressing issues touching on sustainability of the resource. The identified traditionally-embedded and emerging uses that support livelihood, shed light on the extent in which the papyrus resource is valued by the community.

4.2. Sustainability and resilience of papyrus

The understanding of community LEK, perceptions on sustainability and harvesting patterns can reveal relevant information for conservation (Topp-Jørgensen et al., 2005; Dahdouh-Guebas et al., 2006; Raymond et al., 2010). In our study, the harvesters' LEK and age determined the levels of harvesting with utilization pressures being intense on nearer and more accessible points. Owino and Ryan (2007) found that the most accessible areas of papyrus swamp in Lake Victoria experienced more disturbances and were characterized by shorter, less dense stands. During the current study, most respondents aged 40 years and above had noticed difficulties in getting stems of suitable height, a decreasing trend in daily harvests, and spent longer times to obtain enough harvest in nearer locations when compared to young respondents (Fig. 3). This suggested implicit local knowledge (cf. Fazey et al., 2006) perhaps due to the old harvesters' experiences in proper use of other natural resources (e.g. selection and non-destructive nature of picking medicinal plants) which made them aware and keen to detect changes in the new found utilization of papyrus. Meanwhile, the inexperience young harvesters who are assumed to be more energetic than old harvesters could easily penetrate further into the swamp hence were likely to cause further reduction of stem sizes due to the effects of repeated harvesting at the same location. However, the non-sustainable harvesting practices employed by young harvesters were moderated by group-harvesting practice where members were required to make equal number of mats (equal efforts). Meanwhile two groups of harvesters also emerged irrespective of their ages and experiences; namely the individual-harvesters who harvest more on average than the group-harvesters who harvested less (Fig. 3, upper ends of axis 2). This further showed the advantage that goes with group-harvesting practice in the sustainability and wise use of papyrus, in a sense that the actions of inexperienced and the competitions elements are moderated by virtue of group common goals and equitability. Thus it became apparent from this study that inexperienced harvesters and individual harvesting practices are more likely to degrade wetlands than the experienced group-harvesters and their practices. Past studies of papyrus in Lake Victoria showed that continuous harvesting reduced biomass per unit area and height (Owino and Ryan, 2007), with utilization of the papyrus swamp in this region being dominated by individuals and inexperienced harvesters (Terer T., pers. observ.).

The assessment of local Peoples' knowledge on sustainability and resilience of the resource under use is critical in management.

Author's personal copy

Two kinds of sustainability views, namely the majority and minority emerged from our study. The majority of the respondents shared the view that the current level of harvesting was sustainable. This view was primarily based on local knowledge that papyrus regeneration was fast, had enough water available, and the adoption of appropriate harvesting practices by the local people. To a certain extent this understanding formed a prerequisite for the management of the papyrus because significant population of harvesters' knew an increase in their numbers would lead to improper utilization practices and activities, subsequently affecting the ecological health of papyrus stands. Meanwhile some of the appropriate practices (e.g. rotational cutting) highlighted in this study have also been used in the management of other ecosystems (Berkes et al., 2000; Stave et al., 2007; Raymond et al., 2010). However, views of a few of the respondents that the present harvesting regimes are not sustainable are equally important. They believed that papyrus was a communally owned resource and that any member of the community wishing to harvest was free to do so. However, this is a situation that can become risky if the demand and prices of papyrus products increase from the present value of 1 EUR per sleeping mat. In fact, according to harvesters (90%) there was no restriction of who can harvest amongst the residents and the restriction measures that were mentioned by ten percent was referring to the outsiders or non-residents of the area. One way to counteract this situation is by value addition and making of small papyrus products that lead to more monetary value of small harvest as suggested earlier in section 4.1 of this study. Another aspect of LEK in utilization of papyrus that would aid in sustainable use is the majority of the harvesters (76.5%) who are knowledgeable about the recovery period of papyrus, which most estimated to be 4–7 months. According to Muthuri et al. (1989) papyrus takes 6 months to reach maturity. In the meantime a substantial number of people (23.5%) did not to know the time papyrus requires to recover after harvesting despite their involvement in papyrus harvesting for over two years. This is a management concern that requires actions that facilitate sharing and exchange of local ecological knowledge relevant in the wise use and conservation of Loboi swamp. This can be done e.g. through community workshops, given that the current study explicitly documented the local ecological knowledge, perceptions and management practices.

4.3. Understanding threats facing papyrus swamp

It is long recognized that wetlands is one of the threatened ecosystem due to anthropogenic related activities including climate change (e.g. Dugan, 1990). A significant percentage of people living around Loboi swamp were aware of the threats, loss, and degradation of the swamp in spite of the present traditional conservation initiatives. Interestingly, this concurred with aerial photographs taken between 1969 and 2002, which illustrated a decrease in the area covered by swamp by approximately 60% (Ashley et al., 2004). Presumably this is mainly attributed to the siphoning of swamp water for irrigation, which the locals did not fully agree. The local people attributed the decrease of swamp area to frequent and prolonged droughts affecting water inflow from spring aquifers. Though the swamp is fed by underground aquifers, climate changes could certainly affect its hydrology. According to various sources (e.g. Thompson, 1996; Junk, 2002) the impacts of climate change are prevalent in Africa. For instance, the disappearance of 80% of the glaciers on Mount Kilimanjaro as well as other tropical glaciers is attributed to climate change (Thompson et al., 2002; Eggermont et al., 2010). The effects of such phenomena have been a significant reduction in the surface and subsurface flow of water down the slopes, a scenario common in other watersheds worldwide (e.g. Dugan, 1990). Thus communities relying on wetland resources such as fish (Allison et al., 2009), water, and plants for their livelihood are amongst the most vulnerable to the effects of climate change. Meanwhile human related activities such as overharvesting and diversion of swamp water for irrigation were identified as potential threats to Loboi swamp, a situation similar to other well studied wetlands in Eastern Africa (Gichuki, 1992; Owino and Ryan, 2007). While the present utilization of papyrus in Loboi swamp seems to be sustainable, ever increasing poverty and population levels are likely to lead to increased harvesting and greater diversion of water for agricultural uses as was suggested by 70% of the respondents. Viewed as free and an open resource by most members of the community, there is a high potential for over exploitation and degradation leading to a "tragedy of the commons" situation in the near future (Hardin, 1968). For instance, the mere perception that some individuals or group members are benefiting from a communal resources (harvesting papyrus) is enough reason for others to try to obtain that benefit too. To a certain extent PCA results (Fig. 3) captured this trend, though to a lesser degree, that an individual harvester tends to harvest more on average when compared to group-harvesters irrespective of their ages and experiences. It is crucial that this finding is put into consideration in the local management of the swamp by encouraging individual-harvesters to join the existing group (Chelaba Women Group) to help them better assess and monitor swamp resources.

4.4. Local management practices in relation to uses and sustainability

Local ecological knowledge including new and traditionally embedded practices is vital in the management of community natural resources (Robertson and McGee, 2003; Terer et al., 2004; Stave et al., 2007). Our study identified two types of local management practices in Loboi swamp: those relating directly to the harvesting of papyrus and another applying to the general conservation of the swamp. The latter consist of traditional practices meant to protect the swamp from unsustainable practices and include the control of cattle grazing near the swamp (normally by selected men referred to as "grazing guards"), chasing away wild animals and prohibiting cultivation near the swamp. The emerging management practices relating to papyrus harvesting consist of burning bans, rotation, purposeful and selective harvesting, wet-closed seasons, and control of *Typha* proliferation. These new management strategies were in response to emerging papyrus uses particularly that of mat making. It is clear from this study that the inception of mat making and the adoption of new local management strategies in Loboi swamp are very recent as confirmed during focused group discussions. The introduced new management practices relating to harvesting of papyrus consequently led to a positive shift in the resource management paradigm. For many pastoralists, the burning of vegetation in the grazing land or swamp during the dry season was a common practice to remove old growth, control pests and bush encroachment as well as trigger regeneration of fresh grass for livestock (e.g. Solomon et al., 2007). However, burning of Loboi swamp is now regarded as an inappropriate practice and is currently prohibited. The long-term implication of this change in the management paradigm is unclear particularly with respect to the availability of fodder and prevalence of livestock diseases in the area. Importantly, this study confirmed that traditional management practices are still well-rooted in local societies as evident by adoption of new strategies to newly found uses of papyrus, which with no doubt exist in the use of other resources. Elsewhere, studies of riparian societies have shown that they have well established traditional resource management practices e.g. *ekwar* indigenous tree management system among the Turkana people (Stave et al., 2007) and *milalulu* clan-based resource control and allocation in Lower Tana River, Kenya (Terer et al., 2004).

Author's personal copy

As expected a strong linkage existed among the various attributes of papyrus wetland (e.g. regeneration, stem sizes) in relation to its use, conservation, and management practices. Currently the new challenge threatening the existence of the swamp is the unchecked diversion of water from the swamp to nearby agricultural farms coupled with frequent prolong droughts. Indeed continuation of these activities is predicted to have profound effects on Loboi swamp, yet this ecosystem is crucial for local people livelihood as well as swamp ecological life as attested by existence and introduction of conservation based management practices. The swamp is an oasis in the middle of a semi-arid land (Ashley et al., 2004) and forms the lifeline for the Endorois community. As such, the swamp's rich natural resources must be shared not only amongst humans but also with other species (Stern et al., 1993), which include over 36 vascular plant species belonging to 13 families (Muasya et al., 2004), a recently discovered population of Nile tilapia *Oreochromis niloticus* L. native to the swamp (Nyingi et al., 2009) and undetermined number of fauna.

4.5. Application of ethnobiological data in wetland management and conservation policy

The key to sustainable uses of wetlands requires a better understanding of the people and ecological processes unique to wetland systems and using this knowledge in the design and implementation of appropriate management strategies (Herath, 2004; Terer et al., 2004; Dahdouh-Guebas et al., 2006; Rist and Dahdouh-Guebas, 2006; Macharia et al., 2010). Unfortunately, such a framework is nonexistent in Kenya as pointed out in the draft Kenya National Wetland Conservation and Management Policy. Consequently, data and information necessary for informed decision-making is unavailable, incomplete, and unreliable or in an unusable format (G.o.K, 2008). This situation represents a serious conservation and management concern that requires an immediate intervention from key players such as researchers, the government relevant ministries/departments, conservation bodies, and other stakeholders. A careful study of the proposed draft national wetland policy and how it relates to the district development plan identified several conflicting government policies at the community level particularly at implementation levels (Fig. 5). For example, while district development committee (DDC) through agricultural and food security policies encourages irrigated farming, this can lead to excess extraction of the merge water resources in this semi-arid area if it is not supported by water budgets research findings. Diversion of water for irrigation was pointed out as a threat to Loboi swamp by the locals (Sections 3.4 and 4.3, Fig. 5). The demand and exploitation of water resources is expected to increase with the onset of irrigated-fed commercially-driven agriculture in this region. However, it is expected that the adoption and implementation of the draft national wetland policy will correct many anomalies relating to uses of wetlands. Once it is passed and implemented, it will definitely change the perception of wetlands in Kenya in a positive manner because the policy will consolidate the various current sectoral approaches of wetland management into one unified framework. For instance, presently there are more than 77 sectoral pieces of legislation inscribed in various Acts of parliament that relate to wetlands conservation and management (G.o.K, 2008). Importantly, the Kenya national wetland policy will be at par with other government policies such as agriculture thus would get equal attention from DDC on matters touching on wetland ecosystems and its utilization.

While we have highlighted some of the policies contradictions and the benefits that the wetland policy would bring, supportive scientific information both ecological and community knowledge-based are key ingredients in successful implementation of these policies (including LBNR integrated management plan) by wetland stakeholders (e.g. DDC, Councils, NMK, Harvesters, KWS: Fig. 5). Fig. 5 illustrates further how our research findings can contribute to implementation of policies and conservation management plans. The generated site-scale information with respect to (a) the uses of

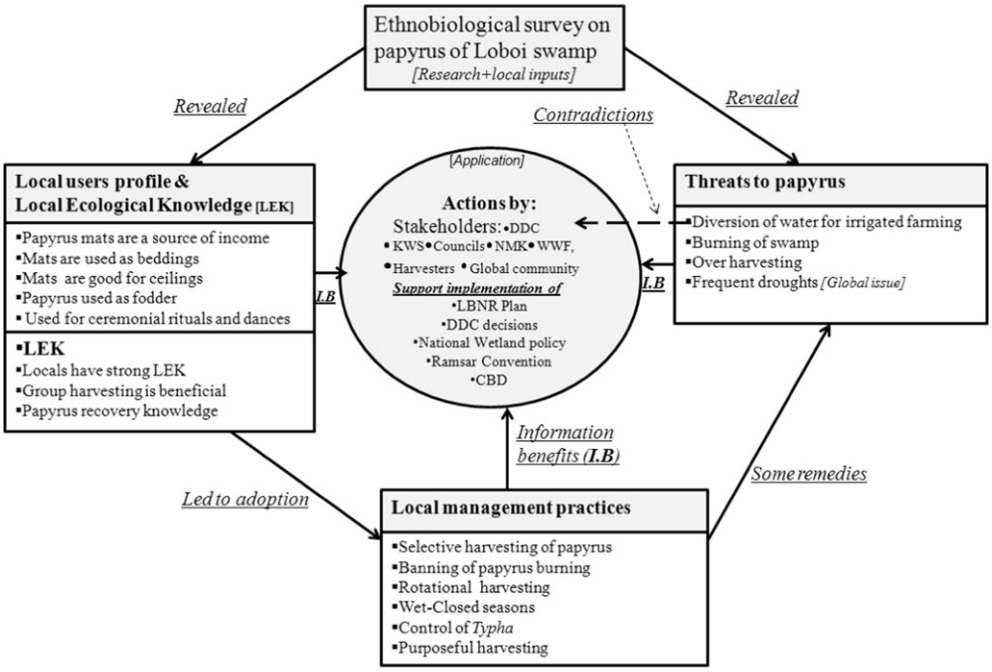

Fig. 5. The use of ethnobiological data in conservation and management. The scheme shows the entry point for research findings for District Development Committee (DDC) and other implementing stakeholders (e.g. KWS: Kenya Wildlife Service, WWF: World Wide Fund for Nature, NMK: National Museums of Kenya, Councils, local community including papyrus harvesters). Identified are: policy contradiction (dashed arrow), uses of papyrus, local ecological knowledge, local management practices and threats. These information are useful in implementation of Lake Bogoria National Reserve (LBNR) integrated plan, national wetland policy and international treaties such as Ramsar Convention and Convention on Biological Diversity (CBD).

Author's personal copy

papyrus, (b) local knowledge about its regeneration, (c) perceptions of current and future harvesting sustainability, (d) threats facing papyrus, and (e) existing local management strategies can be applied directly to the implementation of the wetland policies and management plans. This can be done by promoting sustainable uses of papyrus while appreciating and adapting home-grown strategies that are consistent with wise use principles such as community controlled harvesting (Fig. 5) and regulated water diversion for irrigation. First, the study provides knowledge to key policy and management plan implementers about the local people use of resources and livelihood needs (papyrus users' profile, Fig. 5). This averts stereotype assertion that communities are always destroyers of resources; hence from the onset community livelihood needs are respected. Second, it shows that people hold key local/traditional ecological knowledge (LEK/TEK) that are pertinent in sustainable use and conservation of resources as exemplified by other similar studies (e.g. Stave et al., 2007). The recognition of LEK/TEK is within the framework of LBNR integrated management plan, Kenya National Wetland Policy (draft) and international treaties (e.g. Ramsar Convention; CBD; Posey, 1999; Ramsar Convention Bureau, 2000) which Kenya is a signatory. Third, strengths and levels of LEK understanding in relation to uses of papyrus are identified which had been discussed in detailed and solution suggested in previous sections (Section 4.1–4.4). For example, harvesters developed new management practices in response to emerging uses of papyrus, a testimony that LEK/TEK is still strong (Fig. 5) and can serve well in the wise use of resources, while regeneration knowledge of papyrus was not well understood by some harvesters. This forms an entry point for education and awareness creation where facilitation is from other stakeholders (e.g. DDC, Councils, NMK, WWF: Fig. 5) but trainers and trainees are the community members themselves (Harvesters: Fig. 5). Four, our study obtained first hand information on existing and potential threats facing papyrus and Loboi swamp (Fig. 5) from the local people. This was consistent with threats facing wetlands especially papyrus swamps in other parts of Kenya and Africa such as burning, conversion to agricultural farms (e.g. rice fields as in the case of Yala papyrus swamp, Kenya) and over exploitation (Abila, 2002; Schuyt, 2005; Owino and Ryan, 2007; Macharia et al., 2010). Unique about threats that the local community identified was the reported abnormal prolong frequent droughts (Fig. 5), which they linked to reduced inflow of spring/aquifers water, based on their long-term knowledge on the use of water resources in the area. The links between droughts phenomena and use of papyrus in rituals that community undertake in worship to avert drought calamities was evident (This study, section 3.2 and 4.1). Thus climate change which can be associated with unusual e.g. long droughts is not only a local concern but also a global issue which the world community should address. Thus with information on effects of climate change coming from a local community such as in Loboi, there is need at local, national and international community levels to mobilize resources that ensures sustainability of papyrus resources which is known to be important sinks for green house gases (e.g. carbon dioxide, methane) when protected as well as emitters when degraded (Jones and Humphries, 2002). Given the knowledge provided by this study, key players in wetland conservation should take their rightful position in partnership with the community in; research (research institutions), addressing people livelihood and ecological needs (government-councils, DDC) and mobilization of resources for sustainable use and conservation of Loboi swamp (all players).

Moreover, a number of authors have noted that consultation with stakeholders is becoming a prerequisite for prudent management of the landscapes including wetlands (Stoll-Kleemann and O'Riordan, 2002; Pickaver et al., 2004; Stoll-Kleemann, 2004; Macharia et al., 2010). The current study has demonstrated the need to recognize local communities in research and conservation, and how this gathered information can be used for improvement and implementation of government policies and management plans (Fig. 5). The Endorois community have useful local management practices (e.g. rotational harvesting, *Typha* control) and ecological knowledge (e.g. recovery period of papyrus after harvesting) about the sustainable utilization of papyrus. These can be considered as best practices, and can be replicated in other wetlands in tropical regions facing similar anthropogenic and natural influences. Therefore, this study is one of the few research of its kind in Kenya (e.g. Morrison and Harper, 2009; Macharia et al., 2010) that show the linkage of community-based scientific research with existing local management plans (LBNR plan), national policies (e.g. Wetland policy) and international treaties (Ramsar Convention; CBD). It is envisaged that the implicit practices and LEK that are now well articulated in the current study will help the local people appreciate and build confidence in their own knowledge and capacities to conserve natural resources including papyrus wetlands.

5. Conclusion

This study showed that the Endorois people hold important local ecological knowledge (LEK) and value papyrus swamp because it supports their livelihood. The subsistence uses of papyrus formed a strong basis for its wise utilization as attested by the inception of traditional sustainable management practices. Loboi swamp would continue supporting local livelihood if due diligence and precautions are taken to minimize adverse ecological consequences from excessive abstraction of swamp water for unplanned commercially-driven irrigated agriculture. Ultimately these activities coupled with the effects of climate change will reduce the size of the swamp, its ecological functions, processes and services it provides. Results obtained by this study are expected to provide benefits to the Endorois community, including a strong case for inclusion of their LEK/TEK in the LBNR integrated management plan as well as in the implementation of the country's national wetland policy. Another important feature of this study is that it is possible to strike a balance between conserving wetlands and at the same time undertake income generating enterprises such as harvesting papyrus for making handicraft products for sale. Considering that most wetlands are communally owned, the inherent features of such arrangements that require group responsibility in the use of resources offer hope in the management and conservation of many wetlands amidst increasing human population, poverty and demand for limited resources in many developing countries. The appreciation and integration LEK/TEK, home-grown (bottom-up) management practices, consideration of livelihood needs, and the capacity to identify threats facing Loboi swamp is a milestone toward wise use principles that are enshrined in national plans (e.g. Kenya National Wetland Policy) and international treaties (e.g. Ramsar and UNESCO's World Heritage Conventions). The Endorois people represent good guardians of papyrus and the Loboi swamp assuming appropriate conservation management measures are enhanced and climate change issues are further investigated, and addressed.

Declaration of competing interests

The author(s) declare that they have no competing interests.

Role of funding source

The funding institution, Flemish Inter-University Council (VLIR)-University Development Cooperation (UOS) and supporting institution, National Museums of Kenya had no role in the

Author's personal copy

interpretation of data, writing of this manuscript and in the decision to submit the paper for publication. However their support is highly appreciated and recognized in the acknowledgment as required by the scholarship.

Acknowledgments

This work is within the objectives of PhD study on *Cyperus papyrus* L. in wetlands of Kenya funded by Flemish Inter-University Council (VLIR)-University Development Cooperation (UOS). We greatly thank VLIR-UOS for funding field research and scholarship for T. Terer. We acknowledge logistical support from National Museums of Kenya (NMK), headed by Dr. Idle Farah. We are indebted to field assistant researchers Ann Mbogo and Nancy Njeri (NMK volunteers), local assistants/translators: Amos Kipyarkis (WWF office), Joylene Kanyaris (Moi University), Joseph Kimarus, Maxine Kesubo, Julius Kibarar, Valentine Jepkemoi and Vivian Cherutich. We are extremely grateful for assistance and cooperation received from all interviewees, Chelaba Women Group, peoples of Loboi and Kapkuikui area: you are all great people and good guardian of Loboi wetland. We are also highly indebted to Dr. Adams W. Rollins (Lincoln Memorial University, USA) and Dr. James G. Kairo (Kenya Marine and Fisheries Research Institute, Gazi Bay, Mombasa) for providing valuable comments and proof reading an earlier version of the manuscript. We greatly acknowledge two anonymous reviewers who read and made valuable comments which helped shape and improve our manuscript. The authors are solely responsible for all opinions expressed in this paper, which does not necessarily reflect the views of the VLIR-UOS and their respective institutions.

References

Abila, R., 2002. Utilization and economic valuation of the Yala swamp wetland, Kenya. In: Gawler, M. (Ed.), Strategies for Wise Use of Wetlands: Best Practices in Participatory Management. Wetlands International, Wageningen, The Netherlands, pp. 89–95. IUCN &WWF publication no. 56.

Allison, E.H., Perry, A.L., Badjeck, M.-C., Neil, W.A., Brown, K., Conway, H., Halls, A.S., Pilling, G.M., Reynolds, J.D., Andrew, N.L., Dulvy, N.K., 2009. Vulnerability of national economies to impacts of climate on fisheries. Fish and Fisheries 10 (2), 173–196.

Armitage, D., 2003. Traditional agroecological knowledge, adaptive management and the sociopolitics of conservation in Central Sulawesi, Indonesia. Environmental Conservation 30, 79–90.

Ashley, G.M., Goman, M.F., Hover, C.V., Owen, R.B., Renaut, R.W., Muasya, A.M., 2002. Artesian blister wetlands, a perennial water resource in the semi-arid rift valley of East Africa. Wetlands 22 (4), 686–695.

Ashley, G.M., Mworia, J.M., Muasya, A.M., Owen, R.B., Driese, S.G., Hover, C.V., Renaut, R.W., Goman, M.F., Mathai, S., Blatt, S.H., 2004. Sedimentation and recent history of a freshwater wetland in a semi-arid environment: Loboi Swamp, Kenya, East Africa. Sedimentology 51, 1301–1321.

Becker, C.D., Ghimire, K., 2003. Synergy between traditional ecological knowledge and conservation science supports forest preservation in Ecuador. Conservation Ecology 8 (1), 1.

Berkes, F., Folke, C., 1998. Linking social and ecological systems for resilience and sustainability. In: Berkes, F., Folke, C., Colding, J. (Eds.), Linking Social and Ecological Systems: Management Practices and Social Mechanisms for Building Resilience. Cambridge University Press, Cambridge, UK, pp. 1–25.

Berkes, F., Folke, C., Colding, J., 1998. Linking Social and Ecological Systems: Management Practices and Social Mechanisms for Building Resilience. Cambridge University Press, Cambridge, UK.

Berkes, F., Colding, J., Folke, C., 2000. Rediscovery of traditional ecological knowledge as adaptive management. Ecological Applications 10 (5), 1251–1262.

Bird Life International, 2004. Threatened Birds of the World. Bird Life International, Cambridge, U.K.

Boar, R.R., Harper, D.M., Adams, C.S., 1999. Biomass allocation in *Cyperus papyrus* in a tropical wetland, Lake Naivasha, Kenya. Biotropica 31 (3), 411–421.

Boulé, M.E., 1994. An early history of wetland ecology. In: Mitsch, J.W. (Ed.), Global Wetlands: Old World and New. Elsevier, Amsterdam, the Netherlands, pp. 57–74.

Bridget, L., Tait, J.W., 2000. Papyrus. In: Nicholson, T.P., Shaw, I. (Eds.), Ancient Egyptian Materials and Technology. Cambridge University Press, Cambridge, pp. 227–253.

Brook, K.R., McLachlan, S.M., 2008. Trends and prospects for local knowledge in ecological and conservation research and monitoring. Biodiversity and Conservation 17 (14), 3501–3512.

Brown, K., 2003. Three challenges for a real people centered conservation. Global Ecology and Biogeography 12, 89–92.

Burkill, M.H., 1985. The Useful Plants of West Tropical Africa, vol. 1 (2). Royal Botanic Gardens, Kew.

CBD (Convention on Biological Diversity), 1993. Concluded at Rio de Janairo, Brazil in 5 June 1992. Multilateral Convention on Biological Diversity, vol. 1760, I–30619. http://www.cbd.int/doc/legal/cbd-un-en.pdf (accessed 15.04.10.), pp. 142–383.

Cohen, L., Manion, L., 1994. Research Methods in Education, second ed. Croom Helm, London.

Crisman, T.L., Chapman, L.J., Chapman, C.A., 1996. Conserving tropical wetlands through sustainable use. Geotimes 41, 23–25.

Dahdouh-Guebas, F., Collin, S., Lo Seen, D., Rönnbäck, P., Depommier, D., Ravishankar, T., Koedam, N., 2006. Analysising ethnobotanical and fishery–related importance of mangroves of the East-Godavari Delta (Andra Pradesh, India) for conservation and management purposes. Journal of Ethnobiology and Ethnomedicine 2 (24).

Dugan, P.J., 1990. Wetland Conservation: A Review of Current Issues and Required Action. IUCN, Gland, Switzerland.

Eggermont, H., Verschuren, D., Audenaert, L., Lens, L., Russel, J., Klaassen, G., Heiri, O., 2010. Limnological and ecological sensitivity of Rwenzori mountain lakes to climate warming. Hydrobiologia 648, 123–142.

Fazey, I., Proust, K., Newell, B., Johnson, B., Fazey, J., 2006. Eliciting the implicit knowledge and perceptions of on-ground conservation managers of the Macquarie marshes. Ecology and Society 11, 25–52.

G.o.K (Government of Kenya), 2002. Baringo District Development Plan 2002–2008: Effective Management for Sustainable Economic Growth and Poverty Reduction. Ministry of Finance and Planning, Nairobi, Kenya.

G.o.K (Government of Kenya), 2008. National Wetland Policy (Final Draft) Sessional Paper on National Wetlands Conservation and Management. Ministry for Environment and Mineral Resources, Nairobi, Kenya.

Gadgil, M., Berkes, F., Folke, C., 1993. Indigeneous knowledge for biodiversity conservation. Ambio 22, 151–156.

Gichuki, F.N., 1992. Utilization and drainage of wetlands: an agricultural drainage perspective. In: Crafter, S., Njuguna, S.G., Howard, W.G. (Eds.), Wetlands of Kenya. IUCN, Gland, pp. 147–154.

Gichuki, J., Dahdouh-Guebas, F., Mugo, J., Rabuor, C.O., Triest, L., Dehairs, F., 2001. Species inventory and the local uses of plants and fishes of the Lower Sondu Miriu wetland of Lake Victoria, Kenya. Hydrobiologia 458, 99–106.

Giordano, R., Liersch, S., Vurro, M., Hirsch, D., 2010. Intergrating local and technical knowledge to support soil salinity monitoring in Amudarya river basin. Journal of Environmental Management 91 (8), 1718–1729.

Hammerton, D., 1972. The Nile River – a case study. In: Oglesby, R.T., Carlson, C.A., McCann, M.J. (Eds.), River Ecology and Man. Academic Press, New York, USA, pp. 71–214.

Hardin, G., 1968. The tragedy of the commons. Science 162, 1243–1248.

Herath, G., 2004. Incorporating community objectives in improved wetland management: the use of the analytical hierarchy process. Journal of Environmental Management 70, 263–273.

Huntington, H., 2000. Using traditional ecological knowledge in science: methods and applications. Ecological Applications 10 (5), 1270–1274.

IUCN, 2010. IUCN Red List of Threatened Species. Version 2010.1. www.iucnredlist.org (accessed 05.06.10.).

JMBNR (Joint Management of Lake Bogoria National Reserve), 2007. Lake Bogoria National Reserve Integrated Management Plan 2007–2012. Ministry of Local Government–WWF East Africa Regional Programme Office, Nairobi, Kenya.

Johansson, J., Svensson, J., 2002. Land Degradation in the Semi-arid Catchment of Lake Baringo, Kenya: A Minor Field Study of Physical Causes with a Socioeconomic Aspect. Department of Physical Geography, Göteborg University.

Jones, M.B., 1983. Papyrus a new fuel for the third world. New Scientist 99, 418–421.

Jones, M., Humphries, S., 2002. Impacts of the C4 sedge *Cyperus papyrus* L. on carbon and water fluxes in an African wetland. Hydrobiologia 488, 107–113.

Junk, J.W., 2002. Long-term environmental trends and the future of tropical wetlands. Environmental Conservation 29 (4), 414–435.

Junk, J.W., Ohly, J.J., Piedade, F.T.M., Soares, M.G.M. (Eds.), 2000. The Central Amazon Floodplain: Actual Use and Options for a Sustainable Management. Backhuys Publishers, Leiden, The Netherlands.

Kairo, J.G., Dahdouh-Guebas, F., Bosire, J., Koedam, N., 2001. Restoration and management of mangrove systems – a lesson for and from the East African region. South African Journal of Botany 67, 383–389.

Kipkemboi, J., Kansiime, F., Denny, P., 2002. The response of *Cyperus papyrus* (L.) and *Miscanthidium violaceum* (K. Schum.) Robyns to eutrophication in natural wetlands of L. Victoria, Uganda. African Journal of Aquatic Sciences 27, 11–20.

Kiprotich, A., 2010a. Endorois Finally Return to their Family Land. The Standard Newspaper Kenya. the Standard Group, 21st March 2010.

Kiprotich, A., 2010b. Of the Endorois and How the State Killed their Cherished Culture. The Standard Newspaper Kenya. the Standard Group, 28th February, 2010.

Kramer, S.N., 1969. Cradle of Civilization. Little Brown & Co.

Macharia, J.M., Thenya, T., Ndiritu, G.G., 2010. Management of highland wetlands in central Kenya: the importance of community education, awareness and ecotourism in biodiversity conservation. Biodiversity 11 (1 & 2), 85–89.

Mackinson, S., Nottestad, L., 1998. Combining local and scientific knowledge. Reviews in Fish Biology and Fisheries 8, 481–490.

Author's personal copy

Mmopelwa, G., 2006. Economic and financial analysis of harvesting and utilization of river reed in Okavango Delta, Botswana. Journal of Environmental Management 79, 329–335.
Mnaya, B., Wolanski, E., 2002. Water circulation and fish larvae recruitment in papyrus wetlands, Rubondo Island, Lake Victoria. Wetland Ecology and Management 10, 133–143.
Moller, H., Berkes, F., Lyver, P.O., Kislalioglu, M., 2004. Combining science and traditional ecological knowledge: monitoring populations for co-management. Ecology and Society 9 (3) article 2.
Morel, C., 2004. Defending Human Rights in Africa: The Case for Minority and Indigenous Rights. Essex Human Rights Review, vol. 1. University of Essex. http://projects.essex.ac.uk/ehrr/V1N1/Morel.pdf (accessed 12.04.10.), pp. 54–65.
Morrison, E.H.J., Harper, D.M., 2009. Ecohydrological principles to underpin the restoration of *Cyperus papyrus* at Lake Naivasha, Kenya. Ecohydrology and Hydrobiology 9 (1), 83–97.
Muasya, A.M., Hover, V.C., Ashley, G.M., Owen, R.B., Goman, M.F., Kimeli, M., 2004. Diversity and distribution of macrophytes in a freshwater wetland, Loboi swamp (Rift valley) Kenya. Journal of East African Natural History 93, 39–47.
Mumby, P.J., Edwards, A.J., Arias-gonzález, J.E., Lindeman, K.C., Blackwell, P.G., Gall, A., Gorczynska, M.I., Harborne, A.R., Pescod, C.L., Renken, H., Wabnitz, C.C.C., Llewellyn, G., 2004. Mangroves enhance the biomass of coral reef fish communities in the Caribbean. Nature 427, 533–536.
Muthuri, F.M., Kinyamario, J.I., 1989. Nutritive value of papyrus (*Cyperus papyrus*, Cyperaceae), a tropical emergent macrophyte. Economy Botany 43 (1), 23–30.
Muthuri, M.F., Jones, B.M., Imbamba, S.K., 1989. Primary productivity of papyrus (*Cyperus papyrus*) in a tropical swamp, Lake Naivasha, Kenya. Biomass 18, 1–14.
Nagelkerken, I., Blaber, S.J.M., Bouillon, S., Green, P., Haywood, M., Sasekumar, A., Somerfield, P.J., 2008. The habitat function of mangroves for terrestrial and marine fauna: a review. Aquatic Botany 89, 155–185.
Nyingi, D., De Vos, L., Aman, R., Agnese, J.-F., 2009. Genetic characterization of unknown and endangered native population of the Nile tilapia *Oreochromis niloticus* (Linnaeus, 1758) (Cichlidae; Teleostei) in the Loboi swamp (Kenya). Aquaculture 297, 57–63.
Olsson, P., Folke, C., 2001. Local ecological knowledge and institutional dynamics for ecosystem management: a study of Lake Racken watershed, Sweden. Ecosystems 4, 85–104.
Owino, A.O., Ryan, P.G., 2006. Habitat associations of papyrus specialist birds at three papyrus swamps in western Kenya. Africa Journal of Ecology 44, 438–443.
Owino, A.O., Ryan, P.G., 2007. Recent papyrus swamp loss and conservation implication in Western Kenya. Wetlands Ecology and Management 15, 1–12.
Pickaver, A.H., Gilbert, C., Breton, F., 2004. An indicator set to measure the progress in the implementation of integrated coastal zone management in Europe. Ocean and Coastal Management 47, 449–462.
Posey, D.A. (Ed.), 1999. Cultural and Spiritual Values of Biodiversity: A Complimentary Contribution to Global Assessment. UNEP/Intermediate Technology, Nairobi/London.
Ramsar Convection Bureau, 2000. Ramsar Handbook for the Wise Use of Wetlands. Ramsar Convection Bureau, Gland, Switzerland.
Raymond, C.M., Fazey, I., Reed, M.S., Stringer, L.C., Robinson, G.M., Evely, A.C., 2010. Integrating local and scientific knowledge for environmental management. Journal of Environmental Management 91 (8), 1766–1777.
Rist, S., Dahdouh-Guebas, F., 2006. Ethnosciences – A step towards the integration of scientific and indigenous forms of knowledge in the management of natural resources for the future. Environment, Development and Sustainability 8 (4), 467–493.
Robertson, H.A., McGee, T.K., 2003. Applying local knowledge: the contribution of oral history to wetland rehabilitation at Kanyapella Basin, Australia. Journal of Environmental Management 69, 275–287.
Schuyt, K.D., 2005. Economic consequences of wetland degradation for local populations in Africa. Economics 53, 177–190.
Sculthorpe, C.D., 1967. The Biology of Aquatic Vascular Plants. Edward Arnold, London.
Silvius, M.J., Oneka, M., Verhagen, A., 2000. Wetlands: lifeline for people at the edge. Physics and Chemistry of the Earth (B) 25 (7–8), 645–652.
Simpson, D.A., Inglis, C.A., 2001. Cyperaceae of economic, ethnobotanical and horticultural importance: a checklist. Kew Bulletin 56, 257–360. http://www.jstor.org/pss/4110962 (accessed 10.03.10.).
Solomon, B.T., Snyman, H.A., Smit, G.N., 2007. Cattle-rangeland management practices and perceptions of pastoralists towards rangeland degradation in Borana zone southern Ethiopia. Journal of Environmental Management 82, 481–494.
StatSoft Inc., 1996. STATISTICA for Windows Tulsa, OK, USA.
Stave, J., Oba, G., Nordal, I., Stenseth, N.C., 2007. Traditional ecological knowledge of a riverine forest in Turkana, Kenya: implications for research and management. Biodiversity and Conservation 16, 1471–1489.
Stern, P.C., Dietz, T., Kalof, L., 1993. Value orientations, gender, and environmental concern. Environment and Behavior 25, 322–348.
Stoll-Kleemann, S., 2004. The rationale of socio-economic research for successful protection and use of wetlands: the example of participatory management approaches. Hydrobiologia 527, 15–17.
Stoll-Kleemann, S., O'Riordan, T., 2002. From participation to partnership in biodiversity protection: experience from Germany and South Africa. Society and Natural Resources 15, 157–173.
ter Braak, C.J.F., 1987. Ordination. In: Jongman, R.H.G., ter Braak, C.J.F., van Tongren, O.F. (Eds.), Data Analysis in Community and Landscape Ecology. Cambridge University Press, Cambridge, UK, pp. 91–173.
ter Braak, C.J.F., Smilauer, P., 2002. Canoco for Windows: Software for Canonical Community Ordination, Version 4.5. Biometric. Plant Research International, Wageningen, The Netherlands.
Terer, T., 2011. Conservation Genetics, Utilization and Effects of *Cyperus papyrus* Harvesting: Making Ecosystem Management Work in Kenyan Wetlands. PhD thesis, Vrije Universiteit Brussel. Uitgeverij VUBPRESS Brussels University Press, Brussels, ISBN 978 90 5487 885 8.
Terer, T., Ndiritu, G.G., Gichuki, N.N., 2004. Socio-economic values and traditional strategies of managing wetlands resources in Lower Tana River, Kenya. Hydrobiologia 527, 3–14.
Thompson, J.R., 1996. Africa's floodplains: a hydrological overview. In: Acreman, C.M., Hollis, G.F. (Eds.), Water Management and Wetland Conservation in Sub-Saharan Africa. IUCN /International Waterfowl and Wetland Research Bureau, Gland, Switzerland, pp. 5–20.
Thompson, L.G., Mosley-Thompson, E., Davis, M.E., Henderson, H.A., Brecher, H.H., Zagorodnov, V.S., Mashiotta, T.A., Lin, P.-N., Mikhalenko, V.N., Hardy, D.R., Beer, J., 2002. Kilimanjaro ice core records: evidence of Holocene climate change in tropical Africa. Science 298, 589–593.
Topp-Jørgensen, E., Poulsen, M.K., Lund, J.F., Massao, J.F., 2005. Community-based monitoring of natural resource use and forest quality in Montane forests and Miombo Woodlands of Tanzania. Biodiversity and Conservation 14, 2653–2677.
Turner, N.J., Ignace, M.B., Ignace, R., 2000. Traditional ecological knowledge and wisdom of aboriginal peoples in British Columbia. Ecological Applications 10 (5), 1275–1287.
Van Wyk, B.-E., Gericke, N., 2000. A Guide to Useful Plants of Southern Africa. Briza Publications, Pretoria.
Walters, B.B., Rönnbäck, P., Kovacs, J.M., Crona, B., Hussein, S.A., Badola, R., Primavera, J.H., Barbier, E., Dahdouh-Guebas, F., 2008. Ethnobiology, socio-economics and management of mangroves forests: a review. Journal of Aquatic Botany 89, 220–236.
Warren, D.M., Slikkerveer, L.J., Brokensha, D. (Eds.), 1995. The Cultural Dimension of Development: Indigenous Knowledge Systems. Intermediate Technology Publications, London.