Determinants of Papyrus Harvesting in the Yala Swamp, Kenya

S M Mwakubo, M M Ikiara

Abstract:

Using data from a 2005 field survey, this paper examines the factors that drive papyrus-harvesting pressure in the Yala wetlands. Descriptive statistics were used to understand the socio-economic characteristics of papyrus harvesters and the papyrus production process while a truncated Tobit model was employed to determine the factors influencing the amount of papyrus harvested. The findings show that the number of years one is involved in papyrus activities (proxy for experience), household size, sex of the harvester, and level of ammonia increase the intensity of papyrus harvesting. Non-papyrus income, grass roofed house, and wooden seats, however tend to reduce it. The policy implication emanating from this study hinges on self-regulation, alternative sources of livelihood, and family planning control as the way forward for sustainable utilization of papyrus.

Key words: *Kenya, Papyrus, sustainable utilization, and wetlands*

Introduction

Wetland ecosystems are amongst the most threatened of all natural resources (Turner 1991: 59). In developing countries, the need to use natural resources wisely is greatest as biodiversity is higher in these regions and basic human needs are most acute. As for wetlands all over the world, papyrus (Cyperus papyrus) swamps in East Africa are under increasing threat (Crisman et al., 1996). These wetlands are degraded by unsustainable levels of resource extraction and structural modification. In Kenya, wetlands occupy about 3-4%, approximately 1400 kilometre square, of the land surface and up to 6% in the rainy season. The National Wetlands Standing Committee (NWSC)[1] has defined Kenyan wetlands as: "*areas of land that are permanently, seasonally or occasionally waterlogged with fresh, saline, brackish or marine waters at a depth not exceeding six metres, including both natural and man-made areas that support characteristic biota*". The Kenya Wildlife Service (KWS) is responsible for the management of wetlands under its Wetland Programme which started in 1991. KWS has been instrumental in spearheading major wetland conservation initiatives in the country.

One of the major wetlands in Kenya is the Yala swamp. The Yala swamp (Figure 1) is an expansive wetland at the mouth of Rivers Yala and Nzoia and is located in Bondo, Siaya and Busia Districts. The swamp was formed by the deposition of silt from the Yala River at the point where the river flows into Lake Victoria (GoK, 1987). Hiro River also flows into the swamp although it is seasonal. Likewise, Nzoia River flows through the swamp at the Northern part. Rainfall is low at 1100 mm per year. The swamp is a fresh water wetland, which is a combination of seasonally and permanently covered grasslands, marshes dominated by a wide range of herbaceous plants, and flood plains. The wetland is mainly sustained by water sources other than direct rainfall. The Yala Swamp complex is by far the largest papyrus swamp in the Kenya section of Lake Victoria, making up more than 90% of

the total of papyrus (Nasirura and Njoroge, 1997). Papyrus (*Cyperus papyrus)* is a dominant macrophyte in the Yala wetlands. The other macrophtes are *Cyperus latifolius* (typha), *Phragmites mauritianus* (reeds), sedges, and wetland grasses. The on-going large scale reclamation by Dominion Ltd for agricultural production is a big threat to the current and future availability of papyrus biomass. The short term and long term ecological and socio-economic costs of reclamation are likely to be enormous (Abila, 2005).

In the past, the exploitation of papyrus biomass has been on a small scale and at subsistence level mainly for mats, baskets, ropes, roofing material, and firewood (Gichuki *et al.,* 2001; Kaggwa et al.2001). However, this has changed with the exploitation of papyrus for commercial purposes. (Abila, 1998; Otieno *et al.,* 1998). Mats and baskets are popular as they are utility products, which need continual replacement in households. Mats are sold between Ksh 100-350. Baskets and mats are predominant in Busia, while thatch and reeds are major products in Siaya district (Otieno *et al.,* 1998). Most communities use wetlands for building materials (Abila, 1998). Around Lake Kanyaboli, 12% earn direct income from selling building materials, while around Lake Sare, it is 44% (Abila, 1998). Papyrus has also the potential for use as paper, grazing potential (Muthuri and Kinyamario, 1989), and provision of energy (Jones, 1983; 1984). Studies have also shown that papyrus swamps are net carbon sinks (Jones and Muthuri, 1997) as they have a high net primary productivity and large amounts of detritus that can accumulate below the living mat rhizomes and roots. There can be 65 kg m-2 of carbon contained in organic matter beneath papyrus swamps (Jones & Muthuri, 1997: 347).

Most of the studies cited above have dwelt on the ecological aspects of papyrus and very little on its socio-economics. Further, little has been done to understand the linkages between socio-economics and ecology of the papyrus swamps. In particular none of the studies has assessed the factors driving papyrus harvesting at the both the household and community levels as well as the relationship of these factors to the swamp ecology. These information gaps need to be filled to ensure proper and sustainable management of the papyrus hence the importance for this study.

Due to the importance of swamps and in particular papyrus in the local economy, the objectives of the study were to:

- Characterize the wetlands papyrus users;
- Describe the papyrus production system; and
- Determine factors influencing the harvest of papyrus.

Research Methodology

*Conceptual framework***:** We use a framework as presented in Figure 2. This framework offers a holistic approach for assessing resources and assets that are available to households and how these are linked to the strategies that are used to reach desired household welfare outcomes. Papyrus is one of the important resources that maybe available or accessible by a household. The model illustrates how several factors directly or indirectly influence papyrus harvesting. A number of factors are envisaged to influence the decision to harvest papyrus and/or involved in papyrus related activities in the first stage. These factors include the existing

institutional and policy factors particularly at the macro level, household characteristics and location/area based factors, and the price offered in the market.
In the second stage, the household decides the level of investments to be made. We postulate that this will be a function of household characteristics and prices offered in the market among others. An increase in household size reduces the ability of households to meet the subsistence needs especially where land pressure is high and may subsequently lead to higher amount of papyrus harvested. We also conjecture a negative relationship between education and amount of harvested papyrus as education embodies awareness of the dangers of unsustainable papyrus utilization.

Land tenure insecurity has been found to be a deterrent to investment in resource management and conservation (Hayes et al., 1997; Nowak, 1987). Thus we conjecture households that perceive insufficient security of land tenure would be less willing to reduce papyrus exploitation. When credit markets are imperfect, farm size, when related to wealth may help ease the liquidity constraint to invest in land quality management. Since the type of house is correlated with wealth and welfare of rural households, we expect it to influence papyrus harvesting negatively.

Our maintained hypothesis is that markets are important and that people harvest both for domestic use and also for the market. This implies that the price offered will influence the amount of papyrus harvested. Therefore, the higher the price of papyrus, the higher the amount harvested.

Data: Data for this study was obtained from a survey of rural households that are involved in papyrus related activities. A total of ten sites that had papyrus in the Yala swamp and along the shores of Lake Victoria were purposively selected (Kadenge, Gangu, Musoma, Bukoma, Goye, Sare, Osieko, Buluwani, Namboyo, and Runyu). About 30 papyrus harvesters were randomly selected in each of these sites and interviewed in 2005. The purpose was to understand the driving forces of papyrus harvesting pressure and the dynamics involved. Water quality variables were obtained from every beach during the same period. Sampling and analysis of nutrients were carried out according to Standard Methods for Examination of Water and Waste Water (APHA, 1992). Type and magnitude of nutrients were measured *in situ* using a Hydrolab Datasonda. Measurements were taken in different areas (5) in each area and averaged. Water samples were collected and stored in the dark at 4 ℃ for analysis of nutrients at the Kenya Marine and Fisheries Research Institute (Kisumu) laboratories within 24 hours. The description and measurement of variables are given in Table 1.

Since all the other variables are self-explanatory, we discuss three water quality variables (*TOTAL NITROGEN ,TOTAL PHOSPHORUS ,AMMONIA).* These variables are total nitrogen, total phosphorus and ammonia. Total nitrogen (TN) is a measure of all the forms of nitrogen such as nitrates, nitrites and nitrogen gas. Nitrogen is a necessary nutrient for the growth of aquatic plants and algae. Phosphorus[2] is present in natural water as phosphates and is a plant nutrient. Total nitrogen, total phosphorus and ammonia are important as far as the growth dynamics of papyrus is concerned.

Data Analysis: Before carrying out empirical analysis, *descriptive statistics* was employed. Measures of central tendencies and cross-tabulations among others were carried out to explore the characteristics of papyrus harvesters.

Decision to harvest papyrus and harvesting intensity: Most empirical studies have used different methodologies including linear regression models, to estimate the determinants of participation in certain activities. Non-participators were often excluded from the study sample, thus resulting in sample selection bias and attendant biases in the estimated coefficients (Heckman, 1979; Feder and Umali, 1993). Yet, inclusion of non-participators also yielded biased and inconsistent estimates since clustering of observations, due to the prevalence of zero-values of the dependent variable, violated the ordinary least squares (OLS) assumptions of a continuous dependent variable. Estimation of OLS with a dichotomous dependent variable was also inappropriate because resulting parameters would be inefficient due to the heteroscedastic structure of the error term.

In general, information on dependent variables from population is sometimes limited in its range. This would be true if observations on the dependent variable, corresponding to known values of independent variables, are not observable or are missing. Using OLS yield asymptotically biased estimates. Estimating a model that omits limit observations would create a bias and yet including these observations as though they were ordinary observations also creates a bias. As a result, we used a truncated tobit model specified as:

PAPYRUS = f (YRSPAP, DISTPAP, HHS, AGE, EDUC, SEX, TIMEPAP, HHINC, NONPAPINC, PAPYRUS ROOF, GRASS ROOF, PAPYRUS SEATS, WOODEN SEATS, MUD WALLS, AMMONIA, TOTAL PHOSPHORUS, TOTAL NITROGEN)

Results and Discussion

Socio-economic characteristics of papyrus harvesters and or in related papyrus activities: About 47% of the people involved in papyrus activities (Table 2) are men while women are 53%. This is in contrast to fishing where men are predominant. This may be related to the physical requirements of fishing as an activity and also with traditional beliefs that discourage women from fishing. Although papyrus activities can be tiresome, women undertake them as they often use papyrus for firewood. Another possible explanation is that mat making and basket weaving are activities that women can easily perform and that these are products that women like.

There are also no taboos or traditional beliefs against women being involved in papyrus activities. Likewise, the poor and the vulnerable that are often female-headed households, often depend on papyrus for their livelihoods.

The results also show that 65% of the sampled households (Table 3) reported source of livelihood as the major reason of being involved in papyrus activities. This suggests the importance of papyrus related activities as sources of livelihood in the Yala swamp.

In the course of undertaking papyrus related activities, the respondents reported being faced with many constraints (Table 4). Some of these are dangerous wild

animals (40.3%), diseases (32.1%), lack of markets (20.9%), and transport problems (18%).

The later is particularly important given the fact that the roads in the area are poor and are virtually impassable during the rains. This may likely be the cause of the mentioned problem of lack of markets. With good rural access roads[3], papyrus products can be moved quickly and cost-effectively to markets and therefore fetch good prices.

Given the constraints faced above, the respondents suggested a number of measures to address them (Table 5). Some of these include: marketing (14.1%), provision of protective gear /insect repellents (12.2%), spraying/ clearing of vegetation (10.3%), provision of harvesting tools (6.1%), provision of transport facilities (5.7%), formation of community based organizations (CBO's) (3.8%) and regulations against burning (3.8%). It is noted that some of the suggestions like provision of tools may actually increase effort leading to even more over-exploitation of papyrus.

Solutions such as the formation of CBO's and regulations about burning are in the right direction because "some sort of ownership" will be established and therefore control access to papyrus. The category of others include: government to help, make drugs accessible, increase prices, creation of other income earning activities, provision of loans/finance, swamp to be drained, ensure cooperation, and provide animal traps/animals to be captured or killed.

The suggested solutions above are in line with the roles to be played in wetland management by the various parties: government, community leaders and papyrus users. On what ways papyrus harvesting can be effectively controlled; the major ones are regulation against burning (48.1%), formation of CBO's (7.6%) and co-management (9%). The respondents are of the view that the government needs to regulate the harvesting of papyrus (20.1%) and provide education / awareness (7.1%), provision of credit (6.7%), help in the marketing (6.7%) and support CBO's (1.3%). When it comes to the role of community leaders; regulation and education /awareness are dominant. While for papyrus harvesters, the issue is to cooperate with the government and the community leaders regarding implementing the required regulations.

Table 6 shows the wealth indicators of the sampled households of papyrus harvesters. It is noted that the majority are poor because only 69.5 % of the households are roofed with grasses and that 86.9% of them have walls made of mud. In addition, only about 22.9% of the households had sofa sets. Telephone and electricity are both an issue of supply and demand. However, we note that the coverage is low for telephone and actually none for electricity. There is also a problem of network (or coverage) of mobile phones in most of these areas.

Perception of changes by households in the surrounding environment is very crucial if any meaningful efforts that are geared towards sustainable management of wetland resources are to succeed. Households have to be aware of any negative effects/changes or otherwise before they can undertake any step to address the problems. Table 7 presents results on the perception on dynamic changes over

papyrus use and status. It emerges that about 65% of the respondents acknowledged that papyrus usage and therefore harvest has increased lately. This trend is clearly worrying and does strongly suggest that harvesting pressure of papyrus has been on the increase. This is also in agreement with the fact that the demand for papyrus has also been on the increase (66%). This demand may result from increased awareness of the beauty of some of the products from wetlands such as mats and baskets[4].

However, the results are mixed on whether the harvesters go long distances to harvest papyrus and that the amount of papyrus harvested now is smaller than 5 years ago. Nevertheless, the households are clear that if papyrus is not managed now, it is likely to disappear in the near future.

What comes out clearly which is a major concern is the fact that 75% of the respondents allege that papyrus is often an open access resource. This perhaps is the genesis of the over utilization of papyrus in the wetlands. The national wetlands draft policy acknowledges this problem of open access to wetlands and the fact that users who are not guaranteed of long-term use may not practice or be encouraged to use long-term sound practices. As such, there is no incentive for papyrus conservation.

A substantial proportion of local people's income (about 25%) is derived from the swamp papyrus. If swamp resources are used unsustainably, or in a manner, which reduces societal net benefits, local people's income may decline eventually. Given that this would affect their perceived value of labour, this may further encourage even more unsustainable levels of resource use, ultimately leading to the destruction of swamp ecosystems. This would suggest that as the market for cut papyrus continues to expand as a result of better road networks, cheaper transport and population growth, significant increases in papyrus exploitation would occur.

Determinants of papyrus harvesting pressure: A Tobit analysis: Table 8 shows some descriptive statistics of selected variables that were used in the econometric analysis. It is noted that the age of the papyrus harvesters ranges from 20 to a maximum of 86 with a mean of 47.90. Distance traveled in the course of harvesting papyrus ranges from 0.01 kms to a maximum of 5 kms with a mean of about 1.35 kms. This implies that the papyrus harvesters mostly come from within the area.

Household size ranges from 2 to a maximum of 21 with a mean of 6.13 people. This is above the national average of 5.2. We also find that the number of years respondents were involved in papyrus harvesting ranges from 1 year to 60 years with an average of 13.61 years. This implies that to some people, papyrus harvesting is a life-long activity while others had just started. It is expected that this variable increases papyrus-harvesting intensity.

A correlation matrix among the selected variables shows that correlation is below 60% with the exception of AGE and AGEAGE which is expected (see A1 in the appendix).
The truncated tobit estimated results using STATA econometric package are presented in Table 9. The results show that there are seven variables that drive papyrus-harvesting pressure. These are number of years involved in papyrus

activities (proxy for experience), household size, sex of the papyrus harvester, non-papyrus income, grass roof, wooden seats, and levels of ammonia. The variables that increase the amount of papyrus harvested are experience, household size and sex of the harvester. The number of years one is involved in papyrus activities is positive and significant. This is expected, as it is a proxy for experience. Such knowledge possibly includes selecting the good ones, how to harvest and possibly manufacturing /processing of papyrus products, and social networks in the papyrus business. The latter often helps in accessing and establishing markets for their papyrus. Non-papyrus income, grass roofed house, and wooden seats tend to reduce the amount of papyrus harvested. This suggests it is important to increase alternative sources of income in order to reduce papyrus harvesting pressure. This does not mean that papyrus harvesting is carried out by the poor per say. But that the poor, in order to meet their subsistence requirements, often rely on common property resources. The poor, particularly those living in rural areas, often rely on a variety of natural resources and ecosystem services as a direct source of livelihood and for a significant share of their incomes (Cavendish, 2000; Narrain *et al.*, 2005). Poverty is thus still an important driver of papyrus harvesting pressure.

However, a growing number of studies are finding a u-shaped relationship between household incomes and the amount of resources harvested from common-pool resources (Narain *et al.*, 2005), implying that tackling poverty may reduce environmental degradation up to a point after which there will be increased environmental degradation.

Sex of the head of household is positive and significant implying that male-headed households harvest more papyrus than those that are female headed. This may be linked to the fact that men are physically stronger and thus able to harvest more papyrus. It may also imply that women are much more concerned with the environment and that when they are able to make decisions, there is less exploitation. Another possible reason is that women are kept off, as they fear snakes and wild animals.

Household size implies labour availability and higher subsistence requirements. It thus follows, that this increases the amount of papyrus harvested. Papyrus harvesters with grass roofed houses are less inclined to extract more papyrus compared to those with iron-roofed houses (reference variable). There is no significant difference between harvesters with papyrus- and iron-roofed houses with respect to the amount of papyrus harvested. Since those with grass-roofed houses are relatively poorer compared to others, this finding might suggest that papyrus would be providing more utility in alternative economic arrangements than the thatching exercise. Papyrus harvesters with wooden seats are likely to harvest lower amount of papyrus compared to those with papyrus seats.

The distance to which one goes to harvest papyrus is negative although not significant. The results are as expected, which is an indication of the harvesting pressure. Papyrus harvesters can only move much farther if the papyrus nearby has been exhausted and since the farther the distance, the more effort (costs) required to harvest the same unit of papyrus. This has a tendency of reducing the amount harvested. The amount of effort (direct) in terms of the number of hours spent to harvest papyrus is positive although not significant. This is a variable that is

amenable to policy. Consequently, a program to control the exploitation of papyrus must involve the duration one is allowed to harvest per unit time period. This is also strongly correlated with the type of harvesting tools one has.

Surprisingly, education level is not significant although it has an unexpected sign. This may be related to the kind of education one receives. Perhaps it's not relevant to sustainable use of papyrus. A possible policy direction is vigorous campaigns either through an NGO or even a government agency to increase awareness on the dangers of open access to papyrus. Hand in hand with this, access to wetlands should not be free. The communities need to take it as a common property and regulate its access (CPR) by establishing rules and terms of access. Water quality (ammonia) is positive and significant, indicating that as ammonia levels increase, it encourages /increases eutrophication and therefore the reproduction of papyrus and consequently more harvesting of papyrus.

Conclusions and policy implications

The Yala wetlands are under severe threat as a result of intensive pressure to convert them or over-use their resources under the premise that this benefits the local people. The study shows that there a number of factors that influence papyrus harvesting. This is important because any policy being drawn ought to focus on the drivers of the papyrus harvesting pressure. The study reveals that the number of years involved in papyrus activities (proxy for experience), household size, sex of the household head, non-papyrus income, grass roof, wooden seats, and levels of ammonia are the major determinants.

It is important to note that Kenya does not have a policy on wetlands. However, a draft policy has been prepared by the Kenya Wildlife Service (KWS). The overall objective of the draft National Wetlands Conservation and Management Policy is to promote the conservation, management, rehabilitation and wise use of wetlands and to sustain their natural, social-economic and cultural functions for the benefit of the people of Kenya for the present and future generations. The draft policy however, does not emphasize the importance of papyrus and the need for their sustainable usage.

Many wetlands in East Africa are designated as protected areas on the basis of threatened bird and animal species they contain. Some contradictions and tensions do exist where policy and legislation affect wetlands in Kenya. For example considerable ambiguity surrounds the concept of local authorities holding wetlands 'in trust for people', and confusion over rights, and obligations of ownership on the one hand and management on the other. Without well-established property rights structures the management of wetlands and their resources needs to be regulated. Consequently, the enactment, implementation and enforcement of national policy for the conservation and management of wetland resources should be a priority in the immediate future. The costs associated with the failure to do this will be borne by all sectors of society.

Some instruments are also worthy considering with regards to sustainable utilization of papyrus wetlands or swamps. These are zoning, creation, maintenance and management of parks, and common property resources (CPR). The latter would work through the creation of resource user groups to control access perhaps through self-regulation. Other measures that are worthy considering are taxation and

licensing although transactions or administrative costs may be very prohibitive. We are of the view that the users can create a register that may remain with the local chief. With this, some semblance of regulation may be established.

Another policy option is to undertake measures geared towards poverty eradication strategies. This is because local people could become trapped in a vicious circle of poverty: as swamp use becomes sub-optimal, income drops, and increasing levels of cultivation and harvesting become an attractive option. The swamp will be used unsustainably, reducing the value that can be derived from it, thus further lowering incomes. This would reduce the pressure on papyrus as a major source of livelihood. Along with this, alternative sources of livelihood may be promoted. Such sources may include cotton growing, livestock keeping and some petty trade involving small and medium enterprises. It is also important to continue encouraging family planning practices with a view to limit household sizes. We also propose studies on growth dynamics of papyrus and optimal papyrus harvest that will help in better management of this resource.

Acknowledgements
The authors would like to thank the European Commission for supporting the Ecotools project. We thank the Kenya Marine and Fisheries Research Institute for the valuable collaboration.

References

Abila, Romulus. 2005. Biodiversity and Sustainable Management of a Tropical Wetland Ecosystem: A Case study of Lake Kanyaboli, Kenya. Department of Zoology, Maseno University.

Abila, Richard., 1998. Utilisation and Economic Valuation of the Yala Swamp Wetland. In: Strategies for Wise Use of Wetlands - Best Practices in Participatory Management. (Ed) Gauler, M. Proceeding of the 21st International Conference on Wetlands and Development, November 1998, Dakar.

Byaruhanga, A., P. Kasoma, and D. Pomeroy .2001. Important Bird Areas in Uganda. Nature Uganda: Kampala, Uganda.

Cavendish, W. 2000. Empirical Regularities in the Poverty-Environment Relationship of Rural Households: Evidence from Zimbabwe. *World Development*, 28(11): 1979-2003.

Chrisman, T.L., Chapman L.J and C.A. Chapman . 1996. Conserving tropical wetlands through sustainable use. Geotimes, 41:23-25.

Feder, G. and D.L. Umali . 1993. "Adoption of Agricultural Innovations in Developing Countries: A Review." - *Technology Forecasting and Social Change*. Vol. 43, No.3/4, pp. 215-239.

Gichuki, J. 2003. *Ecosystem functioning in African tropical freshwater wetlands: Insights from stable isotopes and water quality analysis (Nyanza Gulf, L. Victoria, Kenya)*. PhD thesis, Free University of Brussels 180 pp.

Gichuki, J. F., Dahdouh Guebas F., Mugo J., Rabuor C.O., Triest L. and F. Dehairs.

2001. “Species Inventory and the Local uses of the Plants and the Fisheries of the Lower Sondu Miriu Wetland of Lake Victoria, Kenya.” *Hydrobiologia* 458: 99-106.

Government of Kenya, GoK. 2002. *Final Draft Sessional Paper on National Wetlands Conservation and Management*, April 2002.

Hayes, J., Roth M., and Zepeda L. 1997. “Tenure security, investment and productivity in Gambian agriculture: A generalized probit analysis.” *American Journal of Agricultural Economics*, Vol 79(2): 369-382.

Heckman, J. 1979. “Sample Selection Bias as a Specification Error.” - *Econometrica*. Vol. 47, No.1, pp. 153-161.

Jones, M.B.1984. Biofuel development in Central Africa: Technology transfer from Ireland. Energy for rural and Island communities III (Ed. By J. Twidell, F. Riddock and B. Grainger), pp 355-361 Pergamon Oxford.

Jones, M.B. 1983. “Papyrus: A new fuel for the third world.” *New Scientist* 99:419-421.

Jones, M.B., and F.M. Muthuri. 1997. Standing biomass and carbon distribution in a papyrus (*Cyperus papyrus L.*) swamp on Lake Naivasha, Kenya. Journal of Tropical Biology 13: 347-356.

Kagwa, R.C., Mulalelo, C.I., Denny , P. and T.O. Okurut. 2001. The impact of Alum discharges on a natural tropical wetland in Uganda. Water research 35(3): 759-807.

Maclean, I.M.D., R. Tinch, M. Hassall, and R. Boar. 2003. Social and Economic Use of Wetland Resources: a case study from Lake Bunyoni, Uganda. Environmental change and Management Working Paper ECM 03-09, Center for social and Economic Research on the global Environment (CSERGE), University of East Anglia, Norwich.

Muthuri,F.M., and D.I. Kinyamario. 1989. “The nutritive value of Papyrus *Cyperus papyrus* L.” *Economic Botany* 43: 23-30.

Narain, U., Gupta, S. and K. Van’t Veld. 2005. Poverty and the Environment: Exploring the Relationship between Household Incomes, Private Assets, and Natural Assets. World Resources Institute.

Nasirwa, O. & P. Njoroge. 1997. Papyrus-endemic birds in the fringing swamps of Lake Victoria, Western Kenya. Research Reports of the Centre for Biodiversity, National Museums of Kenya Ornithology, 28.

Nowak, P.J. 1987. “The adoption of agricultural conservation technologies: Economic and diffusion explanations”. Rural Sociology, 52(2): 208-220.

Otieno, M., Imende, S., Haya G., Kibos, S. and Z. Ouma.1998. Sustainable Utilization and Magement of Wetlands and Wetlands Products Pilot Project: Market survey of Wetlands Products in Busia, Siaya, Kisumu and Kisii Districts Report. Lake Victoria Environmental Management Project.

Ostrom, E. 1990. *Governing the commons: The Evolution of Institutions for Collective Action*. Cambridge, U.K.: Cambridge University Press.

Turner, R.K. 1991. Economics and Wetland Management. AMBIO, 20: 59-63.

Table 1: Description and measurement of variables

Variables	Description	Measurement
AMTPAP	Amount of papyrus harvested per month	Kilograms
YRSPAP	Number of years involved in papyrus activities	Years
DISTPAP	Distance covered in harvesting papyrus	Kilometers
PAPYRUS ROOF	Papyrus roofed house	Papyrus roof =1, 0 otherwise
GRASS ROOF	Grass roofed house	Grass roof =1, 0 otherwise
IRON ROOF	Iron sheets roofed house	Iron sheet roof =1, 0 otherwise
PAPYRUS SEATS	Seats made from papyrus	Papyrus seats =1, 0 otherwise
WOODEN SEATS	Seats made of wood	Wooden seats =1, 0 otherwise
SOFA SETS	Sofa sets	Sofa sets =1, 0 otherwise
MUD WALLS	A house with mud walls	Mud wall =1, 0 otherwise
HHS	Household size	Number of persons
AGE	Age of papyrus harvester /in related papyrus activities	Years
EDUC	Education level of papyrus harvester	Number of years in formal schooling
SEX	Sex of the papyrus harvester	1=male, 0=female
TIMEPAP	Time taken (effort) in papyrus harvesting per month	Hours
HHINC	Household income per month	Ksh
NONPAPINC	Income from non-papyrus related activities per month	Ksh
TOTAL PHOSPHORUS	Water quality (Total phosphorus)	ugP/l
TOTAL NITROGEN	Water quality (Total nitrogen)	*ugN/l*
AMMONIA	Water quality (Ammonia)	ugN/l

Table 2: Sex of papyrus harvesters /traders in selected beaches

	Frequency	**Percentage**
Male	126	47
Female	142	53
Total	**268**	**100.00**

Source: Field survey, 2005

Table 3: Motivation /reasons for harvesting papyrus

Responses	Frequency	Percentage

Livelihood/income	175	65.3
Ready market	3	1.12
Readily available	13	4.85
Others	20	7.46

Source: Field survey, 2005

Table 4: Constraints faced in papyrus activities

Responses	Frequency	Percentage
Diseases /pests/snakes	86	32.1
Transport problems	48	17.9
Dangerous wild animals	108	40.3
Lack of markets	56	20.9
Burning of papyrus	33	12.3
Others	67	25.0

Source: Field survey, 2005

Table 5: Suggested solutions for problems encountered in papyrus activities

Responses	Frequency	Percentage
Provision of protective gear / insect repellent	32	12.2
Spraying /slashing vegetation	27	10.3
Marketing	37	14.1
Provision of harvesting tools /equipments	16	6.1
Formation of community based groups	10	3.8
Enforce /stop burning	10	3.8
Provision of transport facilities	15	5.7
Do not know	6	2.3
Others	109	41.6
Total	262	100.0

Source: Field survey, 2005

Table 6: Wealth indicators

Wealth indicator	Responses	Frequency	Percentage
Type of roof	Iron sheets	74	28.6
	Papyrus grass	56	21.6
	Other grasses	124	47.9
	Others	5	1.9
	Total	**259**	**100.00**
Type of walls	Mud	233	86.9
	Wood	9	3.4
	Stones /bricks	13	4.9
	Others	4	1.5
	Total	**259**	**100.00**
Type of seats	Papyrus	31	12.0
	Wood	168	65.1
	Sofa sets	59	22.9
	Total	**258**	**100.00**
Telephone	Yes	4	1.6
	No	254	98.4
	Total	**258**	**100.00**
Electricity	Yes	0	0
	No	258	100
	Total	**258**	**100.00**

Source: Field survey, 2005

Table 7: Perception of changes on use papyrus use dynamics

Type of changes	Responses	Frequency	Percentage
Use more papyrus than 5 years ago	Agree	153	65.4
	Disagree	75	32.1
	Not sure with statement	6	2.6
	Total	**234**	**100.0**
Go longer distances to harvest papyrus than 5 years ago	Agree	112	48.1
	Disagree	115	49.4
	Not sure with statement	6	2.6
	Total	**233**	**100.0**
Amount of papyrus harvested smaller than 5 years ago	Agree	109	46.8
	Disagree	114	48.9
	Not sure with statement	10	4.3
	Total	**233**	**100.0**
Demand for papyrus is higher than 5 years ago	Agree	160	66.4
	Disagree	67	27.8
	Not sure with statement	14	5.8
	Total	**241**	**100.00**
Papyrus will disappear unless well managed	Agree	114	47.3
	Disagree	71	29.5
	Not sure with statement	56	23.2
	Total	**241**	**100.0**
Anyone can harvest papyrus in the village	Agree	181	75.1
	Disagree	28	11.6
	Not sure with statement	32	13.3
	Total	**241**	**100.0**

Source: Field survey, 2005

Table 8: Descriptive statistics for some selected variables

Variables	N	Min	Max	Mean	Std. Dev.
YRSPAP	196	1	60	13.61	12.24
DISTPAP	199	0.01	5	1.35	1.04
HHS	207	2	21	6.13	2.81
AGE	211	20	86	47.90	16.98
AGEAGE	211	400	7396	2581.30	1706.53
EDUC	179	0	14	5.30	3.37
SEX	211	0	1	0.52	0.50
TIMEPAP	199	2	336	111.27	56.5
HHINC	195	100	39000	4603.48	5021.96
NONPAPINC	211	0	7650	976.07	1448.13
PAPYRUS ROOF	211	0	1	0.24	0.43

GRASS ROOF	211	0	1	0.44	0.50
PAPYRUS SEATS	211	0	1	0.14	0.35
WOODEN SEATS	211	0	1	0.65	0.48
MUD WALLS	211	0	1	0.86	0.35
AMMONIA	211	11.12	81.36	43.49	23.53
TOTAL POSPHORUS	211	38.29	77.57	53.21	10.99
TOTAL NITOGEN	211	20	86	47.90	16.98

Source: Field survey, 2005

Table 9: Truncated Tobit results of the determinants of papyrus harvesting in the Yala Wetlands [Dependent variable = ln (quantity harvested in kg)]

Variables	*Coefficient*	*Z*	*P>IZI*	*Marginal effect (df/dx)*
YRSPAP	0.036	2.78	0.001	0.036***
DISTPAP	-0.119	-0.87	0.383	-0.119
HHS	0.089	2.14	0.032	0.089**
AGE	-0.062	-1.22	0.223	-0.062
AGEAGE	0.000	0.41	0.678	0.000
EDUC	0.041	0.93	0.352	0.041
SEX	0.628	2.25	0.024	0.628**
TIMEPAP	0.004	1.49	0.136	0.004
HHINC	0.000	0.92	0.356	0.000
NONPAPINC	-0.000	-2.23	0.026	-0.000**
PAPYRUS ROOF	-0.210	-0.61	0.539	-0.210
GRASS ROOF	-0.976	-3.15	0.002	-0.977***
PAPYRUS SEATS	0.245	0.54	0.592	0.245
WOODEN SEATS	-0.591	-1.76	0.079	-0.591*
MUD WALLS	0.259	0.73	0.466	0.259
AMMONIA	0.020	3.22	0.001	0.020***
TOTAL POSPHORUS	-0.011	-0.87	0.383	-0.011
TOTAL NITROGEN	0.000	0.88	0.379	0.000
Constant	6.43	4.37	0.000	6.426***
SIGMA	1.310	16.73	0.000	
Log likelihood	-233.491			
Wald chi2 (18)	99.73			
Prob>chi2	0.000			
N	142			

***, **, * indicates 1%, 5%, and 10% significance levels
Source: Field survey 2005

Table A1: Correlation matrix for selected variables

Variable													
	AMMONIA	*TOTAL PHOSPHORUS*	*TOTAL NITROGEN*	*AGE*	*SEX*	*EDUC*	*HHS*	*YRSPAP*	DISTPAP	HHINC	PAPYRUS ROOF	*WOODEN SEATS*	*GRASS ROOF*
AMMONIA	1.000												
TOTAL PHOSPHORUS	0.3031	1.000											
TOTAL NITROGEN	-0.1457	-0.2952	1.000										
AGE	-0.1600	-0.1401	0.0155	1.000									
SEX	-0.2986	-0.3216	0.3302	0.2608	1.000								
EDUC	-0.0001	-0.0808	0.0638	-0.5040	0.1532	1.000							
HHS	-0.1941	-0.0131	0.1169	0.1517	0.1023	0.0990	1.000						
YRSPAP	-0.1561	-0.1915	-0.0426	0.4903	0.2278	-0.2867	0.0761	1.000					
DISTPAP	0.2452	0.4473	-0.3540	-0.1837	-0.3419	0.0339	-0.1096	-0.2883	1.000				
HHINC	0.2182	0.0137	0.1338	-0.2146	-0.0179	0.0847	-0.1109	-0.0617	0.0415	1.000			
PAPYRUS	0.0394	0.0501	0.1678	0.01	0.02	-	-	0.012	0.025	0.06	1.000		

ROOF				10	41	0.0423	0.0154	6	4	98			
WOODEN SEATS	-0.1563	-0.1842	0.1189	0.0616	0.1007	-0.0113	-0.0320	0.0396	-0.1017	-0.0277	0.0674	1.000	
GRASS ROOF	-0.1057	-0.2589	0.0990	-0.1098	0.1639	0.1818	0.0181	-0.1170	-0.0454	0.0061	-0.4819	0.1927	1.000
MUD WALLS	-0.0510	0.1161	0.1358	-0.0437	0.0053	-0.0205	-0.0411	0.0264	0.0271	0.0395	0.0899	0.1992	0.1790
AGEAGE	-0.1329	-0.1372	-0.0033	0.9883	0.2750	-0.4820	0.1205	0.5040	-0.1932	-0.2268	0.0248	0.0414	-0.1202
NONPAPINC	0.0263	-0.0892	0.0450	-0.0678	0.1569	0.1961	0.0444	-0.0851	-0.0421	0.3584	-0.0191	-0.0806	0.0822
TIMEPAP	0.3984	0.4277	-0.3734	-0.2232	-0.2623	0.1621	0.0351	-0.0799	0.4675	0.0357	0.0854	-0.0316	-0.0856

	MUD WALLS	*AGEAGE*	*NONPAPINC*	*TIMEPAP*
MUD WALLS	1.000			
AGEAGE	-0.0373	1.000		
NONPAPINC	-0.0921	-0.0857	1.000	
TIMEPAP	0.0044	-0.2231	-0.1276	1.000

[1] This is a body that has been mandated to create public awareness on the importance of wetlands, formulation and coordination of national wetlands policy and facilitation of the inventory and characterization of wetlands among others.

[2] Excess phosphorus in water causes algal "blooms".

[3] The Bondo-Osieko road has been paved through Kenya government funding while the Dominion Group of Companies is paving the roads from and leading to Kadenge.

[4] In a number of places, Lake Basin Development Authority (LBDA) has financed the construction of stores and other facilities where wetlands products can be marketed through cooperative societies such as the Bunyala Cooperative Society.