Journal of Ecology and The Natural Environment

Volume 7 Number 3, March 2015

ISSN 2006-9847

Academic Journals

ABOUT JENE

The **Journal of Ecology and the Natural Environment (JENE)** (ISSN 2006-9847) is published Monthly (one volume per year) by Academic Journals.

Journal of Ecology and the Natural Environment (JENE) provides rapid publication (monthly) of articles in all areas of the subject such as biogeochemical cycles, conservation, paleoecology, plant ecology etc.

The Journal welcomes the submission of manuscripts that meet the general criteria of significance and scientific excellence. Papers will be published shortly after acceptance. All articles published in JENE are peer-reviewed.

Submission of Manuscript

Please read the **Instructions for Authors** before submitting your manuscript. The manuscript files should be given the last name of the first author

Click here to Submit manuscripts online

If you have any difficulty using the online submission system, kindly submit via this email jene@academicjournals.org.

With questions or concerns, please contact the Editorial Office at jene@academicjournals.org.

Editorial Board

Instructions for Author

Electronic submission of manuscripts is strongly encouraged, provided that the text, tables, and figures are included in a single Microsoft Word file (preferably in Arial font).

The **cover letter** should include the corresponding author's full address and telephone/fax numbers and should be in an e-mail message sent to the Editor, with the file, whose name should begin with the first author's surname, as an attachment.

Article Types
Three types of manuscripts may be submitted:

Regular articles: These should describe new and carefully confirmed findings, and experimental procedures should be given in sufficient detail for others to verify the work. The length of a full paper should be the minimum required to describe and interpret the work clearly.
Short Communications: A Short Communication is suitable for recording the results of complete small investigations or giving details of new models or hypotheses, innovative methods, techniques or apparatus. The style of main sections need not conform to that of full-length papers. Short communications are 2 to 4 printed pages (about 6 to 12 manuscript pages) in length.

Reviews: Submissions of reviews and perspectives covering topics of current interest are welcome and encouraged. Reviews should be concise and no longer than 4-6 printed pages (about 12 to 18 manuscript pages). Reviews are also peer-reviewed.

Review Process

All manuscripts are reviewed by an editor and members of the Editorial Board or qualified outside reviewers. Authors cannot nominate reviewers. Only reviewers randomly selected from our database with specialization in the subject area will be contacted to evaluate the manuscripts. The process will be blind review.
Decisions will be made as rapidly as possible, and the journal strives to return reviewers' comments to authors as fast as possible. The editorial board will re-review manuscripts that are accepted pending revision. It is the goal of the AJFS to publish manuscripts within weeks after submission.

Regular articles

All portions of the manuscript must be typed double-spaced and all pages numbered starting from the title page.

The Title should be a brief phrase describing the contents of the paper. The Title Page should include the authors' full names and affiliations, the name of the corresponding author along with phone, fax and E-mail information. Present addresses of authors should appear as a footnote.

The Abstract should be informative and completely self-explanatory, briefly present the topic, state the scope of the experiments, indicate significant data, and point out major findings and conclusions. The Abstract should be 100 to 200 words in length.. Complete sentences, active verbs, and the third person should be used, and the abstract should be written in the past tense. Standard nomenclature should be used and abbreviations should be avoided. No literature should be cited.
Following the abstract, about 3 to 10 key words that will provide indexing references should be listed.

A list of non-standard **Abbreviations** should be added. In general, non-standard abbreviations should be used only when the full term is very long and used often. Each abbreviation should be spelled out and introduced in parentheses the first time it is used in the text. Only recommended SI units should be used. Authors should use the solidus presentation (mg/ml). Standard abbreviations (such as ATP and DNA) need not be defined.

The Introduction should provide a clear statement of the problem, the relevant literature on the subject, and the proposed approach or solution. It should be understandable to colleagues from a broad range of scientific disciplines.

Materials and methods should be complete enough to allow experiments to be reproduced. However, only truly new procedures should be described in detail; previously published procedures should be cited, and important modifications of published procedures should be mentioned briefly. Capitalize trade names and include the manufacturer's name and address. Subheadings should be used. Methods in general use need not be described in detail.

Results should be presented with clarity and precision. The results should be written in the past tense when describing findings in the authors' experiments. Previously published findings should be written in the present tense. Results should be explained, but largely without referring to the literature. Discussion, speculation and detailed interpretation of data should not be included in the Results but should be put into the Discussion section.

The Discussion should interpret the findings in view of the results obtained in this and in past studies on this topic. State the conclusions in a few sentences at the end of the paper. The Results and Discussion sections can include subheadings, and when appropriate, both sections can be combined.

The Acknowledgments of people, grants, funds, etc should be brief.

Tables should be kept to a minimum and be designed to be as simple as possible. Tables are to be typed double-spaced throughout, including headings and footnotes. Each table should be on a separate page, numbered consecutively in Arabic numerals and supplied with a heading and a legend. Tables should be self-explanatory without reference to the text. The details of the methods used in the experiments should preferably be described in the legend instead of in the text. The same data should not be presented in both table and graph form or repeated in the text.

Figure legends should be typed in numerical order on a separate sheet. Graphics should be prepared using applications capable of generating high resolution GIF, TIFF, JPEG or Powerpoint before pasting in the Microsoft Word manuscript file. Tables should be prepared in Microsoft Word. Use Arabic numerals to designate figures and upper case letters for their parts (Figure 1). Begin each legend with a title and include sufficient description so that the figure is understandable without reading the text of the manuscript. Information given in legends should not be repeated in the text.

References: In the text, a reference identified by means of an author‘s name should be followed by the date of the reference in parentheses. When there are more than two authors, only the first author‘s name should be mentioned, followed by ’et al‘. In the event that an author cited has had two or more works published during the same year, the reference, both in the text and in the reference list, should be identified by a lower case letter like ’a‘ and ’b‘ after the date to distinguish the works.

Examples:

Abayomi (2000), Agindotan et al. (2003), (Kelebeni, 1983), (Usman and Smith, 1992), (Chege, 1998; 1987a,b; Tijani, 1993,1995), (Kumasi et al., 2001)
References should be listed at the end of the paper in alphabetical order. Articles in preparation or articles submitted for publication, unpublished observations, personal communications, etc. should not be included in the reference list but should only be mentioned in the article text (e.g., A. Kingori, University of Nairobi, Kenya, personal communication). Journal names are abbreviated according to Chemical Abstracts. Authors are fully responsible for the accuracy of the references.

Examples:

Chikere CB, Omoni VT and Chikere BO (2008). Distribution of potential nosocomial pathogens in a hospital environment. Afr. J. Biotechnol. 7: 3535-3539.

Moran GJ, Amii RN, Abrahamian FM, Talan DA (2005). Methicillinresistant Staphylococcus aureus in community-acquired skin infections. Emerg. Infect. Dis. 11: 928-930.

Pitout JDD, Church DL, Gregson DB, Chow BL, McCracken M, Mulvey M, Laupland KB (2007). Molecular epidemiology of CTXM-producing Escherichia coli in the Calgary Health Region: emergence of CTX-M-15-producing isolates. Antimicrob. Agents Chemother. 51: 1281-1286.

Pelczar JR, Harley JP, Klein DA (1993). Microbiology: Concepts and Applications. McGraw-Hill Inc., New York, pp. 591-603.

Short Communications

Short Communications are limited to a maximum of two figures and one table. They should present a complete study that is more limited in scope than is found in full-length papers. The items of manuscript preparation listed above apply to Short Communications with the following differences: (1) Abstracts are limited to 100 words; (2) instead of a separate Materials and Methods section, experimental procedures may be incorporated into Figure Legends and Table footnotes; (3) Results and Discussion should be combined into a single section.
Proofs and Reprints: Electronic proofs will be sent (e-mail attachment) to the corresponding author as a PDF file. Page proofs are considered to be the final version of the manuscript. With the exception of typographical or minor clerical errors, no changes will be made in the manuscript at the proof stage.

Fees and Charges: Authors are required to pay a $550 handling fee. Publication of an article in the Journal of Ecology and the Natural Environment is not contingent upon the author's ability to pay the charges. Neither is acceptance to pay the handling fee a guarantee that the paper will be accepted for publication. Authors may still request (in advance) that the editorial office waive some of the handling fee under special circumstances

Journal of Ecology and the Natural Environment

Table of Contents: Volume 7 Number 3, March 2015

ARTICLES

academicJournals

Vol. 7(3), pp. 56-71, March 2015
DOI: 10.5897/JENE2014.0448
Article Number: F6E540352117
ISSN 2006-9847

http://www.academicjournals.org/JENE

Journal of Ecology and the Natural Environment

Full Length Research Paper

Institutional pluralism, access and use of wetland resources in the Nyando Papyrus Wetland, Kenya

Serena A. A. Nasongo[1,5]*, Fred Zaal[1,2], Ton Dietz[1,3] and J. B. Okeyo-Owuor[4,5]

[1]University of Amsterdam, The Netherlands Fred Zaal, The Netherlands.
[2]Royal Tropical Institute, Amsterdam, The Netherlands.
[3]African Studies Centre, Leiden, The Netherlands.
[4]School of Environmental Sciences, University of Eldoret, Kenya.
[5]VIRED International, Kisumu, Kenya.

Received 11 April, 2014; Accepted 17 March, 2015

Wetlands support livelihoods of communities living around them as in the Nyando Papyrus Wetland in Kenya. The Nyando Papyrus Wetlands provide multiple resources hence there are multiple uses and users who often overlap spatially and seasonally causing conflicts. More claims are being exerted on these wetland resources from different sides and institutional levels with different actors. The actors involved refer to various legal systems and mechanisms, and frequently create new hybrid law as in the case in the Nyando papyrus wetlands. These institutions, in various degrees of transformation, still have an important role in determining how resources are used. The objective of this study is to find out about the institutions affecting wetland resource use in the past and in the present and to determine the dynamics of specific natural resource-related institutions in four sub-locations in the Nyando Papyrus Wetlands, Kenya. The study shows that there is legal pluralism in the Nyando Wetlands, which requires synergy for sustainable livelihoods in the local communities and for ecosystem management.

Key words: Nyando Papyrus Wetlands, legal pluralism, institutions.

INTRODUCTION

Wetlands comprise of a number of physical, biological and chemical components that yield numerous benefits, which provide both direct and indirect services of value to humans such as wildlife, fisheries and forest resources (Denny, 1997; Carter, 1996; Bergstrom and Brazee, 1991). They also perform important ecological functions such as flood control, shoreline stabilization, water purification and the preservation of biodiversity (Millennium Ecosystem Assessment, 2005). As environmental degradation of farmlands and population pressure in rural areas force more people to seek livelihood strategies other than agricultural ones, the use of wetlands for harvesting of wetland resources has increased all over Africa. As many governments have failed to recognize the significance of local wetland services and indeed the value of wetland functions, they have stimulated rather than mitigated or prevented the intensification of wetland exploitation to improve livelihoods for riparian communities (Wee and Heyzer, 1995; IWMI, 2006; Bikangaga et al., 2007). Increasingly

*Corresponding author. E-mail: adedeserena@gmail.com.

therefore, there is evidence that exploitation and transformation is exceeding the potential for the sustainable use of wetlands, resulting in degradation and the loss of livelyhood benefits for all (Millennium Ecosystem Assessment, 2005).

To conserve wetlands properly, it is important to understand the institutions that govern their use and management, and the activities and behaviour of human societies within and around those wetlands, and to devise ways to address processes, activities and behaviour that have a deleterious effect on their survival and sustained use through adapted management and use.

One important question of course is what constitutes the ‘proper use' of wetlands. In the framework of this paper, it is necessary to start from the assumption that the definition of proper management differs per stakeholder or user, over time and from one geographical location to the next. We can only give a very general and flexible definition therefore of what constitutes proper use, and although various frameworks have been proposed, one important description is related to the Ramsar convention (Ostrovskaya et al., 2012). The Ramsar convention refers to ‘wise use', and defines this as 'maintaining their ecological character, achieved through the implementation of ecosystem approaches within the context of sustainable development' (Ramsar handbook 1, 2007). This mainly shifts the problem to the next level, as this ‘ecological character' is also a variable characteristic. However, described systematically, it can thus serve as one particular type of ‘proper use'.

The institutions needed for this ‘proper use' have been for a long time seen to be either informal or formal. Informal institutions are also called traditional ones. They are local, culturally determined and part of the social and historic background of a people and/or area. Formal institutions are often initiated by a national government; they are law-based and often go back to Colonial origins. There are however a number of problems with this dichotomy. The most important one is that these two types of institutions exist together, at the same time and place (Kemerink et al., 2013). The situation is one of legal pluralism rather than either one or the other, with very clear categories of institutions belonging to either formal or informal institutions. According to Quinne et al. (2007) and Ostrom (1990, 2000) institutional design or institutional crafting in this perspective is an impossible goal. There is no clear-cut and rational way of organizing a set of institutions of very different character, depending on how strong the institutions that existed were, and how strong any new institutions that have come in are given that they can be traditional/informal, or formal. In this respect, we arrive at an institutional map, with very many different colours, shades of colours and mixed colours.

This paper departs from the idea that the reality of the institutional landscape on the ground shows a diverse pattern of institutions. Cleaver uses the concept of Institutional Bricolage (Cleaver, 2001) Kemerink and others adopted the concept of legal pluralism (Kemerink et al., 2013; Bavinck et al., 2012; Von Benda Beckman et al., 2009). In this paper we adopt the former, normative institutional, framework as the most relevant. Legal pluralism is the interaction of different normative frameworks within the same space. These spaces can be socio-politically or indeed geographically defined (Kemerink et al., 2013, Von Benda Beckman et al., 2009). These normative frameworks are the result of the interaction of people and their environment thus described as sets of rules and regulations, norms and expectations, in one word, institutions, that regulate this interaction.

Within the present study therefore, we use the concept of institutions as describing sets of norms, rules and systems of values (North, 1990) that control, organize, imprint a pattern on and shape the behaviour of actors during their interaction with each other and the environment to satisfy their requirements of life (Vatn, 2005). As stated above, we can distinguish formal and informal institutions, but we want to make it clear from the start that these are convenient constructions, used to describe normative frameworks in an analytical framework. In reality, as we imply with the use of the legal pluralist concept, these ‘pure' versions of normative frameworks hardly exist. They are in constant flux, change depending on local population dynamics, and changes in the environment, and because of intrusions from other legal frameworks. They are hybrid, a situation described as institutional pluralism.

Therefore having said that, informal institutions are socially shared rules, usually unwritten, created, communicated and socially enforced outside of officially sanctioned channels. Informal institutions are as well-known as are formal rules, but they are not laid down in writing and tend to be more persistent (North, 1997). Although, commonly accepted throughout the community, practices related to informal institutions are not officially established. Defined as openly codified, established formal institutions are communicated through channels that are widely accepted as official, written form, supported by legally recognized actors/ entities rather than socially defined categories (Helmke and Levitsky, 2004).

Turning now to the context of the Nyando Wetland, we establish that formal and informal institutions do exist, but that a plethora of hybrid institutions has developed through the interacting normative frameworks, reacting to changes in the community and environment. Taking the pre-colonial situation as a reference point (as a construct used for this discussion, we do not want to be so presumptuous as to state that we know the informal normative framework prevalent at the time in detail), changes in resource use did lead to a significant transformation in informal institutions present at that time. These institutions, in various degrees of transformation, still have an important role in determining how resources are used. Some of the factors that have caused changes in traditional institutions in the Nyando Papyrus Wetlands

include ecological drivers: droughts and floods, and changing vegetation because of changing climate. Others are more human-driven: human population growth, comercialization of the use of natural resources, changes in religious characteristics and changes in governance situations. In the past, most communities exploited wetlands for consumption rather than for commodities exchange and/or money. This scenario is changing with increasing commercialization of wetland resources. Papyrus wetlands support the livelihoods of millions of people by providing food, construction materials, clean water and other benefits.

One last and important issue that pervades this process is the issue of informal and formal normative frameworks having completely different sets of characteristics. However, for an entirely different context, namely the USA, Arnold and Gunderson (2012) have pointed at the fact that these two normative frameworks have different characteristics. USA laws are not well adapted to the ever-changing ecological and social systems. This formal maladaptive framework is characterized as narrow in its description of goals, monocentric, unimodal and fragmented, inflexible and based on a rational, linear and legal-centralist way of thinking (Arnold and Gunderson, 2012). This may, as a thought experiment, be set against local informal frameworks which may be characterized as more adaptable, inherently flexible, holistic and with multiple goals, and above all: legally pluralistic with negative feedback loops when resource use is threatening sustainability of the socio-ecological system. Even when this is not applicable to all institutions (we will discuss this below), these two sets of frameworks have indeed many of the prescribed characteristics. This juxtaposition has inspired Scott (1998) to study the impact of bureaucracy and 'high-modernist' ideology, linked with the power of the state, on the necessary role of local knowledge and expertise. Those newly introduced, inflexible normative frameworks can damage and even eliminate the structure on which a socio-ecological system rests. On the other hand, they can assist such a system to adapt to new and strange development for which the local framework was never going to be sufficient.

The point is of course that both systems rest on a power structure in the respective societies in which they developed. Their functional merging may strengthen this power position of old and new (or merged) elites alike, and when the resulting normative framework does not lead to the required flexible set of institutions, it may be both more damaging to the socio-ecological situation in the long run, and more persistent in its characteristics. The challenge in any real practical situation, such as the Nyando Wetland, is to see how flexibility can be maintained, while at the same time emergent institutions can be supported to provide a long-term assurance of sustainable use of wetland resources.

The objective of this study therefore was to examine the institutions that govern wetland resource use in Nyando wetland. Specific objectives were: (1) to describe the use of wetland resources in Nyando wetland by local communities; (2) to describe the current institutions controlling wetland resource use; (3) to link the two issues to come to an understanding of the causal linkages between these institutions and use practices. All these are discussed in the context of sustainability of resource use, and from there derive recommendations for management policy.

The study area

The Nyando Papyrus Wetland near the city of Kisumu on the shores of Lake Victoria in western Kenya is a typical example of exploited papyrus wetlands that are very common in the Lake Victoria Basin and in other parts of central, eastern and southern Africa (van Dam et al., 2011). The Nyando Wetland is a swamp situated at the mouth of the Nyando River between Nyakach Bay and the Kano Plains (0°11'- 0 °19'S/34°47'-34°57'E). The Nyando River is the major source of water of this wetland but additional waters come from the seasonal Asawo, Nyatini, Ombeyi and Awach-Kano River. Three ecological zones found in the wetland are permanent swamps, seasonal swamps and floodplains (Wakwabi et al., 2006).

The permanent swamp has hydric soils dominated by papyrus throughout the year. They are valuable ecosystems and are of significance particularly to the biota and water quality of the lake where they are situated. In the past, these wetlands supplied sand, clay, papyrus, fuel wood, herbs, and water. Wetlands were infused with a cultural significance and were also used for livestock grazing, hunting, fishing and the provision of grass for thatching houses. Traditional uses were sustainable under low population densities and had self-regulatory systems (Hongo and Masking, 2001; Dixon and Wood, 2003; Kipkemboi, 2006; Adede, 2008). However, use patterns have changed over the years.

The vast majority of the population in this area belongs to the Luo ethnic group, the only Nilotic group in Kenya (Adamson, 1967). They speak the Dholuo language, which belongs to the Western Nilotic branch of the Nilo-Saharan language family. Amongst the Luo, the family is part of a larger group of families called *Dhoot* or clan, which combines to form a Luo sub-group or *ogendni*. Several *ogendni* (plural for *oganda*) form *piny* (meaning a country or nation). According to the Luo, the *Dhoot* (clan) is a group of people united by kinship relationships even if this kinship-based bond is only symbolic in nature. The present day Kenya Luo consist of about 25 *ogendni* (the opinion of the members as to the definition of an *ogendni* differs and so does the number identified), each composed of various clans and sub-clans. Two Luo *ogendni*, the Nyakach and the Kano, are the predominant occupants of the study area.

The Luo were predominantly polygamous and the number of wives and children was a sign of wealth and prestige. They also practiced levirate marriage, in which

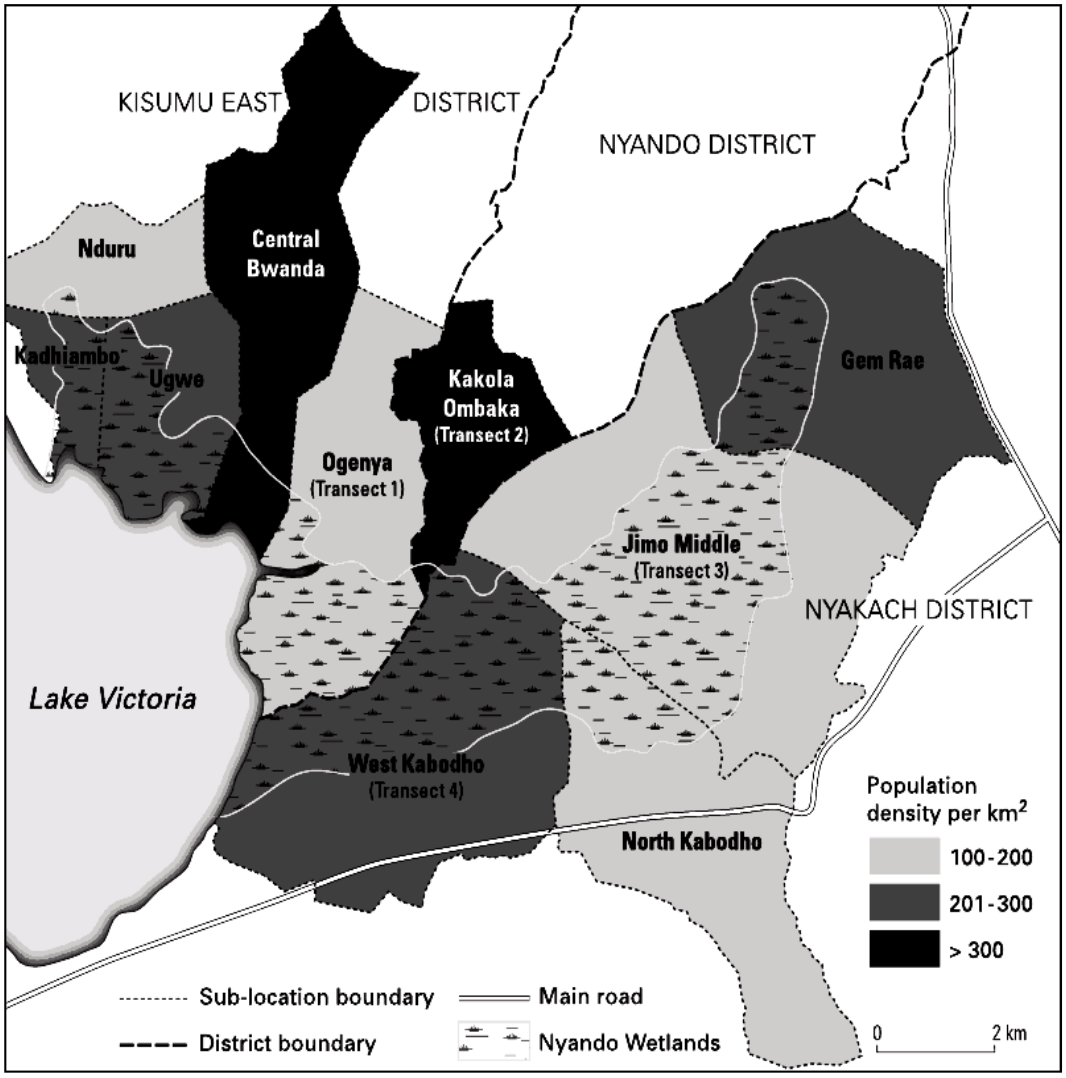

Figure 1. Map showing the study area.

a distant cousin or younger brother might enter into a union with the widow(s) of the deceased cousin or brother to help socialize children and continue child bearing on behalf of the deceased (Potash, 1986). The Luo live in family compounds, with strict dwelling arrangements that delineate seniority amongst wives and their children. There is also a strict seniority as far as brothers' domestic career is concerned; a younger brother could not marry unless his elder brothers were married first.

The above social arrangements and institutions, briefly described, already suggest that very inflexible arrangements and institutions (around seniority in marriage and the location of the house in particular) were combined with very flexible institutions of the levirate and woman-woman marriage, to absorb incidental and unfavorable crises situations that would threaten the local and regional socio-economic fabric if arranged too stringently.

METHODOLOGYS

The study carried out between October 2009 and May 2011 was in four sub-locations in Nyando wetland: Ogenya, Kakola Ombaka, Jimo Middle and West Kabodho, Kenya (Figure 1), with a population density of 153, 704, 131, and 225 persons per km^2, respectively.

To be able to meet the objectives of the study, data were both qualitative (on community institutions) and quantitative data (on personal normative frameworks and on resource use). Collection of qualitative data was through key informant interviews and focus group discussions. Quantitative data were collected using a household survey with 411 respondents in four transects in the area (Figure 1).

Key informants were people with particular knowledge and understanding of the wetland, its resource users and their problems. The total number of interviews held were 30 and included men and women engaged in fishing and fish trade, harvesting and sale of papyrus mats and sand, officers from government departments, parastatals, and civil society organizations working in the area. The key informant interviews included children who were heads of homes. Topics discussed covered old informal institutions

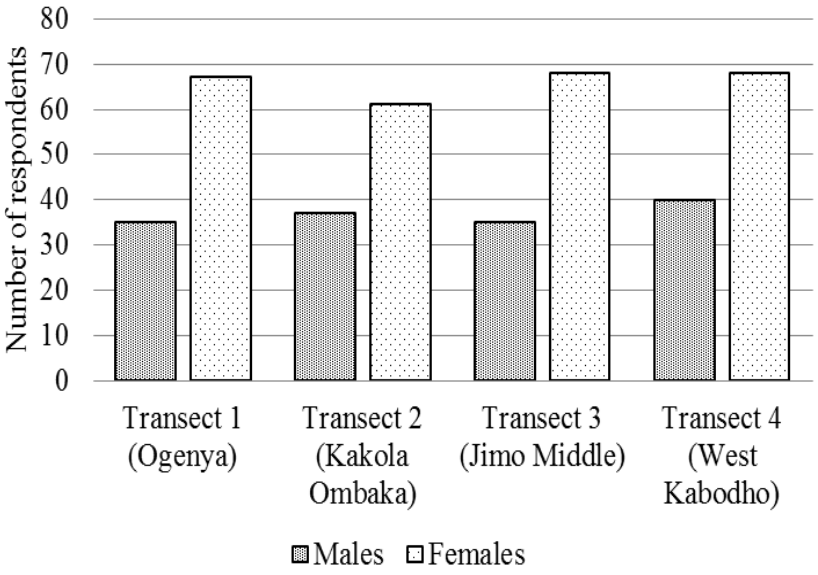

Figure 2. Sex of respondents by transect.

that guided wetland resource use, new formal and current hybrid institutions, and the reasons for 'institutional pluralization' taking place. Discussions included trends and changes in resource use within the Nyando wetlands, Kenya. The results from the key-informant interviews (KII) shows that respondents from government departments, parastatals and civil society organizations did not have knowledge of traditional and hybrid institutions since most of them are employed and may not be originally from the area.

The focus group discussions conducted were 13 and these contributed to a better understanding of data from the quantitative survey, triangulating these findings, and to obtain insights into perceptions, needs, problems, beliefs, practices and institutions related to them. The participants interviewed in the focus group discussions comprised both males and females as mixed groups who use a particular resource and drawn from different age groups. Coded verbatim transcripts of information from the focus group discussions and key informants interviews was analyzed using Atlas.ti (Scientific Software Development GmbH, Berlin) to obtain insight in similarities and develop trends.

The data from the survey used to obtain information on the personal belief systems of the respondents and on their reasons for conforming or not conforming to informal institutions that guided wetland resource use, and on the wetland use was analyzed using Statistical Package for Social Sciences (SPSS, IBM Corporation, New York) to generate frequencies and cross tabulations.

Household composition: The key to institutions for access

There were a total of 411 respondents with transects 1, 2, 3, and 4 having 102, 98, 103 and 108 respondents, respectively. Figure 2 shows the sexes of the respondents by transect. As suggested above, household composition and in particular whether a household is male headed, female headed or actually child headed (a recent phenomenon), is crucial for the understanding of household access to resources, and the degree in which a household is dependent on these (common property) wetland resources. Linking informal, formal and hybrid institutions to resource access and the impact of these institutions on access explains why certain resources are likely to be overused. For example, certain resources are only accessible to men, or women may have access to them only when not on their menstrual cycle. Children hardly ever have access to any resources until they have fulfilled certain obligations or reached a certain legal age. The age of respondents is shown in Figure 3. However, things are changing: women now have access to fisheries resources and land when they are single mothers, a consequence of formal regulations, based on the new constitution.

Figure 4 shows that 70% of the households in transect 1 were headed by males, 72% in transect 2, 71% in transect 3 and 69% in transect 4 respectively, while 25% were headed by females in transect 1, 24% in transects 2 and 4, and 26% in transect 3 respectively. In households where the husbands worked away from home or were incapacitated, females were responsible for running affairs at home and taking decisions (male headed, female managed households). In transect 1, the respondents in male headed- female run households was 4% while transect 2 had 2%, Transect 3 had 3 and transect 4 had 6%, respectively. Child-headed homes are a minority at only 1%. However, this is a telling increase, as they did not exist before. Their prevalence is a result of the decline in the strength of traditional institutions, the weakening of kinship networks and in the duty to absorb remnants of households when crises have struck. These crises relate to the increase in deaths associated with HIV/AIDS and the impossibility to absorb remnants of surviving household members due to over-burdened livelihood options. The last dimension: being a monogamous or polygamous household, is still very important: 44% of male-headed households and slightly more than 13 percent of female-headed households were polygamous. Only 0.2% of the female-headed homes were in a levirate union (Figure 5).

The increase in deaths resulting from HIV/AIDS-related diseases has profoundly affected nearly all forms of household capital, livelihood social networks, and household access to community assets. This is leading to increased household vulnerability, particularly if the deceased was a productive adult household member (Haddad and Gillespie, 2001; Yamano and Jayne, 2004), and the remainder of the household does not have the level of access the former head of the household had. Death or illness caused by HIV-AIDS affects almost 90% of the households in the Nyando wetlands as reported by the key informant interviews.

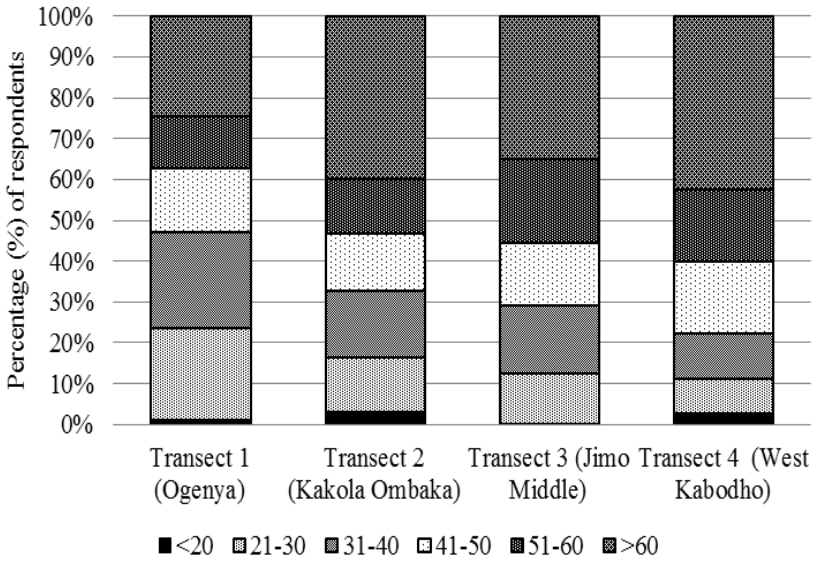

Figure 3. Age of respondents in the Nyando wetlands, Kenya.

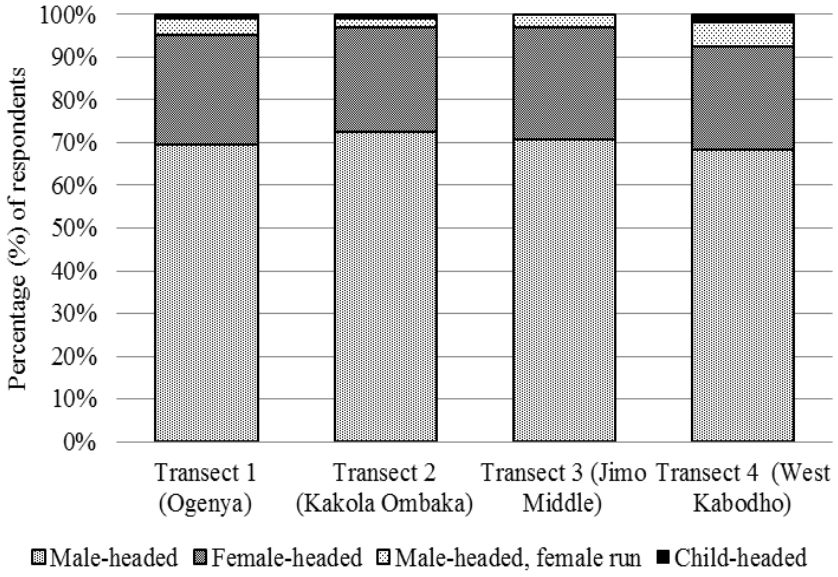

Figure 4. Types of household head of respondents by transect in the Nyando wetlands, Kenya.

Ecological conditions

According to 60% of the key informants interviewed, the main factors associated with the historical decline of some fish populations in the Nyando Papyrus Wetlands are interference of spawning and rearing habitat and blockage of adult passage to suitable spawning and rearing areas. Other factors that may affect population abundance include diversion of juveniles off the primary migration path, fishing of juveniles in diversions, toxic discharge to the rivers, and uncontrolled fishing in the lake. Temperature is a primary factor influencing the breeding and survival of *Protopterus aethiopicus* (Kamongo) which breeds in shallow pools of water in the wetlands.

In transect 1 (Ogenya), the ecological gradient is characterized by cropland with settlement, sugarcane, papyrus and a channel (Aguko) which is suffocated by water hyacinth that joins the lake. The socio-economic activities in the site include farming, fishing, harvesting papyrus and making mats. In this transect, the wetland is influenced by the lake. In transect 2 (Kakola Ombaka), the wetland is influenced by western distributary of the Nyando River. The ecological gradient starts from irrigated rice fields, sugarcane and food crops to the wetlands along the river. The major crops grown in this area are maize and sugarcane. Socio-economic activities include livestock grazing, farming, fishing and papyrus harvesting. The ecological gradient in Transect 3 (Jimo Middle)

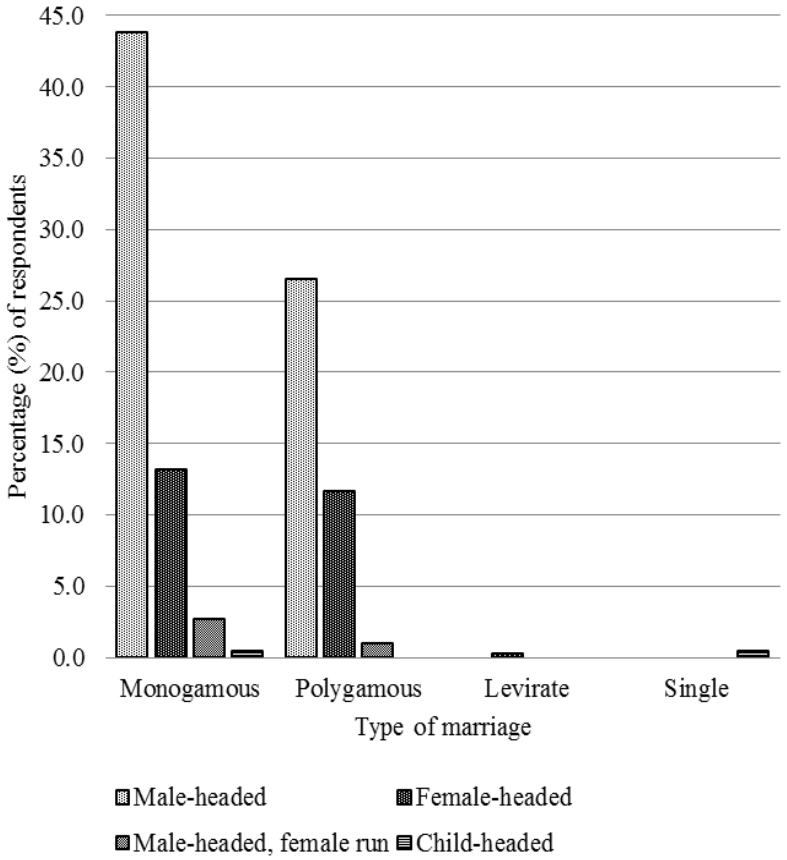

Figure 5. Types of marriages of respondents in the Nyando wetlands, Kenya. Polygamous marriage is the practice or state of being married to more than one person at a time. Levirate marriage is a type of marriage in which the brother of a deceased man is obliged to marry his brother's widow.

starts with the floodplain on the left bank which is colonized by indigenous herbs, invasive plant species and occasional wetland vegetation especially during flooding. The wetland is found on the right bank. The area appears to be rich in avifauna some of which nest, feed and rest along the river and especially where human disturbance is minimal. There is also diverse fish species that are found in the river and numerous hippo pools. The main socio-economic activities on left side of the river are cattle grazing, fishing and on the right side lies the wetlands in which the main socio-economic activities include crop farming, cattle grazing, fishing, harvesting wetland products and brewing of local brew (Chang'aa). Transect 4 (West Kabodho) has mostly sandy soils and the vegetation is characterized by euphorbia, cactus and *Lantana camara*. Some of the socio economic activities include fishing, wetland farming, petty trade along the landing beaches, grazing of livestock and harvesting of wetland products.

Wetland resource use

Products harvested from the Nyando papyrus wetlands include fish, plants, birds, wildlife and insects used for food, medicine, building materials and livestock feed. Figure 6 shows that 88% of the respondents harvest wetland products and 70% use the harvested products for both commercial and subsistence use. Only 4% use the products exclusively for commercial purposes. There are several ways of grouping wetland resources based on use for subsistence or commercial purposes, use for building and making of handicrafts, as fodder, as medicinal plants or as vegetables (Figure 7). These resources are accessible to all types of households but exclusion of groups of people at various times happens due to institutions governing wetland resource use. Outsiders are locked out from accessing certain resources such as land, and in West Kabodho, where harvesting of papyrus is by clans, it is not easy for outsiders to get access.

Both men and women harvest plants for building and making of handicrafts which include *Cynodon prescostalgi, Cyperus papyrus, Phragmites mauritaianus, Pycreus nitidus* and *Sesbania seban*. Women harvest plants such as *Aspilia* sp., *Rhynchosia* sp., *Harmania uhligii*, *Ipomea wrightii*, *Tragia insuavis* and *Tristemma incompletum* used for medicinal purposes and as vegetables. Men harvest plants such as *Echinochloa pyramidalis* and *Vigna luteola* used as feed supplements for livestock. The plants harvested as vegetables include *Amaranthus spinosa, Cleome gynandra, Corchorus tridens, Ipomea aquatic and Solanum nigram. Cyperus papyrus* provides art and craft making materials such as mats, baskets, chairs, tables, beds and building materials. It is the most important natural wetland product harvested in the Nyando wetlands, the percentage of respondents harvesting different parts and stages of papyrus is shown in Figure 8.

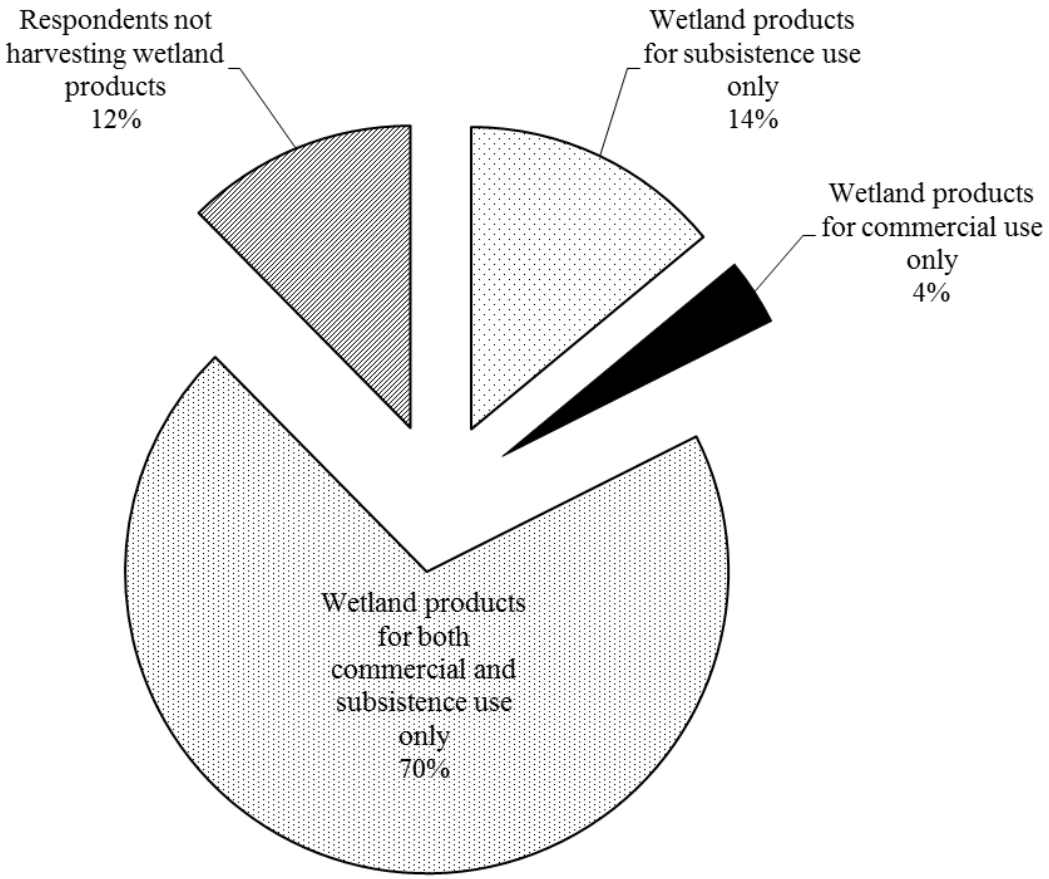

Figure 6. Respondents harvesting wetland products for commercial or subsistence use in the Nyando wetlands, Kenya.

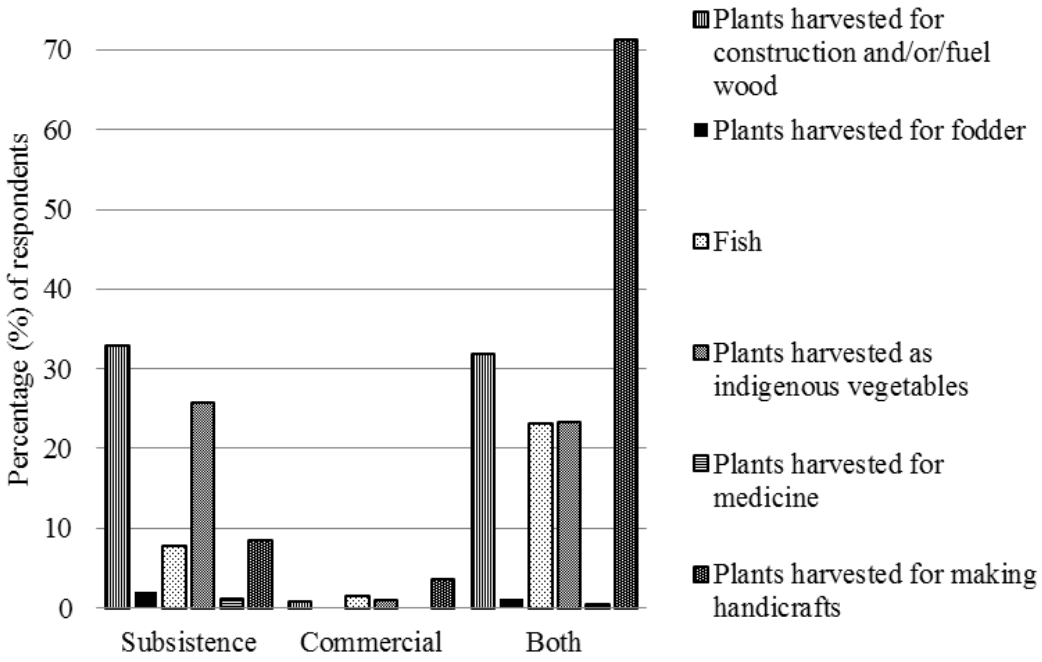

Figure 7. Categories of natural products harvested by respondents in the four transects of the Nyando wetlands, Kenya.

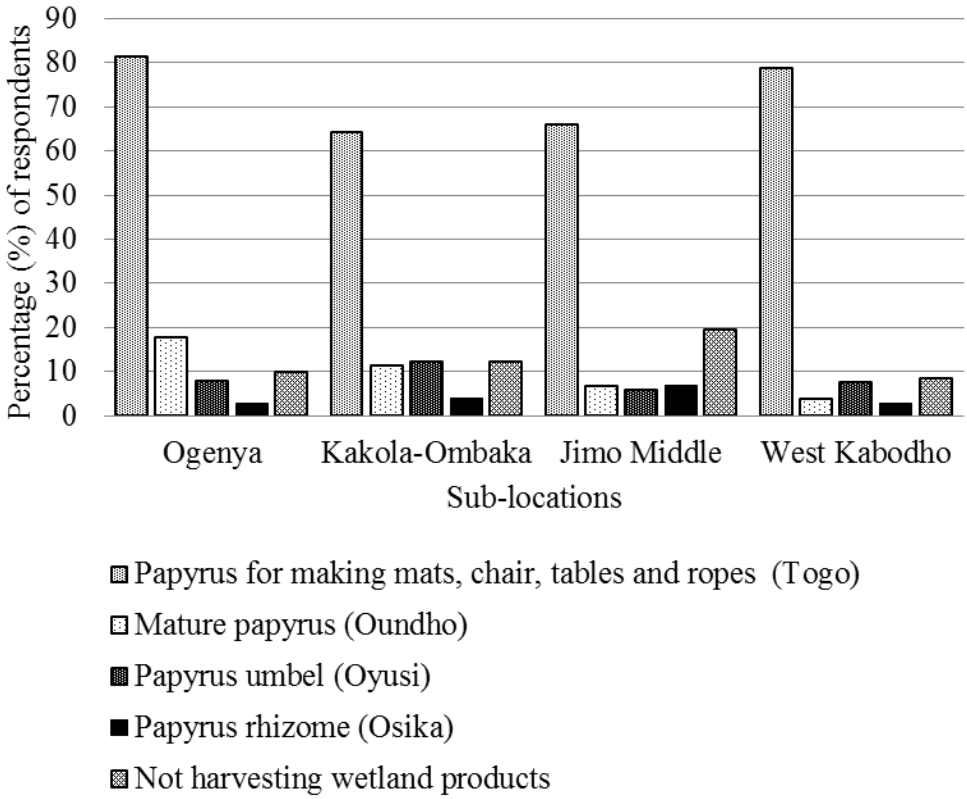

Figure 8. The percentage of respondents harvesting different parts of the papyrus plant in each of the four transects in the Nyando wetlands, Kenya.

The types of fish commonly caught in the Nyando wetland area include *Clarias gariepinus* (locally called mumi, okong' or nyapus depending on size), *Clarias werneri, Labeo* sp., *Lates niloticus*, *Oreochromis niloticus, Protopterus* sp., *Rastrioneobola argentea, Schilbe* sp. and *Synodontis* sp.

Fish such as *C. gariepinus* fingerlings (nyapus) are also used as fish bait for the Nile perch fishery and thus are interesting for commercial purposes hence attracting external players who more often than not engage in bad fishing practices. Furthermore, there are several small fish species such as *Mormyrus* sp. and *Oyuso*, used by the local poor population for food and sales. Figure 9 shows the types of fish species commonly caught by respondents in the Nyando papyrus wetlands, Kenya.

Although not formally protected as Important Bird Areas (IBAs), the wetland is also an important habitat to endangered bird species, and has some habitats crucial for their survival. There are numerous important endemic bird species, many valued by local people and tourists alike.

Wildlife commonly used for food includes hippo (*Hippopotamus amphibius*), hare (*Lepus microtis*) and sitatunga (*Tragecephalus spekeii*). Other species reported to occur are mammals such as otters and mongoose as well as reptiles including snakes (e.g. the African rock python *Python sebae*). Crocodiles (*Crocodylus niloticus*) have declined in numbers over time and now are quite rare in the area. Found in the Nyando papyrus wetlands are numerous insect larvae, earthworms and adult insects used as fish bait.

Land in the wetlands is also an important resource since it is fertile and has high water retention capacity suitable for crop production, especially during the dry season. The local communities grow a variety of crops for subsistence and commercial purposes. Common crops grown are high value fruits and vegetables, maize, rice, pulses and sugarcane.

Institutions and resource use for local livelihoods

Institutions governing the fisheries sector

The artisanal wetland fishery is an important activity. Within the informal normative framework, their exploitation has been largely male dominated, and thus male headed households dominate their access. Traditional dugout fishing boats or papyrus rafts (in Dholuo: *odesso*) and different fishing gears are used including the irreversible fish traps (*osadhi*) (Figure 10) and fish spears (*bidhi*).

Male dominance in fishing is partly rationalized based on the physical strength needed to stay overnight on the open waters, which women are assumed not to have, hence women are not allowed to stay out at night. Another reason for excluding women from open lake fishing is their vulnerability to sexual abuse by men. Other reasons include the fact that men have more resources like money to buy fishing boats and fishing gears whereas women can only afford the less expensive traditional fishing gears. Results from the household survey show that 5% of the women and 2% of the youths own boats and fishing nets and different types of fishing gears with the youth taking to illegal methods of fishing using mosquito nets and also the modified traditional traps. All KII reported that although in the Nyando wetland, women still do not engage in open lake fishing and none of the fishing boat owners employ women as crew members, they now can own boats. In other places, the change in gender-based restrictions to livelihood

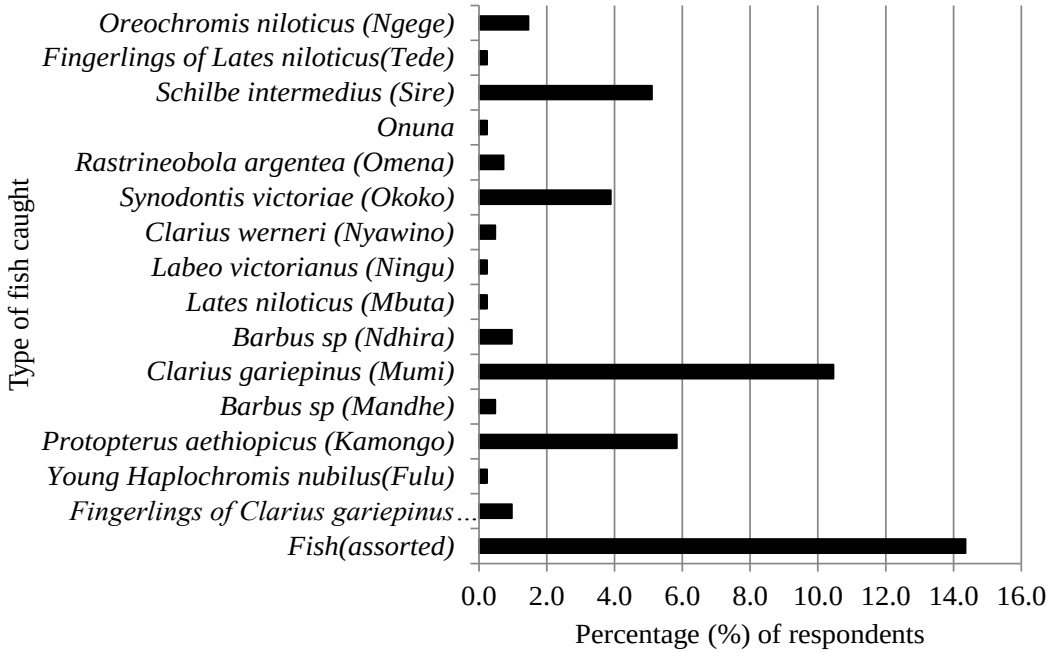

Figure 9. Types of fish harvested by respondents in the Nyando wetland, Kenya.

Figure 10. Traditional fishing traps from left ounga, sienyo and osadhi.

capitals, is mostly caused by poverty as a consequence of increasing numbers of male-less households, women are increasingly employed as crew members in fishing vessels that go out on the open lake.

Notwithstanding, some form of fisheries is also accessible to women. The most common fishing gears for women are the wide-mouthed one-sided traps *ounga* and *sienyo* (Figure 10). The method of using

these fishing gears is called *teng'o,* usually done in shallow waters after the floods recede. It is likely to be close to home and does not necessitate a stay over at night. However, the fish catch per unit of effort is lower, and hence income from sale of such fish is usually lower.

Some forms of fisheries are accessible to both men and women, especially when there do not seem to be the possibility of competition for scarce fish. Both men and women use *sienyo* to fish in freshly flooded waters which carry with it large numbers of fish, especially *Clarias* sp. (*mumi*). The method of digging out mudfish using a hoe called *kunya* is more popular during the dry season. While men made *ounga* and *sienyo*, women owned and used them. In contrast, men made fishing boats and rafts, spears and the irreversible trap (*osadhi*), and in the past men were the exclusive owners and users of fishing boats. Women were restricted from open lake fishing hence were not allowed to own fishing boats.

Results from KII show that 50% of respondents agree that women are now actively catching and trading in *C. gariepinus* fingerlings, used as bait for Nile perch fishing especially in Transect 4 (West Kabodho). In areas occupied by the water hyacinth, women stand in the water for hours searching for these fingerlings. On the one hand, this has allowed women access to income from fish resources in the wetland, but on the other hand, it has causes stress on their livelihood practices and results, as they do not have any protective gears. Consequently, they suffer from health and occupational risks including snakebites and diseases such as schistosomiasis, malaria, foot rot and other skin diseases. All traditional herbalists been interviewed confirmed that there is an increased number of women seeking their services due to injuries suffered as a result of catching *C. gariepinus* fingerlings. The related costs of treatment should be taken into account if the net benefits in economic terms are calculated.

Furthermore, results from the survey show that 40% of the respondents reported that christianity has changed the belief systems and suppressed related customs that previously restricted the use of certain fishing gears. These groups of people prefer to conduct prayers instead of engaging in traditional practices such as cleansing of new boats before being released into the lake or performing cleansing rites when a corpse is found while fishing. In the past, informal institutions regulated the fisheries sector in a variety of ways. Results from FGDs and KII show that there were prohibitions from catching immature fish of any species and when caught accidently these were put back into the water to enable them to grow to maturity. The traditional fishing gears were to catch only mature fish while allowing the juveniles to pass through the open spaces. Discussions held with key informants further indicate that fishing was traditionally prohibited in known fish breeding and spawning grounds in the wetlands and places like Kusa, Sango, Rachuonyo and Gode Ariyo. Folklore about harmful wildlife and diseases were used to scare people from venturing into these areas to fish. In addition, fishing was traditionally restricted between February and August since this coincided with the main cropping season. This ensured that people put concerted efforts on farming giving time for fish to breed and grow hence safeguarding the fisheries sector. In the current wetland fishery, the situation has changed with the introduction of fishing nets in the 1970s. Fishing is carried out in the traditionally restricted areas with all sites used as landing beaches, a situation brought about by increased demand for fish both locally and internationally (SOFIA, 2010).

Sixty percent of the fishermen interviewed reported that they no longer return juvenile fish into the water since they are selling them as bait or as food in the case of young Nile perch (locally called *tede* or *ondhedhe*). Despite government prohibition and scouting, 75% of the fishermen interviewed reported that they use unauthorized fishing gears such as fishing nets with undersized openings and do not observe the closed seasons due to poor enforcement of laws. Bribery of fisheries officers by some rich boat owners was reported by 30% of the key informants and this is frustrating efforts of beach management units (BMU) to enforce the use of correct fishing gears since the illegal fishing nets have bigger catches since they catch fish indiscriminately. Results from FGDs show that antagonistic relationships within families have also prevented BMU officials from working effectively especially when taking disciplinary action on relatives.

The reasons behind these changes are numerous, but an important driving force of change is the new nation-wide formal institutional arrangement developed by the Ministry of Fisheries Development for the governance of fisheries. This change according to key informants is important since enforcement is by government machinery. These include the Fisheries (Prohibitions) Regulations 2003 and the Fisheries (Beach Management Units) Regulations 2007.

The Fisheries (Prohibitions) Regulations 2003 aims to curb destructive fishing methods, by prohibiting fishing for, landing, processing, moving of and trading in Nile perch (*L. niloticus)* of a total length which is less than 85 cm, from the Kenya waters of Lake Victoria. Also, fishing for, landing, processing, moving of or trading in *Rastrineobola argentea* (*Omena*) fish from the Kenya waters of Lake Victoria during the closed season (1st April to 31st July each year) is prohibited.

In 2007, the Fisheries (Beach Management Units) Regulations brought into operation Beach Management Units (BMUs) for co-management of fisheries resources between the government and fishing communities where communities play a key role in resource management, allocation and decision making in order to enhance compliance and reduce costs. The main aim was to decentralize development and enforcement of fisheries polices. The role of BMUs is law enforcement: registration of boats, enforcement of gear regulations and protection of fishing grounds; beach development: fish bandas and sanitation; collection of fisheries data; conflict resolution and welfare matters and handling emergencies. The government on the other hand is responsible for building capacity of these new institutions through training in fisheries management, environment protection and financial management. Results from KII and FGDs show that in the Nyando wetland, all landing beaches have BMUs with democratically elected officials of which at least one third are women, as stipulated in the regulations. Despite the efforts of the government to empower women in the fisheries sector through the BMUs, their contribution in decision making is very limited and they only serve to meet the requirements for registration of the BMU. Results from all the KIIs interviewed and FGDs conducted showed that no woman has ever held the post of chairperson or secretary in any BMU within the Nyando wetlands. This shows that incorporating women in BMUs does not translate to them having more authority as stated by Mayoux (1995), Cleaver (1999), Nightingale (2011) and Zwarteveen (2012) who suggest that more complex and profound processes of social structures and agency shape gender relations.

Registration of new boats and fishing nets with the BMU is necessary before being licensed. Regulations prohibit persons below the age of 18 years from fishing in the open lake. The regulations include mechanisms for sharing fish proceeds among boat owners and crew members as well as rules for fish trade at the beach. For instance, 30% of the proceeds of gill net (*rimba* or *sarip*) fishing should go to the crew, the boat owner taking 70% of the proceeds. Fish sales at the beach give priority to people buying for home consumption, those with disabilities and women with infants before sale to traders. The arrangement prohibits selling fish at night, on the lake and on beaches other than where the boat is registered. It also prohibits catching undersized fish, stealing of fish and gears, fighting and drunkenness while fishing.

Some formal institutions conflict with the traditional norms and practices. Traditionally, institutions prohibited any form of fishing in the open lake from April to August, whereas The Fisheries (Prohibitions) Regulations 2003 recognizes the closed season between April and July but only for open lake fishing of *omena*.

Some rules and regulations however do not conflict with traditional norms, but are not effective either. For instance, youth below the age of 18 still go fishing and some of them have lost their lives in the process. The Standard Newspaper reporter Buluma on December 16, 2012 wrote a story on the situation as follows:

> "A fishing adventure turned tragic after six fishermen died when a boat they were in capsized at Bumbe beach in Lake Victoria on Saturday evening. The six were part of a seven-man team that included a 16-year-old boy hired by a local fisherman to help pull fishing nets locally referred as 'Egogo'. … The victims whose aged between 16 and 21 years had been warned against fishing in the lake because they did not have valid permits that allow them to fish".

In the FGDs, 50% of the respondents reported that for fear of arrest, the young fishers are now using modified traditional fishing gears, which have smaller openings hence potentially, as equally destructive as the undersized fishing nets. They argue that such a method helps evade new government enforcement institutions as the law does not clearly address their use and only addresses the use of fishing nets and vessels as was repeated in all four FGDs conducted with fisher folk and fish traders. The BMU rule has shortcomings in its effort to contain corruption too, since fishermen can bribe fisheries scouts to avoid arrests and persist in harmful fishing practices.

The changing institutional landscape introduces new rules and regulations and these have modified the prevalent informal rules, but have not yet given the power to relevant actors to control the enforcement of these hybrid rules and regulations. On the contrary, where previously informally controlled common property resources existed, they have taken away from those relevant actors the capacity to develop new enforcement measures or to implement the old ones, effectively creating open access resources.

Institutions governing harvesting and use of papyrus

Several traditional institutions govern harvesting and use of wetland plants, a key activity for the livelihoods of the local communities. Key informants reported that women and youths were prohibited from going deep into the wetland because of the risks involved in harvesting of papyrus and other wetland vegetation. Moreover, it was also not allowed to harvest wetland plants when the crops were still in the field and during heavy rains or floods. Men are the main custodians of natural wetland vegetation and are responsible for its harvesting and protection. Traditionally, men who built houses and granaries harvested vegetation. They also used papyrus products for making ropes (for fishing and livestock tethering), fish traps and baskets. While working in the wetlands, men harvest and eat papyrus rhizomes (omundo) as a source of energy and they monitor any bad practices that may destroy papyrus in the wetlands. Women use papyrus to make mats, pot-holding rings (tach) and cooking materials.

Although, traditionally done only by adult men, nowadays women and young people are also involved in harvesting of papyrus for home use. Around the wetland, the percentage of women harvesting papyrus was 37 while 19 engaged in harvesting other products. Amongst the women were 8.5% not harvesting any wetland products, whereas 20.7% of the men engaged in papyrus harvesting while 11.2% harvested other wetland products with 3.9% not harvesting any wetland products. The local community considers papyrus as a common property since anybody can find and harvest it without any restrictions. Perceived as abundant, papyrus and other wetland resources are exploited limitlessly. However, the local communities acknowledge a decline in the quantity of the papyrus stocks due to population pressure resulting in burning and clearing for farming, and negative attitudes that do not allow for sustainable use of this important natural resource. Due to increasing pressure and overdependence on papyrus, the riparian communities developed local informal institutions, which have been in place from the mid-1990s.

The emergence of child-headed homes with no sources of income has forced the heads of these poverty-stricken families into papyrus harvesting. Poverty is also driving children and youths into harvesting papyrus especially during the school holidays. Prohibited from harvesting papyrus are expectant and lactating women.

Institutions governing wildlife management

Many folk tales are told to younger generations about wildlife. The hippo respected is culturally amongst the Luo communities who live in wetlands and frequently interact with them. Hippos are believed to be of human spirit and associated with the heritage of some local communities which prohibit their killing. Although the Kenyan law prohibits hunting hippos, their meat remains a delicacy among many local people. The skin is thick and used for making whips. Hunted for meat despite a ban, is the sitatunga also a delicacy among the Luo.

With the introduction of the Wildlife (Conservation and Management) Act CAP 376 in 1985, there are now harsh penalties for those who kill wildlife and this has made people refrain from hunting. Part IV, Section 22 (1 And 2) prohibits unlicensed hunting of wild animals and is meant to protect wildlife. There is however illegal hunting of sitatunga for game meat. This often goes unnoticed since the sitatunga is small and its meat easily sneaked out of the wetland. There is the belief that the hippo is a spirit which is respected and strong; hence, the traditional institutions regarding consumption of hippo meat are still strictly adhered to.

Institutions governing farming

Both subsistence and commercial farming are a major occupation for local residents and for people coming from as far as 20 km inland. The seasonal swamps are cleared and farmed during the dry season when water recedes, while farming in the hinterland commences with the onset of the long rains (this is the main cropping season). During the main cropping season, numerous clan and household institutions exist that govern an orderly sequence of ploughing, planting, weeding and harvesting of the crops. There are also institutions that regulate grazing of livestock during the cropping and dry seasons. All these institutions were set to ensure food security for all throughout the year and to minimize land and wetland degradation. During the main cropping season, people were restricted from going to the lake to allow for concentrated efforts on food production.

Over time, the traditional subsistence farming in wetland areas, which was small-scale and did not destroy the ecosystem, has changed to commercial culture of sugarcane, rice, fruit and vegetables. The high water table and hydric soils have encouraged cultivation even during dry seasons. In the past, sweet potatoes and cassava were the crops planted in the wetlands but this changed with the introduction of new crops such as butternut, kales, tomatoes, sweet pepper and watermelons. Traditional institutions, which controlled farming in the wetlands, have also changed and are hardly obeyed by farmers, some of whom are from other parts of the country and have encroached to make a profit from commercial farming. There are also formal institutions that govern the land and land use, including agricultural, environmental and planning legislation.

DISCUSSION

Access and control of wetland resources is shaped by the

intersection of various institutions and the relationships of power and authority that exist between them (Maconachie, 2008). Institutions are often multi-functional, semi-opaque and contingent. They are shaped by historic factors, by the power relations which prevail in social life and by world views which incorporate the roles of the human, natural resources and the supernatural (Cleaver and Franks, 2005). Institutions can be shaped or crafted by external intervention and, providing due attention is paid to the structures (rules and roles) and norms (relations of trust and co-operation) contained within them, then collectively beneficial outcomes may be achieved (Uphoff and Wijayaratna, 2000). Human adaptation refers to both biological and cultural processes that enable a population to survive and reproduce within a given or changing environment (Joralemon, 2010). There have been ecological, economic, demographic and social changes taking place in the Nyando papyrus wetlands. The existence of several actors, at various organizational levels, managing the same natural resource, results in a redundancy in governance. This is generally criticized in policy analysis, although it has been defended in the management of complex adaptive systems like wetland ecosystems (Low et al., 2003), which require institutional flexibility. In response to these changes taking place, there have been changes in the context of legal arrangements (formal institutions) as well as social norms and conventions (informal institutions. In the Nyando papyrus wetlands, institutions can be broadly categorized as traditional, local informal, government or co-management.

Traditional institutions are those that are embedded in the Luo culture and comprise of norms and taboos based on indigenous belief systems of the Luo people. Customary governance through sanctions, which are punishments for those who disobey, enforces traditional institutions. Traditional institutions in local communities indicate the pattern of power distribution and the amount of influence exerted by each actor in the community in the course of decision making and activities related to wetland resource use. In the Nyando papyrus wetland, categorization of traditional institutions can be based on who has to abide by the respective institution. There are general institutions to be followed by children, men, women and the youth, whereas some have to be followed by specific groups, that is, children, men, women or the youth. The general institutions are those related to death, order, and/or seniority and those based on myths. Myths are passed down through generations by strong oral traditions, and these play a significant role in the psyche of people. Though mythology is seeded in the mysterious realm, helps to adapt human behavior to the demands and offerings of the environment and conservation. As such, mythology still plays a role in rural African communities including the Luo of Kenya. There are institutions based on myths affecting the use of resources such as farmlands, fish, papyrus and wildlife (Cohen, 1969).

Put in place with British Colonization, a centralized system of government is added to traditional systems of governance. Christianity and formal education now regarded as ‘frontline civilization' made African ways of doing things seen as primitive, archaic and regrettably unacceptable in the public domain. The impact of christianity has been the most important single factor in the process of westernization in many parts of Africa. Western education, involving literacy and the mastery of a European language, became the condition for entry into the modern sector. For most of the colonial period, education was in the hands of the christian missionaries, who sought not only to convert Africans but also to inculcate western values. Christianity challenged traditional belief systems and institutions and promoted the diffusion of new ideas and modes of life (Arowolo, 2010).

The local institutions, which are crafted by the community have helped fill the gaps created by the poor performance of public systems of governance and are enforced by local sanctions. Resource use often overlaps spatially and seasonally causing resource use conflicts. The local institutions were crafted to guide the changing scenarios in resource use in the same space, for example, the grazing livestock on harvested papyrus. As Babin and Bertrand (1998) put it: "It is extremely unusual for a single area to have only one use or user, or to be used for only one period of the year, and the opposite is more generally the case: a combined plurality of simultaneous and/or successive uses by different users, each of whom is subject to precise rules regarding access and use, and may or may not have management or decision-making power over the resources of the area in question."

Local institutions are specific to a location and also to a resource and are enforced by community mechanisms. In the West Kabodho sub-location, papyrus is harvested according to clans and therefore it is easier to exclude outsiders than in the other sub-locations. This is also due to the fact that there were more respondents involved in papyrus harvesting in West Kabodho than in any other sub-location. Local institutions are usually rooted in community social capital, rather than depending on external top-down decision-making processes. They are regarded as important ‘buffering’ mechanisms that promote sustainability and resilience at the environment-society interface (Mazzucato and Niemeijer, 2002).

Government institutions comprise of laws, policies, rules and regulations, enforced by government officers.

These formal institutions have not been successful due to inadequate staff on the ground. In Kenya, formal state institutions, dealing with wetlands may be weak and fragile due to the sectorial nature of these institutions and the lack of clear policy guidelines as to who is responsible for wetlands. The main institutional arrangements that are relevant to wetlands in Kenya include but are not limited to The Agriculture (Basic land usage) Rules L.N.26/1965, Environmental Management Act (EMCA 1999); Wildlife (Conservation and Management) Chapter 376; Water Act 2002; Physical planning Act Chapter 286; Forestry Act No

7 of 2005 and Fisheries Act Chapter 378. The sectorial nature of legislature inscribed under various Acts for wetland conservation and management is problematic because responsibility is diffused to several unrelated and uncoordinated departments resulting in jurisdictional overlaps and conflicts.

The government institutions around land have brought about many social changes and increased women's land rights which in the past were insecure since they only had usufructuary rights and did not enjoy the rights of ownership or disposition. Amongst the Luo, land tenure was corporately held through patrilineages and not individually alienable. The family enjoyed security of tenure through membership of the particular lineage of the family's male head. Although women could not inherit land, they held positions of structural significance, serving as the medium through which individual rights passed to their sons (Mackenzie, 1989). This has now changed with land adjudication and after the introduction of title deeds, more women increasingly became land-owners.

Land adjudication has, however, disadvantaged foreigners (Jodak) assimilated into the community. They were normally assigned land by clan elders but with the individualization of title deeds the rights of Jodak to access land are adversely affected (Karanja, 1991). It has also disadvantaged women who raised different crops in small parcels of land, which were scattered over a wide area. This was a form of ensuring food security lest there was pest invasion, storm, localized natural disaster or crop failure (Pala, 1983).

The co-management institutions such as the Beach Management Units (BMU) are largely enforced at local level by the community and have had a good degree of success in institutions and the way the work can be analyzed in terms of output and appropriateness. Thus, the most successful co-management institutions in the Nyando papyrus wetland in terms of output have been the Fisheries (Beach Management Units) Regulations, 2007. Enforced jointly by the community through the BMU officials and by the government through the fisheries officers, the latter play an advisory and supervisory role. However, it should be noted that due to the complex nature of formal institutions, transparency and accountability is undermined therefore, despite formation of BMUs, illegal and destructive methods of fishing are still used. These include using clubs and cutlasses to cut and kill fish; clearing wetland vegetation to catch all stages of fish; scaring off hippos to give way for fishing; using mosquito nets to catch juvenile fish; and the use of poisonous bait. It is difficult to control fishing along the Nyando River and in the wetlands since there are different types of fishing activities taking place there including sport fishing by young men and children and because fishing activities are open for all people within the Nyando papyrus wetland and for those from outside the area.

Demographic changes due to increased commercialization of wetland resources such as papyrus and fish and the demand for food and grazing land during the dry season has seen an influx of people into the Nyando Papyrus Wetland. Over the last century, there has been a rapid increase in population within the Nyando River basin establishment and expansion of urban centers. The small land parcels are an indication of the high rate of land fragmentation that is associated with increased population size and the number of households that need to survive on the wetlands. The increase in the population density within the perimeter of the wetland can also be attributed to the fact that these wetland areas had fertile soils and had lots of moisture especially during the dry season (Maithya et al., 2011). The total catch, the variety of fish caught and the average size of fish has seriously declined because of an increasing number of fishers and fishing boats. The total catch, variety of fish caught and size of fish caught have also declined due to overfishing.

The sub locations in the study Ogenya (Transect 1), Kakola Ombaka (Transect 2) Jimo middle (Transect 3) and West Kabodho (Transect 4) have a population density of 153, 704, 131 and 225 persons per km^2, respectively. Almost two thirds of the respondents in FGDs agreed that the high population has resulted in deterioration of quality of the water in the Nyando papyrus wetlands owing to industrial waste, household waste, sewage and pollution from engine boats which consequently impacts on the ecological functions of the wetland.

The post-election violence experienced in Kenya in 2008 and other forms of political instability have also caused people who were employed in affected parts of the country to migrate back into the Nyando papyrus wetland area, to temporarily or permanently seek income from fisheries and other wetland resources. In areas where farmers had undergone a number of harvest failures, and where availability of and access to land had become scarce, members of farming households are turning to fisheries. Thus, households previously labeled as farming households have become fisher folk and fishing communities with income from fisheries becoming the main source of sustenance (FAO, 1998).

This mobility has also has increased the spread of HIV/AIDS amongst the fishing community leading to an increased number of and female-headed and child headed homes. The HIV/AIDS scourge has caused a decline in literacy levels as a result of school dropout due to poor health, lack of resources, care of the sick, etc. The co-management institutions and by-laws of BMU's have tried to some degree to address the issues of HIV/AIDs and sanitation along beaches. Local community institutions have also relaxed rules on harvesting of papyrus to allow needy children over 14 years of age to engage in papyrus harvesting during school holidays as reported by respondents in the FGDs.

Despite the fact that some of these traditional

institutions cannot keep pace with the ecological, economic, demographic and social changes taking place in the Nyando papyrus wetlands, some persist and are still in use. The local institutions are flexible and also change with the changing situations experienced in the Nyando papyrus wetlands. Local community institutions as tradetional institutions are discriminatory, particularly towards women. This is because of their child bearing role hence they are considered as weak for example men who go fishing eat the most palatable parts of fish while the women and children eat the less palatable parts since fishing is considered as hard work. Women are also prohibited from performing certain tasks in fishing and farming during their menstrual periods when they are considered unclean. The diffuse nature of government legislature on wetlands makes traditional and local informal institutions to persist and retain legitimacy within the Nyando wetlands. Choices for livelihood strategies in the Nyando papyrus wetlands are offered by institutions and by the condition of ecosystem services. Local institutions that are flexible and are enforced by local sanctions therefore protect ecosystem integrity and contribute positively to long-term human well-being. There is a need to develop a fine interplay between formal and informal institutions in order to safeguard wetland based livelihoods in the Nyando Papyrus wetlands.

Conclusions

To get a better grip on management of wetland resources, Cleaver (2001) talks of institutional bricolage which is a process by which people consciously and unconsciously draw on existing social and cultural arrangements to shape institutions in response to changing situations. The institutions that result are a mix of ‘modern' and ‘traditional', ‘formal' and ‘informal'. The bricoleurs are the different resource users in the wetlands, the external factors such as traders, government, etc. who come up with institutions to guide resource use and access. It has been noted that in the Nyando papyrus wetland, hybrid institutions help to enforce natural resource management at the local level and therefore, there should be synergy and co-operation between the formal and informal systems.

In line with the different orientations of the relevant institutions and programmes in the various sectors, the government may adopt a nationwide strategy that envisions diversified approaches to wetland conservation and management. A new, diversified vision for wetland conservation and management is needed- one that nevertheless takes into account the legal pluralism in the Nyando papyrus wetlands. It is recommended that implementation of these solutions should engage participation of the local community based on their socio-cultural beliefs that enhance conservation. Different communities hold beliefs and have different views on the relationship between humans and nature. Therefore, the views and attitudes of the local communities should be taken into account in the formulation of conservation measures and policies

Conflict of interests

The author(s) did not declare any conflict of interest.

ACKNOWLEDGEMENTS

This study was funded by UNESCO-IHE Partnership Research Fund (UPaRF). The authors would like to acknowledge their partners in the ECOLIVE project: UNESCO-IHE, Delft, The Netherlands; Egerton University, Kenya; VIRED International, Kenya; and the University of Amsterdam, The Netherlands; African Studies Centre (ASC) Leiden, The Netherlands and the other collaborators, Water Resource Management Authority, Kenya; Government ministries; Nyando Wetland Communities (Ogenya, Jimo Middle, Kakola-Ombaka and West Kabodha).

REFERENCES

Adamson J (1967). The peoples of Kenya. Collins.
Adede S (2008). Gender mainstreaming in the conservation of the River Nyando Wetland in Kisumu East and Nyando Districts, Kenya. M Phil Thesis, Moi University, Eldoret.
Arnold CA, Gunderson L (2012). Adaptive Law (October 22, 2012). Resilience and Law, Craig R. Allen & Ahjond S. Garmestani, eds., Columbia University Press, 2013.
Arowolo D (2010). The effects of western civilization and culture on Africa. Afro Asian J. Soc. Sci. Volume 1, No. 1 Quarter IV.
Babin D, Bertrand A (1998). Managing Pluralism: Subsidiary and Patrimonial Mediation. Unasylva 49(194):19-25.
Bavinck M, Johnson D , Amarasinghec O,Rubinoffd J, Southwolde S, Thomson KT (2012). From Indifference to Mutual Support - A Comparative Analysis of Legal Pluralism in the Governing of South Asian Fisheries. Eur. J. Dev. Res. Adv. 25: 621–640.
Bergstrom JB, Brazee R (1991). Benefit Estimation. In: R.E. Heimlich (ed.), A National Policy of "No Net Loss" of Wetlands: What Do Agricultural Economists Have to Contribute? Staff Report No. AGES 9149, U.S. Dept. Agr, Econ. Res. Serv., pp. 18-22.
Bikangaga S, Picchi MP, Focardi S, Rossi C (2007). Perceived benefits of littoral wetlands in Uganda: a focus on the Nabugabo Wetland. Wetlands Ecol. Manage. 15:529-535.
Buluma R (2012). Six fishermen killed in fishing expedition. Standard Newspaper, Kenya Sunday, December 16 2012.
Carter V (1996). Wetland Hydrology, Water Quality, and Associated Functions, In: Judy D. Fretwell, John S. Williams, and Phillip J. Redman (eds.) National Water Summary on Wetland Resources, USGS Water- Supply Paper 2425. USDI, U.S. Geological Survey. Washington, DC, pp. 35-48.
Cleaver F (1999). Paradoxes of participation: Questioning participatory approaches to development. J. Int. Dev. 11: 597-612.
Cleaver F (2001). Institutional bricolage, conflict and co-operation in Usangu, Tanzania. IDS Bulletin 32(4):26-35.
Cleaver F, Franks T (2005). How institutions elude design: river basin management and sustainable livelihoods, Bradford Centre for International Development, University of Bradford.
Cohen PS (1969). Theories of Myth. Man (N.S) 4 (3): 337-53.
Denny P (1997). The importance of Wetlands or Biodiversity: A prime

conservation and development issue. In: Wetlands, Biodiversity and Development. Proceedings of Workshop 2 of the International Conference on Wetlands and Development held in Kuala Lumpur, Malaysia, 9-13 October. Wetlands International, Kuala Lumpur.

Dixon AB, Wood AP (2003). Wetland cultivation and hydrological management in East Africa: matching community and hydrological needs through sustainable wetland use. Nat. Resour. Forum 27(2): 117-129.

Wakwabi EO, Balirwa J, Ntiba MJ (2006). Aquatic biodiversity of Lake Victoria basin, In: Odada EO, Olago DO, Ochola W (Eds) (2006) Environment for Development: An Ecosystems Assessment of Lake Victoria Basin, UNEP/PASS. pp. 77-121.

FAO (1998). The state of world fisheries and aquaculture 1998. Rome.

Haddad L, Gillespie S (2001). Effective Food and Nutrition Policy Responses to HIV/AIDS What We Know and What We Need to Know. J. Int. Dev. 13(4): 487-511.

Helmke G, Levitsky S (2004). Informal Institutions and Comparative Politics: A Research Agenda. Perspectives on Politics 2(4):725-740.

Hongo H, Masking M (2001). Impact of livestock grazing to fringing wetlands of Lake Victoria. In a report of the Regional Scientific Conference, 3-7 December 2001.

IWMI (2006). Working Wetlands: a new approach to balancing agricultural development with environmental protection. International Water Management Institute, Colombo, Sri Lanka. Water Policy Briefing Issue 21.

Joralemon D (2010). Exploring Medical Anthropology. Upper Saddle River, NJ: Prentice Hall. p.165.

Karanja PW (1991). Women's Land Ownership Rights in Kenya. Third World Legal Studies. Vol. 10, Article 6.

Kemerink JS, Méndez LE, Ahlers R, Wester P, van der Zaag P (2013). The question of inclusion and representation in rural South Africa: challenging the concept of Water User Associations as a vehicle for transformation. Water Policy 15 (2): 243–257

Kipkemboi J (2006). Fingerponds: seasonal integrated aquaculture in East African freshwater wetlands, exploring their potential for wise use strategies PhD thesis UNESCO-IHE Institute for Water Education, Taylor and Francis/Balkema, Leiden, The Netherlands.

Low B, E Ostrom, C Simon, J Wilson (2003). Redundancy in social and ecological systems. Pages 83–114 in F. Berkes, J. Colding, and C. Folke, editors. Navigating nature's dynamics: building resilience for adaptive capacity in social–ecological systems. Cambridge University Press, Cambridge, UK.

Mackenzie F(1989). Land and Territory: The Interface Between Two Systems of Land Tenure. 59:1 Africa (Lond).

Maconachie R (2008). Creating and sharing knowledge to help end poverty. BWPI Working Paper 24, Brooks World Poverty Institute ISBN: 978-1-906518-23-3.

Maithya JK, Kariuki W, Njoroge JB, Adimo AO (2011). Socioeconomic activities in Kadibo Division of Nyando wetlands and their implication for wetland conservation. Afr. J. Hortic. Sci. 4:31-47.

Mayoux L (1995). Beyond naivety: women, gender inequality and participatory development. Dev. Change 26: 235-258.

Mazzucato V, Niemeijer D (2002). Population growth and environment in Africa: local informal institutions, the missing link. Econ. Geogr. 78 (2):171–193.

Millennium Ecosystem Assessment (2005). Ecosystems and Human Well-being: Synthesis. Island Press, Washington, DC.

Nightingale AJ (2011). Bounding Difference: the embodied production of gender, caste and space. Geoforum special issue on gender and environment 42(2): 153-162.

North DC (1990). Institutions, Institutional Change and Economic Performance, Cambridge: Cambridge University Press.

North DC (1997). Prologue. In: The Frontiers of the New Institutional Economics, edited by John N. Drobak and John V. C. Nye. San Diego and London: Academic Press. pp. 3-28.

Ostrom E (1990). Governing the commons: the evolution of institutions for collective action. Cambridge University Press, Cambridge, UK.

Ostrom E (2000). Collective Action and the Evolution of Social Norms. J. Econ. Perspect. 14(3):137-158.

Ostrovskayaa E, Douvena W, Schwartza K , Patakib B, Mukuyua P, Kaggwa RC (2012). Capacity for sustainable management of wetlands: lessons from the WETwin project. Environ. Sci. Policy 34: 128–137.

Pala AO (1983). Women's Access to Land and their Role in Agriculture and Decision making on the Farm: Experiences of the joluo of Kenya. J. East. Afr. Res. Dev. 13:69-87.

Potash B (1986). Wives of the grave: Widows in a rural Luo Community, in Betty Potash, (ed.), Widows in African Societies, Stanford, Stanford University Press, pp. 44-46.

Quinn CH, Huby M, Kiwasila, Lovett JC (2007). Design principles and common pool resource management: An institutional approach to evaluating community management in semi-arid Tanzania. J. Environ. Manage. 84: 100-113.

Ramsar Convention Secretariat (2007). Wise use of wetlands: Concepts and approaches for the wise use of wetlands. Ramsar handbooks for the wise use of wetlands, 4th edition, vol. 1. Ramsar Convention Secretariat, Gland, Switzerland.

Scott J (1998). Seeing Like a State: How Certain Schemes to Improve the Human Condition Have Failed. Yale University Press.

SOFIA (2010). The state of world fisheries and aquaculture 2010 FAO Fisheries and Aquaculture Department Food And Agriculture Organization Of The United Nations, ROME, 2010.

Uphoff N, Wijayaratna C (2000). Demonstrated benefits from social capital: the productivity of farmer organisations in Gal Oya, Sri Lanka. World Development 28(11):1875 - 1890

van Dam A, Kipkemboi J, Zaal F, Okeyo-Owuor JB (2011) The ecology of livelihoods in East African papyrus wetlands (ECOLIVE). Rev. Environ. Sci. Biotechnol. 10:291-300.

Vatn A (2005). Institutions and the Environment. Cheltenham, Edward Elgar.

Von Benda Beckmann F, Von Benda Beckmann K, Griffith A (2009). Space and Legal Pluralism, an introduction. In: Von Benda Beckmann, F., K. Von Benda Beckmann, A. Griffith (eds) (2009) Spatialising law, an anthropological geography of law in society. Ashgate, Farnham UK.

Wee V, Heyzer N (1995). Gender, Poverty and Sustainable Development: Towards a Holistic Framework of Understanding and Action. Singapore: ENGENDER.

Yamano T, Jayne TS (2004). Measuring the Impacts of Working-Age Adult Mortality on Small-Scale Farm Households in Kenya. World Development 32(1):91-119.

Zwarteveen M (2012). Diverting the Flow: Gender Equity and Water in South Asia edited by Margreet Zwarteveen, Sara Ahmed and Suman Rimal Gautam. - New Delhi: Zubaan.

academicJournals

Vol. 7(3), pp. 72-80, March 2015
DOI: 10.5897/JENE2015.0505
Article Number: BB1CC9F52118
ISSN 2006-9847

http://www.academicjournals.org/JENE

Journal of Ecology and the Natural Environment

Perspective

Emperor Jahangir's method of observation and approaches to investigation of Kashmir ecology: An appraisal of his 'deep sense of sensitivity' towards nature

Mumtaz Ahmad Numani

Centre of Advanced Study, Department of History, A. M. U., Aligarh, India.

Received 18 February, 2015; Accepted 23 March, 2015

Historically speaking, 'ecology' today is an interdisciplinary as well as complex science. Modern ecology characterises more facts than possibly known. Any ecologist is today a specialist, with favourite and specialised questions. And hence, there are different sub-disciplines in ecology with its own set of concept(s) and all try to unify looking only at 'ecology'. Moreover, it is now an established fact, that plants and animals both exhibit behaviour, but plant behaviour is most often examined in the context of its morphological growth. And behaviour is in part, the ability to respond rapidly and reversibly in response to environmental stimuli during the life time of an individual. Hence, the main objective of writing this paper is to trace and better synthesize, "Jahangir's method of observation and approaches to investigation of Kashmir ecology", in order to gain more from the past in the present about: how man should communicate better with other living things of different species.

Key words: History, ecology, Kashmir, Jahangir, approaches to investigation.

INTRODUCTION:

Ecology today is an interdisciplinary as well as complex science. Modern ecology characterises more facts than possibly known. Any ecologist is today a specialist, with favourite and specialised questions. And hence, there are different sub-disciplines in ecology with its own set of concepts and all try to unify looking only at 'ecology'. The term ecology was first coined by Reiter (1885) followed by Haeckel (1886), who defined ecology as the science that is concerned with 'all the relations of animals and plants to one another and to the outer world'. Haeckel was followed by Elton (1927), who defined ecology as 'scientific natural history'. And, Elton was followed by Woodbury (1955) who defined ecology 'as a science which investigates organisms (species of all kind) in relation to their environment; a philosophy in which the world of life is interpreted in terms of natural processes' (Subrahmanyam and Sambamurty, 2004, pp. 1-4). But, all definitions rest on the fact that the natural environment itself consists of two broadly distinguishable sectors: the inanimate and the animate. The inanimate ('the outer world') includes the earth's structure with which geology and physical geography deal. The animate (comprising

E-mail: mumtaznumani@gmail.com.

all levels of 'organisms') include all plant and animal species (the 'flora and fauna' of formal usage), whose study is often described by the term 'natural history', which, however, usually excludes from its purview, the human and the domesticated species (Habib, 2010, p.20).

As of now, the much established shows goes that, plants and animals exhibit behaviour, but plant behaviour is most often examined in the context of its morphological growth. And, behaviour is in part, the ability to respond rapidly and reversibly in response to environmental stimuli during the life time of an individual. Interestingly, here it bears to mention that, Jahangir's own-way of study on the eco-morphology, anatomy and behaviour of the different species has covered one important aspect of them in relation to their basic environment. He has sought to examine the 'environmental influences' upon the 'species' in order to understand and explain the 'study of structure and function of nature'.

SOURCE AND METHODOLOGY

The Mughals' had a flourishing tradition of history writing (Thackston, 1999, p. xxi). And our best textual source on Jahangir is Jahangir himself in his *Jahangirnama*, an autobiography in which he reveals his multi-faceted persona as a sovereign, naturalist-cum-ecologist, aesthete, hunter, patron of the arts and collector (Jahangir, 1624; Khan, 1864). The importance and complexity of this text begins only now to be fully understood by modern historians, has been earlier pointed out by Lefevre-Agrati, and subsequently highlighted by Ebba Koch (Koch, 2009, p. 298). Indeed, the interdisciplinary discourse between natural scientists and art historians is brought about by Jahangir himself to explain the advantages of a combined method, written and visual, in representing natural phenomena, and sees in it an improvement of his ancestor Babur's approach (Koch, 2009, p. 298). Ebba Koch (2009) goes on to point out that: scientists have explored the *Jahangirnama* for its observation(s) on geology and biology (botany, ornithology and zoology). Whereas, art historians have analysed how Jahangir directed his artists to turn his observations of natural phenomena into nature studies (Koch, 2009, p. 297). If we consider Jahangir's methodology, we will find that, as a scientist, he has a selective approach; he investigates, observes, records, depicts, measures, enumerates and tests what he considers as noteworthy and outstanding (Koch, 2009, p. 298). All of which shows that, he was fond of "scientific" experiments of his own devising. For example, he debunked the accepted reason for the mountain sheep's pugnacity, he tested the reported efficacy of bitumen for broken bones on a chicken and found that it had none; he took an active interest in animal husbandry and goat breeding; he determined the gestation periods for elephants with nearly correct results; and he examined a lion's and wolf's livers to see whether their gall bladders were inside or outside the liver as a measure of courage (Thackston, 1999, p. xxiv).

JAHANGIR'S METHOD OF OBSERVATION AND APPROACHES TO INVESTIGATION OF SOME MAMMALS AND BIRDS IN KASHMIR

Nur-ud-din Muhammad Jahangir (August 30, 1569-29 October, 1627) was the fourth Mughal Emperor from 1605 until his death in 1627. Jahangir was the eldest son of Mughal Emperor Akbar and was declared successor to his father from an early age. Jahangir built on his father's foundations of excellent administration. And, he possessed sensitivity to nature, acute perception of human character, and an artistic sensibility, all of which took him to be an outstanding personality (Jahangir, 1624; Khan, 1864, p.1-3; Thackston, 1999, pp. xix, xxiii, 4). Despite the fact that, the geographical and topographical out-look of Kashmir resembles too much that of Central-Asia, and the valley of Kashmir exhibits both rich floral and faunal diversity, Jahangir's own-way of observation and approaches to investigation of Kashmir ecology is in itself an endeavour of his scientific study.

Here much need is to go with the above discussion in order to trace and better synthesize, the 'anatomical', 'behavioural' and 'morphological' aspects of some mammals and birds that Jahangir himself had gone on observing, investigating and recording in Kashmir. The complete list of quotations (as examples) below is from Jahangir himself. He says:

Wild ram: "I [Jahangir][1] have frequently heard from the hunter that, at a certain time a warm develops in the horns of the wild ram which irritates him into fighting with his kind and that if he finds no rival, he strikes his head against a tree or a rock to allay the irritation. After investigation, the warm was found in the horns of the female sheep also, and since the female would not fight (on that account) the story does not seem to be based on truth" (Alvi and Rahman, 1968, pp. 20-21)[2].

Ibex: "The Ibex, which is brought from Bhakkar and the hills of Garmser, is extremely good-looking, but it has little wool. Animals that thrive in the mountains have a lot of hair and are ugly due to the severity of the cold and snow. The Kashmiris call the Ibex, *Kayll Kail* (Jahangir, 1624; Khan, 1864, p. 302; Alvi and Rahman[3], 1968, pp. 28-30; Thackston, 1999, p. 335). During these days

[1]In all the quotations "I" represents Jahangir henceforth

[2]Alvi and Rahman identify this mammal as *Oviscyclaceros hutton*. According to them, it is known as *Shapo* and *Sha* (male) and *Shamo* (female) in Ladakh.

[3]They identify this mammal as *Capra sibirica* and it is known as *kayl* in Kashmir, *Sakin* (male) and *Dabmo*/ *Danmo* (female) in Ladakh.

Sayyid Bayazid Bukhari[4], the commander of the Bhakkar garrison, sent as a gift, an Ibex he had captured young in the mountains and reared in his house. It was viewed and I liked it a lot. I had seen many markhor goats and mountain rams domestically reared, but I had not seen an Ibex so reared. I ordered to keep it with a Barbary goat so that they would mate and produce offspring. Without exaggeration, it was beyond comparison with a markhor or a mountain ram. Sayyid Bayazid was promoted to the rank of 1000/700" (Jahangir, 1624; Khan, 1864, p. 284; Thackston, 1999, p. 318).

Papiha: "In Hindustan, there is a bird called Papiha. It has a beautiful voice, and during the monsoon season it sings heart-rending laments. Just as the cuckoo lays its eggs in a raven's nest, and the raven raises the young as its own, in Kashmir, the papiha was seen to have laid its eggs in a ghawghai's nest, and the ghawghai raised the chicks" (Jahangir, 1624; Khan, 1864, p. 309; Alvi and Rahman, 1968, p. 80, Thackston, 1999, p. 342).

Humay: "Prior to this, it had been repeatedly reported that there was an animal known as the humay in the Pir-Panjal Mountains, and the people of that region said that it fed on small bones. It could often be seen flying through the air, and it rarely alighted. In as much as His Majesty [Jahangir] was very much inclined to investigate the truth of this report, it was ordered that any of the scouts who shot such a bird would be rewarded with a thousand rupees. By chance, Jamal Khan Qaravul shot one with a musket and brought it to the Emperor's presence. Since it had been wounded in the leg, it was brought to the Emperor alive and healthy. He ordered its crop inspected to find out what it ate. When the crop was opened, small bones came out of its gullet, just as the people of the mountains had said that its food consisted of small bones and that it always flew in the air with its gaze upon the earth, and wherever it spotted a bone, it would pick it up in its beak, fly away, and cast it onto a rock to break it into little pieces. Then it would pick at it and eat it. In this case, the prevailing opinion was that this was the famous humay. Really, the humay is superior to all birds because it eats bones and harms no creature. Its head and beak looked like a buzzard's, but a buzzard's head has no feathers while this one had black feathers. In the Emperor's presence it weighed 415 tolas, which is equivalent to 1,037 (1/2) mithcals[5]" (Jahangir, 1624; Khan, 1864, pp. 398-99; Alvi and Rahman[6], 1968, pp. 85-87; Thackston, 1999, pp. 434-35).

Jan Bahman: "Baso, the Zamindar of Talwara brought for my inspection a bird the people of the hills call *Jan Bahman*. Its tail is like that of a qirqavul, which is also called tazarv [pheasant]. In colour, it is exactly like a female qirqavul, but its body is larger by a ratio of ten to fifteen. Around this bird's eyes is red, while around a pheasant's eyes is white. Baso, reported that, this bird lives in snowy mountains and eats grass and herbs"

(Jahangir, 1624; Khan, 1864, p. 338; Alvi and Rahman[7], 1968, pp. 61-63; Thackston, 1999, p. 372).

Sonlu: "One of the birds seen in the hill country is the horned pheasant, which the Kashmiris' call *Sonlu.* It is an inch smaller than a peahen. The tail and both wings are blackish, rather like the wings of a bustard, and have white spots. The belly up to the breast is black with white spots, and in some places there are red spots too. The ends of the legs are a brilliant, beautiful fiery red. From the tip of its beak to the front of the neck is also shiny black, and on top of its head are two fleshy turquoise coloured horns. Around its eyes and mouth the skin is red, and its crop is a piece of round skin about the size of two palms. In the middle of that skin is a violet coloured patch the size of a hand with turquoise-coloured spots, and turquoise-coloured spots around it too consisting of eight plumes, and around those is a line two fingers wide that is peach-blossom red. Around that is another turquoise-coloured line. Its feet are also red. I ordered to weigh it alive, and it was 152 tolas. And, after being killed and cleaned, it weighed 139 tolas" (Jahangir, 1624; Khan, 1864, pp. 338-39; Alvi and Rahman[8], 1968, pp. 60-61; Thackston, 1999, p. 372).

Gil-Char'd: "In the stream, I saw a bird that looks like a starling. A starling is black in colour and has white spots, while this one was the colour of a nightingale with white spots. It dives under the water, stays under for a while, and comes up somewhere else. I ordered two or three of them are caught and brought to me so that I could see whether the feet were webbed like a duck's or open like other birds of the field. Two of them were caught and brought. One died immediately, and the other remained a day. Its feet were not webbed like a duck's. I ordered Master Nadirul'asri Mansur the painter to draw its likeness. The Kashmiris call them *gil-char'd*, that is, water starlings" (Jahangir, 1624; Khan, 1864, pp. 305-6; Alvi and Rahman[9], 1968, pp. 78-79; Thackston, 1999, p. 339).

Pooth: "Another is the zarrin bird, which the inhabitants of Lahore called *shan* and the Kashmiris call *Pooth*. In colour it is something like peacock's breast. It has a tuft on top of its head and its tail is yellow, the length of four or five fingers, like the long feathers of peacock. Its body is equal in size to a goose, although a goose's neck is long and ill-proportioned, while the zarrin's is short and elegant. My brother, Shah Abbas, had requested [for] a zarrin. And, several were sent with an emissary" (Jahangir, 1624; Khan, 1864, p. 339; Alvi and Rahman[10],

[4]Sayyid Bayazid Bukhari, was governor of the province of Thatta, and was awarded the title of Mustafa Khan. The Emperor Jahangir, promoted him to the rank of 1000/700, for that he brought a rarity to Jahangir, liked

[5]One mithcal= 4.6 grams (i.e., 0.161 ounce).

[6]They identify this bird as *Gypaetusbarbatushemachalnus* (Lammergeier).

[7]They identify this bird as *Tetraogallushimalayensis* (Himalayan Snow-Cock). It is known as Gurka-kao in Kashmir.

[8]They identify this bird as *Tragopanmelanocephalus* (Horned Pheasant). It is known as Sonlu in Kashmir

[9]They identify this bird as *Ciacluscinclus* (Dipper)

[10]They identify this bird as *Lophophorus impejanus lathan* (Impeyan Pheasant). According to them, it is known as Jungli Mohr in Kashmir.

Table 1. List of the animals.

Vernacular name	English name	Scientific name
Suh (in Kashmir)	Yellow Lion	*Pantheraleo*
	Leopard	*FelisPardus*
Rama Hun (in Kashmir)	Wolf	*Canis lupus*
Jangli Dand	Wild Ox	*Bosaurochi/Bosurus*
Ha'angul (in Kashmir)	Black Antelope	*Antilopecervicapra*
	Chikara Antelope	*Antilopechikara*
Hiran	Hog Deer	*Hyelaphusporcinus*
Neelgau	Nilgai	*Bosephalustragocamelus*
Botakhar	Wild ass	*Equushemionus*
Riyang (in Ladakh/Khargosh in other parts of Kashmir)	Hare (woolly)	*Lepusoiostolus*
Eeh (in Ladakh)	Lynx	*Felis lynx*
JangliBeror	Jungle Cat	*Felischaus*
Susmar	Lizard	Acanthodoctylus(sp)
NA*	Porcupine.	*Hystricomorfhystricidae*

*Not available.

1968, pp. 56-57; Thackston, 1999, pp. 372-73).

Markhor goat: "The Shinwari Afghans brought a hunted markhor goat the like of which I had never heard of or imagined. I ordered the painters to draw a likeness of this animal. It weighed four Hindustani mounds. The horns measured one and a half yards', by the yard stick" (Alvi and Rahman[11], 1968, p. 22).

Bustard and crane: "It is an amazing thing that in all birds the windpipe, which the Turks call *Chanaq*, goes straight from the top of the neck of the crop, while in the bustard, unlike any other bird, there is a single windpipe from the top of the throat from a distance of four fingers, then it splits in two and goes to the crop. At the point at which it forks there is a blockage, like a knot, that can be felt with the hand. In the crane, it is even stranger, for its windpipe twists like a snake through the bones of the chest and passes to the root of the tail, and then it turns around and comes back to the throat. There were thought to be two kinds of bustard, one black and spotted and the other dun coloured. Recently, it was learnt that they are not two types: the spotted black one is male and the dun coloured one is female. The proof was that testicles were found in the spotted one and eggs in the dun-coloured one. And, the experiment was made repeatedly" (Jahangir, 1624; Khan, 1864, p. 379; Thackston, 1999, p. 416).

Fish: "It is well known that the fish of Anantnag spring are blind. I stopped a moment at the spring and cast a net in. Twelve fish were caught in the net. Three of them were blind, and the other nine had eyes. Apparently, the water of this spring has the influence of making the fish blind" (Jahangir, 1624; Khan, 1864, p. 314; Thackston, 1999, p. 346).

Interestingly, Jahangir also does mention about the carnivorous and herbivorous animals, especially those of which he could not come across in Kashmir. According to him, these animals do not belong and/or exist in this habitat (most probably, he was confused)[12]. The list he provides goes is as shown in Table 1 (Jahangir, 1624; Khan, 1864, p. 311; Bernier, 1983, pp. 395-396; Lawrence, 1895, pp. 108-117; Thackston, 1999, p. 344).

It is very important to note that, Jahangir also records a list of the birds he found in Kashmir. He also adds to our information that, since the name(s) of some of these birds are not known in Persia-(they do not even exist in Persia), they have been written in Hindi. The list of the birds recorded by Jahangir goes are as shown in Table 2 (Jahangir, 1624[13]; Khan, 1864, p. 311; Lawrence, 1895, pp. 117-115; Alvi and Rahman, 1968, pp. 88-90; Thackston, 1999, p. 344).

[11]They identify this mammal as *Capra megaceros hutton* (Wild Goat). It according to them is known as Markhor in Kashmir, and Rawche (Female) and Rapoche (Male) in Ladakh.

[12]It appears that, Jahangir seems to be confused while recording a list of the animals (especially those of which) he had not found in Kashmir. Because, it has been reported that, some of the carnivorous and herbivorous animals such as: leopard, antelope, wolf, hare, the lynx, wild ass and porcupine are quite possible to exist in Kashmir during that period also, and many of them are existing in Kashmir even today. See also, Bernier, Travels in the Mogul empire, trans. A. Constable, (Revised by V. A. Smith), Reprint: Delhi, 1983, pp. 395-396; And also, Walter Lawrence, The valley of Kashmir, (London, 1895), 2nd ed. Srinagar, 2005, pp. 108-117. For identifying these animals with scientific and vernacular names, I sought the help of some teachers, and research scholars pursuing research in Wild-Life Department of Aligarh Muslim University, Aligarh.

[13]Interestingly, the underlined birds are never heard to exist in Kashmir which Jahangir records to be found in. Here, (H) stands for Hindi and (P) stands for Persian.

Table 2. List of the birds.

Vernacular name	English name	Species or genus only
Kulang (p)	Lord Lilford' Crane	*Gruslilfordi*
Saras (H)	Sarus Crane	*Grusantigoneantigone*.
Taus (P)	Peacock[14]	*Pavocristatus*
Charz (P)	Bustard	Otis (sp).
Laglag (H)	Stork	Ciconia (sp).
Tughdari (P)	Great Bustard	*Otis tarda*
Taghdagh (H)	Lesser Bustard	*Otis tetrax*
Karwanak (P)	Stone-curlew	*Burhinusoedicnemus*
Zardpilak (P)	Grey-headed Bunting	*Emberizaarcuata*
Nuqra (P)	White-legged courser	*Cursoriuscoromandalicus*
Hawasil (P)	Pelican	*Pelecanusphilipensis*
Qaz (P)	Goose	Anser (sp).
Konkla (H)	European Cuckoo	*Cuculuscanorus*
Durraj (P)	Partridge	Perdix*(sp);* Francolinus (sp).
Sharak (P)	Starling	Sturnus (sp).
Nolsurkh (P)	Red-crested Pochard	*Brantarufina*
Haryal (H)	Green pigeon	Treron (sp).
Dheek (H)	Adjutant	Leptoptilos (sp).
Quail (H)	Indian cuckoo	Coturnix (sp).
Shakar-khwara (P)	Sunbird	Nectarina (sp).
Mahokah (P)	Crow-pheasant	Centropus (sp).
Mahalat (H)	Tree pie	*Dendrocittaformosac*
Hans (H)	Bar-headed goose	*Anserindicus*
Kalchidri (H)	Black robin	*Petroica traverse*
Tatiri (H)	Lapwing/ Sandpiper	Vanellus/Tringa (sp).
Bachirm (P)	NA	
Lelorah (H)	Shrike	Lanius (sp).
Makshah (P)	NA	
Taqlah (P)	NA	
Musichah (P)	Wood-pegion	*Columba hodgsoni*

FLOWER PLANTS: SOME NOTES ON MORPHOLOGY AND BEHAVIOUR

Jahangir's botanical interests were primarily horticultural. Alvi and Rahman, best elaborate this phenomenon of Jahangir in the words they write: "Jahangir tells us of having made it possible to cultivate high altitude trees like the cypress, juniper, pine and the jawanesesandal tree in the plains of India. He laid out some beautiful gardens. He compares the fruits and grains of various regions and notes down average and record weights of some of the specimens. Unfortunately, most of his paintings of flower plants have been destroyed by the passage of time. The extent of this loss can be imagined from the fact, that of the more than a hundred paintings of Kashmir flowers, painted by Mansur alone, not one has survived to this day"(Alvi and Rahman, 1968, p. 6).

Moreover, at about the earliest botanical illustrations, Ebba Koch proposes to remind that, Ustad Mansur's famous Tulips, c. 1620, at the Maulana Azad Library, Aligarh Muslim University, could possibly be the earliest botanical illustration of *TulipaLinifolia Regel* (Figure 1), 1884 (Koch, 2009, p. 309). She further adds that, it grows in western Central Asia, reaching into the Himalayas in Kashmir and North India, Mansur renders correctly the undulating leaves, and the broad glowing red petals that abruptly contract to a fine point and curve outward, all characteristic of the species (Koch, 2009, pp. 309-313). Another favourite of the Mughals, says Ebba Koch, was *Fritillaria imperialis*, or *crown imperial*. Jahangir described one (along with some other species) he saw during a trip to Kashmir in March 1620, and in this context, also comments on the problem of methodology in assessing his material (Koch, 2009, p. 313). For example, Jahangir

[14]Here underline shows that, this bird does not exist in Kashmir. Jahangir seems to be confused while recording the list.

Figure 1. Tulips, signed Mansur, c. 1620, opaque water colour on paper, Maulana Azad Library, Aligarh Muslim University, Aligarh. (Adapted from S. P. Verma, Mughal Painter of Flora and Fauna Ustad Mansur, Plate XI. Verma identifies this flower as *Tulipa clusiana*, but, Koch rightly argues that it fits the description of *Tulipa linifolia* better).

writes: "In some near place of Bambyar[15] there was one strange flower in particular with an odd shape. It had five or six orange coloured flowers blooming with their heads down, and several leaves were poking out from inside the flowers. It was something like a pine apple. The name of this flower is *bulanik*. There was another flower like the *boni*, and around it were the tiny flowers shaped and coloured like *jasmine*. Some were blue and others were pink with a yellow spot in the middle. It is extremely nice looking and harmonious. Its name is *ledor posh*[16]. The flowers of Kashmir are beyond counting or enumeration. Which ones shall I write about? How many can one write about? Only that which are really special can be recorded" (Jahangir, 1624; Khan, 1864, p. 294; Alvi and Rahman[17], 1968, p. 100; Thackston, 1999, pp. 327-328; Koch, 2009, p. 309).

Thus, it bears to mention that Jahangir qualifies as a keen researcher and finest observer of the flowers of Kashmir, too. And keeping the accuracy at that, he records many of the examples (describing physical appearance and behaviour of the flower plants) with which we can go as under:

Lotus, lily and the black bee: "The lotus flower is larger than the water lily, and it is pink. I saw many lotuses in Kashmir with a hundred petals. It is a fact that lotus opens by day and closes into a bud by night; whereas the water lily is vice-versa. The black bee, (the people of India call *Bhaunra*), always alights on both these flowers and goes inside to suck the nectar inside them. The lotus flower often closes up and traps the Bhaunra inside for the whole night. It also happens with the water lily. But when they open, it comes out and flies away. Because the black bee is a constant visitor to these flowers, the Hindi poets consider it to be like the nightingale in love with the rose, and they produce marvellous poetic conceits based on it" (Jahangir, 1624; Khan, 1864, p. 204; Alvi and Rahman, 1968, p. 96; Thackston, 1999, p. 239).

Tulip and jasmine flowers: "In the Fifteenth Regnal year, the tulips in Kashmir bloomed exceptionally well in the palace garden and on the roof of the congregational Mosque. There is abundant blue jasmine in the gardens, and the white jasmine, which the people of India call *chambeli*, is fragrant. Another variety is the colour of sandalwood, and it too looks very beautiful and occurs only in Kashmir. Red roses of several varieties were seen, and one was very fragrant. There is another sandal-wood coloured flower whose fragrance is extremely subtle and fine. It is something like a red rose, and its bush also resembles the rose. There are two sorts of lilies. The one that grows in gardens is very tall and green in colour, the other grows in fields. Although its colour is less vibrant, but, it is fragrant. The *ja'fari* flower grows large and is fragrant, and its bush gets taller than a man. Some years, however, when it gets large and sets flowers, it is caught by worms that spin something like a spider's web over the leaves, destroying them and desiccating the bush. It happened this year also. The flowers seen in the summer pastures of Kashmir are beyond enumeration. Those drawn by Master Nadirul'asri Mansur, the painter, number more than a hundred" (Jahangir, 1624; Khan, 1864, pp. 299-300; Thackston, 1999, pp. 332-333).

Hollyhock: "In this land [Kashmir] I saw a flower fiery red and shaped like a marshmallow flower, but smaller in size. So many flowers had blossomed next to each other, that from a distance, it looked like one flower. The tree is the size of an apricot tree. There were also many wild violets growing on the mountain slopes. They were extremely fragrant and their colour was lighter than that of a normal violet" (Jahangir, 1624; Khan, 1864, p. 289; Alvi and Rahman[18], 1968, p. 98; Thackston, 1999, p. 323).

Saffron flower: About saffron flower, Jahangir, records a surprising observation he passed through. He says: "When the river [Bahat] reaches Pampur, ten kos from the city, it increases. All the saffron of Kashmir is produced here.

[15]Name of a place in Kashmir

[16]Flower named in Kashmiri language

[17]They have described this flower as *Fritillaria imperialis* (Crowned Imperial lily) and the other as *Thistle*.

[18]They identify this flower as *Althea oficinalis* (Hollyhock).

Table 3. Flower plants.

Vernacular name	English name	Species or genus only
Gul-i Bulanik	Crowned Imperial Lily	*Fritillariaimperialis*
Lidarposh	Thistle	*Centaureasolstitialis*
Arghwan-i Zard	Buttercup	Ranunculus (sp).
Nargis	Narcissus	*Narcissus poeticus*
Banafshah	Violet flower	*Viola odorata*
Gul-i Badam	Almond flower	*Prunusamygdalus/ Amygdaluscommunis*
Gul-i Shaftalu	Peach flower	*Prunuspersica*
YasmanKabud	Lit. Blue Jasmine	Jasminum (sp).
YasmanSafaid	Jasmine white	*Jasminumpubescens*
YasmanSandali	Sandal coloured Jasmine	Jasminum (sp).
Nilofer	Lotus	*Namphaeastellata*
Kanwal	Indian Lotus	*Nymphaeapurpurea*
Gul-i Surkh	Rose	Rosa (sp).
Susan	Iris	*Iris persica*

It is not known whether so much saffron is produced anywhere else in the whole world. Every year five hundred Indian maunds, (which is the equivalent of four thousand Persian maunds), of saffron are produced. I once came to this land with my exalted father during the saffron flowering season. With all other flowers in the world, first is the stalk, and then the leaves and flowers are produced. The saffron flower is just the opposite: when the stalk is up four fingers from the dry earth, an iris-coloured flower with four petals blossoms. In the middle of the flower are four filaments as orange as a safflower and as long as one finger joint. This is the saffron. It grows in un-ploughed, un-watered earth in the midst of clouds. In some places, the saffron fields extend for a kos, and in others for half a kos. It looks better from a distance. At the time of picking, all my inmates got headaches from the intense smell. I got a headache too. I asked the Kashmiris- who were picking the flowers, how they were. And, from their answer, it was obvious that, it had never occurred to them in all their lives to have a headache" (Jahangir, 1624; Khan, 1864, p. 45; Alvi and Rahman[19], 1968, pp. 91-93; Thackston, 1999, p. 70).

And, in their work, Alvi and Rahman (1968, pp. 100-102), have scientifically classified all those flowers of Kashmir, which Jahangir himself had gone on observing and recording. The same list of the flower plants is given in Table 3.

FRUIT TREES IN KASHMIR: SOME SIGNIFICANT NOTES OF JAHANGIR

Interestingly, Emperor Jahangir had also been keenly observing and investigating the fruit trees of Kashmir. His scientific observation bears typical example of the fact that he records, measures, counts and gives a logical comparison of the fruits he had eaten before. Say for instance, he writes: "Before his Majesty Arsh-Ashyani's reign [Akbar], there [Kashmir] were absolutely no cherries. Muhammad Quli Afshar brought them from Kabul and grafted them. Now there are ten or fifteen fruit-bearing trees. There were also a few trees of grafted apricots. The same person spread grafting throughout the land, and they are now abundant. The Kashmiri apricot really grows well. There was a tree in *Shahrara Garden* in Kabul called the Mirza'i, which bore better fruit than any we had ever eaten. In Kashmir, there are several of such trees in the gardens. The pears are of the finest sort, better than those of Kabul and Badakhshan, and almost as good as the pears of Samarkand. The Kashmiri apple is renowned for being good, but the guavas are middling. Grapes are abundant, though most of them are sour and inferior. The pomegranates are not so great. Watermelons grow very well, and Persian melons get extremely sweet and aromatic. Mostly, however, when they ripen they get worms inside that spoil them. Occasionally, when they escape being wormy, they are extremely fine. Since there are no black mulberries, there are fields of ordinary mulberries. At the base of every mulberry tree climbs a grape vine. The mulberries are not edible, only those from a few trees that have been grafted in gardens are edible" (Jahangir, 1624; Khan, 1864, p. 300; Thackston, 1999, p. 333). He further adds to our information that, the earliest fruit to mature in Kashmir is the *Ashkin*. It is smaller than a sour cherry, it is much better in terms of flavour and delicacy. I commanded that henceforth the *Ashkin* should be called *Khoshkin*. Apparently it also grows in the mountainous regions of Badakhshan and Khurasan, where the people call it

[19]They identify this flower as *Crocus sativus linn* (Saffron), and in Kashmir it is known as Zaaff'ran.

Table 4. Fruit trees.

Vernacular name	English name	Species or genus only
Shah Alu	Sweet cherry	*Prunusavium*
ZardAlu	Apricot	*Prunusarmeniaca*
Naspati	Peer	*Pyruscommunis*
Saib	Apple	*Malussylvestris*
Amrud	Guava	*Psidium guava*
Angur	Grape	*Vitisvinifera*
Anar	Pomegranate	*Punicagranatum*
Tarbuz	Water-melon	*Citrullus vulgaris*
Kharpuzah	Melon	*Cucumismelo*
Tut	Mulberry	*Morus alba*
Ashkin	Straw-berry	*Fragariavesca*
AluBalu	Sour cherry	*Prunuscerassus*

Najmad. The largest ones weight is half a mithcal (Jahangir, 1624; Khan, 1864, p. 306; Alvi and Rahman, 1968[20], p. 108, Thackston, 1999, p. 340). The cherries in the Nurafza garden, says Jahangir, appeared to be about the size of a chickpea on the fourth of Urdibihisht [April 14]. By the twenty-seventh [May 17], they changed colour, and on the fifteenth of Khurdad they were perfectly ripe and the first crop was taken in. The cherry to my taste is the most delicious of all fruits. Four trees had borne fruits in *Nurafza Garden*. I named one of them *Shirinbar* [of sweet fruit], the second *Khoshguvar* [of good taste], the third which produced the most fruit of all, *Purbar* [full of fruit], and the fourth, which had the least fruit, *Kambar* [of little fruit]. One tree in Khurram's Garden had borne fruit, and I named it *Shahwar* [kingly]. There was a sapling in *Ishratafza Garden* I named *Nawbar* [newly bearing]. The cherries of Kashmir are not inferior to those of Kabul, in-fact, they are even larger. The biggest ones weighed a tank and five surkhs. From the four trees in the *Nurafza* Garden fifteen hundred cherries were picked, and from all others, five hundred. I ordered the officials of Kashmir to have cherry trees grafted in most of the gardens and let them to propagate (Jahangir, 1624; Khan, 1864, pp. 306-07; Thackston, 1999, p. 340-41).

And, on the account of Jahangir's significant notes, Alvi and Rahman (1968, pp. 106-08), have further scientifically classified these fruit trees of Kashmir (Table 4).

CONCLUSION

Indeed, much that has been presented in this paper will remain fragmentary, but, this paper, as proposed, will work as a key concept to the further study of what has been paid a little attention so far. The extra-ordinary qualities of Emperor Jahangir are positive inspirations to explore further in his field of science in general and his ecological concerns, in particular, as they promise very much possibilities of not only being historically important, but, permanently relevant which may have escaped the analytical eye so far. Perhaps, most importantly, the constant mobility of Jahangir's royal court offered him the opportunity of satisfying his 'scientific passion' almost daily.

What is now set forth as an ideal is that, the existence of the largest possible number of species (viz., birds, animals, plants, and etcetera) is considered an indicator of the ecological health of an area and these in combination are an essential part of the aesthetic life-scape of humans. It was, in-fact, Emperor Jahangir whose own-way of observation and approaches to investigation (whether anatomical, behavioural and/or morphological) of different species' brought us to gain more about: how the natural environment in different ways attracts man, and how man in turn by his concerns was thinking of the biodiversity in several ways in the past. Including how man should communicate better with other living things of different species.

It was, Reiter and Haeckel, in late 19th Century, who acquainted us with the concept of, 'ecology' in general, and now, by others, 'behavioural' and 'morphological' ecology as specialised branch(s) in particular, yet, equally it appears that, Jahangir, was no less than a person-of-having also 'deep sense of sensitivity' towards nature. Needless to put that he was acquainted with the concept of 'ecology' before, though in a different manner. Interestingly, the only demerit covered him was his habit of hunting inherited from his predecessors' which unlike others brought him close to the set procedure of knowing 'anatomical structure' of the different species, he did. As it goes that, the 'ecologists', today observe nature, conduct experiments and construct mathematical models, thus my findings about Jahangir would not go wrong proposing that, he had also been observing, conducting and experimenting all, long ago in some significant manner. Or, briefing in other words is to theorise that, Jahangir had some greater scientific bent of mind than any other contemporary ruler of his period in and around. As of now, he is very much in the know that he was a naturalist, but his environmental concerns and scientific notes on 'behavioural' and 'morphological' ecology of different species, proves that he was no less than a person as an 'ecologist' who lived in the past for the use of the present. And all this showcase that, he was not only an Emperor, but was many men rolled into one.

Conflict of interests

The author did not declare any conflict of interest.

ACKNOWLEDGEMENTS

The author's mentor and supervisor Dr. (Mrs.) Gulfishan

[20]They have described this fruit as *Fragaria vesca* (straw-berry).

Khan, associate professor in Centre of Advanced Study, Department of History, A.M.U., Aligarh, deserves to be thanked for improvement and guidance throughout the study. Thanks are due to the reviewers' whose comments helped in improving this paper also. And, also thankful Zia-ul Haq Rafaqi, for technical guidance while finalizing this paper.

REFERENCES

Alvi MA, Rahman A (1968).Jahangir-The Naturalist, National Institute of Sciences of India, New Delhi.

Bernier F (1983). (1656-1668), *Travels in the Mogul empire,* (Trans.) Constable, A., Oriental books reprint, Delhi.

Habib I (2010). Man and Environment: The Ecological History of India, Tulika Books, New Delhi.

Jahangir NM (1624). Tuzuk-i- Jahangiri, (Ed). Khan, S. A., (1863-1864). Sir Syed Academy reprint, (2007). Aligarh Muslim University, Aligarh.

Koch E (2009). Jahangir as Francis Bacon's Ideal of the King as an Observer and Investigator of Nature. J. R. Asiatic Soc. Lond. Third Series 19 (3): 293-338.

Lawrence W (1895). The valley of Kashmir, Gulshan publishers, Srinagar.

Subrahmanyam NS, Sambamurty AVSS (2004). Ecology, Narosa, New Delhi.

Thackston WM (1999). (Trans. Ed.). The Jahangirnama: Memoire of Jahangir, Emperor of India. Oxford University Press, New York.

academicJournals

Vol. 7(3), pp. 81-86, March 2015
DOI: 10.5897/JENE2015.0500
Article Number: 960D8BB52121
ISSN 2006-9847

http://www.academicjournals.org/JENE

Journal of Ecology and the Natural Environment

Full Length Research Paper

A study on ecological distribution and community diversity of spiders in Gulmarg Wildlife Sanctuary of Kashmir Himalaya

Mansoor Ahmad Lone[1], Idrees Yousuf Dar[1]* and G. A. Bhat[2]

[1]Department of Environmental Sciences, University of Kashmir, Srinagar -190 006, J&K, India.
[2]Department of Environmental Sciences, Centre of Research for Development, University of Kashmir, Srinagar -190 006, J&K, India.

Received 23 January, 2015; Accepted 17 March, 2015

The present study was an attempt to assess and evaluate the distribution, diversity and occurrence of spider community in Gulmarg Wildlife Sanctuary. India has 59 of the 110 spider families and at least, 1442 formally described species of the 39,000 known worldwide. Documenting spider assemblages assumes greater importance in the context of current rate of loss and degradation of forests which is known to have detrimental effect on many invertebrate groups. In order to assess the diversity and distribution of spiders at four sites during the months of May, June, July, October and December 2012, standard protocol was used to collect the spider community across the study area. The spider community was found to be represented by 18 taxa. Araneidae was dominant family followed by Lycosidae, Linyphiidae, Pholcidae, Salticidae, Sparassidae and Clubionidae. Differences in vegetation cover or human use showed variation in diversity and composition of spiders between different sites. Forest sites showed relatively higher diversity as compared to meadow sites.

Key words: Spider community, diversity, Araneidae, Gulmarg.

INTRODUCTION

Spiders form a diverse group of invertebrates in varied ecosystems and are known to be sensitive indicators of environmental change (Hodge and Vink, 2010). India has 59 of the 110 spider families and at least 1442 formally described species of the 39,000 known worldwide (Siliwal et al., 2009). Spiders also have an added advantage of being conspicuous, amenable to capture by relatively cheap, easily deployable and replicable techniques. These attributes make spiders as a group, suitable for statistical appraisal, comparisons and monitoring of sites or habitats. Arachnids are an important albeit poorly studied group of arthropods that play a significant role in the regulation of other invertebrate populations in most ecosystems (Russell-Smith, 1999). Spiders, which globally include about 42,055 described species (Platnick, 2011), are estimated to be about 60,000-170,000 species (Coddington and Levi, 1991). They include a significant portion of the terrestrial arthropod diversity, being one of the dominant macro invertebrate predator groups in terrestrial environments (35 - 95%) (Specht and Dondale, 1960; Van Hook, 1971; Moulder and Reichle, 1972; Edwards et al., 1976).

*Corresponding author. E-mail: wilderness4@gmail.com. Tel: +919018448827 or 9419458248.

Spiders are copious in both natural and cultivated environments, in which their average annual abundance ranges from 50 to 150 individuals per square meter but can periodically reach maximal densities of more than 1000 individuals per square meter (Pearse, 1946; Duffey, 1962). They occupy a wide range of spatial and temporal niches, exhibit taxon and guild responses to environmental change, extreme sensitivity to small changes in habitat structure, primarily vegetation complexity and microclimate characteristics (Uetz, 1991). Furthermore, strong associations exist between plant architecture and species that capture prey without webs (Duffey, 1962; Uetz, 1991). Spiders respond distinctly to altered litter depth, and structural complexity and nutrient content of litter (Uetz, 1991; Bultman and Uetz, 1982). They employ a remarkable variety of predation strategies. As they are generalist predators, they are of immense economic importance to man because of their ability to suppress pest abundance in agro ecosystems. The population densities and species abundance of spider communities in agricultural fields can be as high as that in natural ecosystems (Riechert, 1981). In spite of this, they have not been treated as an important biological control agent since very little is known of the ecological role of spiders in pest control (Riechert and Lockley, 1984). Spiders regulate decomposer populations (Clarke and Grant, 1968) and by doing so, they influence ecosystem functioning (Lawrence and Wise, 2000, 2004). Their high biomass also makes them a critical resource for larger forest predators such as salamanders, small mammals and birds. Spiders can be used as successful biological indicators to assess the 'health' of an ecosystem because they can be easily identified and are differentially responsive to natural and anthropogenic disturbances (Pearce and Venier, 2006). For a species to be identified as an effective ecological indicator, it must meet the primary criteria of being feasible and cost effective to sample, easily and reliably identified, functionally significant, and have ability to respond to disturbance in a consistent manner. Spiders readily meet the first three criteria. Their high relative abundance, ease of collection and diversity in habitat preferences and foraging strategies allow for effective monitoring of site differences (Yen, 1995). Many studies have widely recommended the potential of spiders as bioindicators (Duchesne and McAlpine, 1993; Niemelä et al., 1993; Beaudry et al., 1997; Atlegrim et al., 1997; Churchill, 1997; Duchesne et al., 1999; Bromham et al., 1999; Werner and Raffa, 2000; Heyborne et al., 2003). This paper intends to study the diversity of spiders at different vegetation types.

MATERIALS AND METHODS

Study area

The study was conducted at Gulmarg (Figure 1), Gulmarg literally means 'meadow of flowers'. Gulmarg is a town, a hill station and Kashmir's premier ski resort. It is located 56 km south west of Srinagar. Gulmarg's legendary beauty, prime location and proximity to Srinagar naturally make it one of the premier charming luxury hill resorts in the country. The study sites selected had relatively different vegetation and anthropogenic impacts. Site-1 represented Drang Forest with geographical coordinates of N 34° 02′ 04.0″ and E 74° 24′ 25″ and an elevation of about 2328 m. The site was having dominant tree cover of *Pinus wallichiana* and *Picea smithiana*, while *Taxus baccata* was less prominent. The prominent shrubs were *Viburnum grandiflora* and *Geranum wallicianum*. Site-2 represented Drang Meadow (N 34° 03′ 35.7″ and E 74° 25′ 31.7″; Elevation 2328 m). It was dominated by herbaceous vegetation but witnessed grazing and anthropogenic activities. Site-3 represented Gulmarg Forest (N 34° 02′ 41.6″ and E 74° 23′ 09.3″; Elevation 2684 m). This site had a mixed type of vegetation dominated by *Populous migra*, *Rolinia pseudacacia* and dotted with *P. wallichiana* trees also. Site-4 represented Gulmarg meadow (N 34° 02′ 51.6″ and E 74° 23′ 09.3″; Elevation 2687 m).

Spiders have been sampled using many methods, each with its own limitations, such as direct searches, pitfall traps, canopy fogging, vegetation beating, litter shifting or extraction, sweap net and suction sampling (Churchill and Arthru, 1999). Established sampling protocols for spider collection (Sorensen et al., 2002) were adopted in different sampling plots. The study was carried out using belt transects vegetation beating, pitfall traps and leaf litter extraction. Pitfall traps method was used to capture the spiders (Curtis, 1980; Kitching et al., 2000). The belt transects were of 10 m length and 2 m width with sampling restricted to the maximum height of 1 m. At each site, exercise was conducted for 30 min. Vegetation beating method is employed to collect spiders living in the shrub, high herb vegetation, bushes and small trees and branches (Coddington et al., 1996; Coddington and Levi, 1991). Spiders were collected by beating the vegetation with a stick and collecting the samples on a cloth (1 m²). The spiders were preserved in different vials filled with ethyl alcohol (75-80%) and marked using a piece of paper with the sample number.

Statistical analysis

No single index encompasses all characteristics of an ideal index, that is, high discriminate ability, low sensitivity to a sample size, and ease in calculation (Margurran, 1988). Therefore an observation of the different indices reflecting species evenness, dominance and diversity heterogeneity provide some valid viewpoints. Shannon's index of diversity (Price, 1997) reflects both evenness and richness (Colwell and Huston, 1991) and is commonly used in diversity studies (Krebs, 1989). It is calculated as $H = -\sum(ni/N)Ln(ni/N)$; i =1–n; where n is the number of species and Pi is the proportion of the ith species in the total. Index of dominance is calculated as $= \sum(ni/N)^2$ where ni is the number of individuals of a species and N is the total number of individuals of all species. Evenness indicates the degree of homogeneity in abundance between species and is based on the Shannon index of diversity. Shannon evenness [$E = H/H_{max} = H/lnS$; where H is the Shannon diversity index and S the number of species in the community] ranges from 0 to 1.

RESULTS

Taxonomical diversity

The spider community (order Araneae) was found to be represented by 18 taxa. Araneidae was a dominant family followed by Lycosidae, Linyphiidae, Pholcidae, Salticidae,

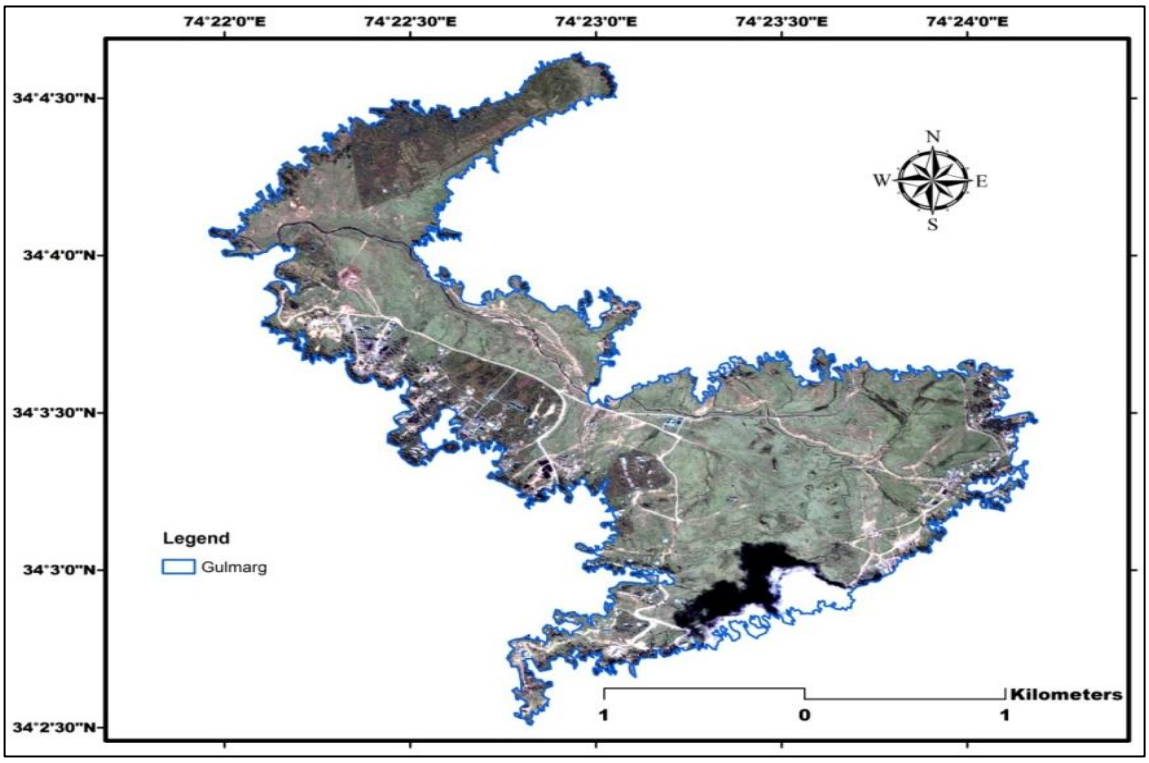

Figure 1. Satellite image of the study *area* (Gulmarg).

Table 1. Monthly variation in spider community density (Ind./m^2) at site I from May 2012-December 2012.

S/N	*Taxa*	May	June	July	October	December	Mean (n_i)
	Site I (Drang Forest)						
1	*Lycosa* sp.	6	4	0	0	1	2.2
2	*Araneus* sp.	2	4	4	3	2	3
3	*Obscuriphantes* sp.	0	2	0	0	0	0.4
4	*Stegodyphus* sp.	0	1	0	3	0	0.8
5	*Sparassus* sp.	0	0	2	4	0	1.2
6	*Lepthyphantes* sp.	0	0	1	0	0	0.2
7	*Pholcus* sp.	2	1	2	0	0	1
8	*Microlinphia* sp.	0	0	0	6	0	1.2
9	*Pardosa* sp.	0	0	0	2	1	0.6
	Total	10	12	9	18	4	10.6

Sparassidae and Clubionidae. Among the four sites selected, site I (Drang forest) showed the maximum number of taxa followed by site III (Gulmarg Forest), II (Drang meadow) and IV (Gulmarg meadow). At site I (Drang Forest) *Araneus* sp. was found to be dominant taxa throughout the study period. *Araneus* sp. recorded its maximum density (4 individual/m^2) in the month of July 2012 and lowered to 2 individual/m^2 in the month of December 2012. While the *Lepthyphantes* sp. was least dominant at site I having a maximum density (1 individual/m^2) in the month of July and was not recorded in the month of December (Table 1). At site II (Drang Meadow) *Lycosa* sp. and *Padosa* sp. were two dominant taxa throughout the sampling. In the month of June, *Lycosa* sp. showed the highest dominance (10 individuals/m^2) and was totally absent in the month of July. While *Salticus* sp. and *Thomisius* sp. were present only in the month of December (Table 2). At site III (Gulmarg Forest), *Lycosa* sp. was found to be dominant taxa throughout the study period. In the month of June,

Table 2. Monthly variation in spider community density (Ind. /m^2) at site II from May 2012-December 2012.

S/N	Taxa	May	June	July	October	December	Mean (n_i)
	Site II (Drang Meadow)						
1	*Lycosa* sp.	4	10	0	2	4	4
2	*Pardosa* sp.	4	6	0	4	0	2.8
3	*Microlinphia* sp.	0	0	3	4	0	1.4
4	*Salticus* sp.	0	0	0	4	0	0.8
5	*Thomisius* sp	0	0	0	6	0	1.2
	Total	8	16	3	20	4	10.2

Table 3. Monthly Variation in Spider Community Density (Ind./m^2) at Site III from May 2012-December 2012.

S/N	*Taxa*	May	June	July	October	December	Mean (n_i)
	Site III (Gulmarg Forest)						
1	*Lycosa* sp.	3	4	2	1	1	2.2
2	*Araneus* sp.	2	2	4	2	1	2.2
3	*Clubiona* sp.	1	0	2	0	0	0.6
4	*Dictyna* sp.	2	0	2	0	0	0.8
5	*Microlinyphia* sp.	0	0	2	0	0	0.4
6	*Salticus* sp.	0	0	4	0	0	0.8
7	*Loxosceles* sp.	0	0	4	0	0	0.8
8	*Pholcus* sp.	1	2	3	1	0	1.4
	Total	9	8	23	4	2	9.2

Table 4. Monthly variation in spider community density (Ind./m^2) at site IV from May 2012-December 2012.

S/N	Taxa	May	June	July	October	December	Mean (n_i)
	Site IV (Gulmarg Meadow)						
1	*Lycosa* sp.	15	2	2	1	0	4
2	*Pardosa* sp.	4	4	6	2	0	3.2
	Total	19	6	8	3	0	7.2

Lycosa sp. showed the highest dominance (4 individual/m^2) and lowest (1 individual/m^2) in the month of December. While *Clubiona* sp. was least dominant at site III having a maximum density (2 individuals/m^2) in the month of July and lowered to 0 individual/m^2 in the month of December (Table 3). At site IV (Gulmarg Meadow), only *Lycosa* sp. and *Pardosa* sp. were observed, out of which *Lycosa* sp. was found to be more dominant. In the month of May, *Lycosa* sp. showed the highest dominance (15 individual/m^2) but no individuals were recorded during December. *Pardosa* sp. was dominant in the month of July (6 individual/m^2) while no individuals were encountered in the month of December (Table 4). At site I (Drang Forest), *Araneus* sp. was found to be dominant taxa throughout the study period. *Araneus* sp. recorded its maximum density (4 individual/m^2) in the month of July 2012 and lowered to 2 individual/m^2 in the month of December 2012. While *Lepthyphantes* sp. was least dominant at site I having a maximum density 1 individual/m^2 in the month of July and was not recorded in the month of December.

At site II (Drang Meadow), *Lycosa* sp. and *Padosa* sp. were two dominant taxa throughout the sampling. In the month of June, *Lycosa* sp. showed the highest dominance (10 individual/m^2) and was totally absent in the month of July. While *Salticus* sp. and *Thomisius* sp. were present only in the month of December.

At site III (Gulmarg Forest), *Lycosa* sp. was found to be dominant taxa throughout the study period. In the month of June, *Lycosa* sp. showed the highest dominance

(4 individual/m^2) and lowest (1 individual/m^2) in the month of December. While *Clubiona* sp. was least dominant at site 3 having a maximum density (2 individual/m^2) in the month of July and was absent in the month of June, October and December.

At site IV (Gulmarg Meadow), only *Lycosa* sp. and *Pardosa* sp. were observed, out of which *Lycosa* sp. was found to be more dominant. In the month of May, *Lycosa* sp. showed the highest dominance (15 individual/m^2) and lowered to 0 individual/m^2 in the month of December. While *Pardosa* sp. was dominant in the month of July (6 individual/m^2) and lowered to 0 individual/m^2 in the month of October and December.

Araneus sp. and *Lycosa* sp. were two dominant taxa throughout the study period; they are cosmopolitan in distribution and have high species diversity. However, the families like Lycosidae and Araneidae are more tolerant and overcome harsh climatic conditions and can survive in low temperature.

Also, site I (Drang forest) has high diversity than site III (Gulmarg forest), this may be due to the fact that the site I is away from the dwelling areas and its natural conditions while the site III which is a tourist spot is in a relatively more stress.

Also site II (Drang meadow) showed high diversity than site IV (Gulmarg meadow), the reason may be that in site IV, there is high anthropogenic and more biotic interferences taking place.

DISCUSSION

Spider community of the study area was found to be represented by 18 genera belonging to order Araneae. Araneidae was the dominant family followed by Lycosidae, Linyphiidae, Pholcidae, Salticidae, Sparassidae and Clubionidae. Among arthropods, spiders are the most abundant predators in many terrestrial ecosystems, playing an important role in ecosystem functioning throughout habitats (Van Hook, 1971). While spiders in forest ecosystems contribute to the maintenance of insect community equilibrium, the distribution of species and the composition of assemblages are significantly influenced by environmental conditions (Ziesche and Roth, 2008). Spiders seem well suited to discriminate habitat type and quality, since they play important role as diverse and abundant invertebrate predators in terrestrial ecosystems. Despite their ecological role in many ecosystems, high diversity, documented threats and the known imperilment of some species, spiders have received little attention from the conservation community (Skerl, 1999). While this lack of attention may be related to negative public attitudes towards spiders (Kellert, 1986), a paucity of compiled information on spider conservation status and distribution may be a more important issue. However, it is important that imperiled and vulnerable spiders and other invertebrates are not left out of conservation planning efforts, as they may have unique ecological requirements or require particular site selection and management activities.

The diversity of spiders in the two forest sites was noted to be higher as compared to the two meadow sites. This may be due to the increased anthropogenic stress in the meadow areas which lead to the decrease in biodiversity and also the less availability of food in the meadow. Meadows are open areas in which there are high chances of predation. There are several other environmental factors that may also affect spider species diversity such as, spatial heterogeneity, competition, predation, habitat type, environmental stability and productivity (Rosenzweig, 1995). On the other hand, forests have large number of microhabitats which help spiders to escape there predators. Availability of food also effects diversity. In forests, food is available in abundance which is another reason why forests show high diversity as compared to meadow.

Also, the results showed that the number of individuals recorded from the sampling sites linearly decreased with the increasing altitude and also found that the family diversity showed a constant negative value with altitude. As spiders are sensitive to even small changes in the environment especially vegetation topography and climatic changes, patterns of linear decline may also be probably related to more severe climatic conditions terrain and landscape of study site. Similar results of spider abundance and declining linearly with elevation were observed in the studies of Otto and Swenson (1982) and McCoy (1990). Diversity is supposed to peak at mid elevation via primary productivity, which is considered to peak at mid elevations. The study provides information on spider community in different ecosystems and the effects of both biotic and a biotic factors, as well as anthropogenic impacts on diversity and distribution of these spiders. Different sites with differences in either vegetation cover or human use showed variation in diversity and composition of spiders. The number of individuals recorded from the sampling sites linearly decreased with the increasing altitude and also found that the family diversity showed a constant negative value with altitude. As was observed from the results of the study, altitude, habitat type and temperature play an important role in distribution and composition of spiders. Forests showed highest diversity as compared to meadow.

Gulmarg Wild Life sanctuary is interestingly diverse in spider fauna. During study, it was found that there have been less attention towards spiders in the state and therefore similar research in other parts of the Kashmir valley will surely provide information in this direction. It is also important to note that spider fauna is ubiquitous in nature and their diversity cannot be explained by quantifying one aspect of the environment. It does depend on many other factors or a combination of factors, apart from altitudinal variation and habitat

structure. Looking into these factors would surely bring in more interesting results which can be relevant for maintenance and management of spider diversity of this region.

Conflict of interests

The authors did not declare any conflict of interest.

ACKNOWLEDGEMENT

The authors are highly grateful to Prof. Azra N. Kamili, Head, Department of Environmental Sciences, University of Kashmir, for providing the laboratory and other needed facilities.

REFERENCES

Atlegrim O, Sjoberg K, Ball JP (1997). Forestry effects on a boreal ground beetle community in spring: selective logging and clear-cutting compared. Entomol. Fenn. 8:19-26.

Beaudry S, Duchesne LC, Cote B (1997). Short-term effects of three forestry practices on carabid assemblages in a jack pine forest. Can. J. Forest Res. 27: 2065-2071.

Bromham L, Cardillo M, Bennett AF, Elgar, MA (1999). Effects of stock grazing on the ground invertebrate fauna of woodland remnants. Aust. J. Ecol. 24: 199-207.

Bultman TL, Uetz GW (1982). Abundance and community structure of forest floor spiders following litter manipulation. Oecologia 55:34-41.

Churchill TB (1997). Spiders as ecological indicators in the Australian tropics: family distribution patterns along rainfall and grazing gradients. In P.A. Selden, Ed., Proceedings of the 17th European Colloquium of Arachnology, Edinburgh.

Churchill TB, Arthur JM (1999). Measuring spider richness: effects of different sampling methods and spatial and temporal scales. Journal of Insect Conservation. Kluwer Academic Publishers, 4: 287-295.

Clarke RD, Grant PR (1968). An experimental study of the role of spiders as predators in a forest litter community. Ecology 1152-1154.

Coddington JA, Levi HW (1991). Systematics and evolution of spiders Araneae. Annu. Rev. Ecol. Syst. 22: 565-592.

Coddington JA, Young LH, Coyle FA (1996) Estimating spider species richness in a southern Appalachian cove hardwood forest. J Arachnol 24:111–128

Colwell RK, Huston MA (1991). Conceptual framework and research issues for species diversity at community level. In: Solbrig O.T. (Ed.), From genes to ecosystems: a research agenda for biodiversity. International Union of Biological Sciences, Paris, France, pp. 37-71.

Curtis DJ (1980). Pitfall in spider community. (Arachnida : Aranaea). J. Arachnol. 8: 280-281.

Duchesne LC, Mcalpine RS (1993). Using carabid beetles Coleoptera: Carabidae as a means to investigate the effect of forestry practices on soil diversity. Forestry Canada Petawawa National Forestry Institute, Chalk River, Ontario, Canada Report No. 16.

Duchesne LC, Lautenschlager RA, Bell FW (1999). Effects of clearcutting and plant competition control methods on carabid Coleoptera: Carabidae assemblages in north western Ontario. Environ. Monit. Assess. 56: 87-96.

Duffey E (1962). A population study of spiders in limestone grassland. J. Anim. Ecol. 31: 571–599.

Edwards CA, Butler CG, Lofty JR (1976). The Invertebrate fauna of the park grass plots II. Surface fauna. Rep. Rothamst. Exp. Stn. 1975, Part 2: 63–89.

Heyborne WH, Miller JC, Parsons GL (2003). Ground dwelling beetles and forest vegetation change over a 17-year period, in western Oregon, USA. Forest Ecol. Manage. 179:123-134.

Hodge S, Vink CK (2010). An evaluation of Lycosa hilaris as an indicator of organophosphate insecticide contamination. New Zealand Plant Prot. 53:226-229

Kellert SR (1986). Social and perceptual factors in the preservation of animal species. In B.G. Norton, Ed., The Preservation of Species: The Value of Biological Diversity. Princeton University Press, Princeton, New Jersey.

Kitching RL, Vickerman G, Laidlaw M, Hurley K (2000). The comparative assessment of Arthopod and tree biodiversity in old world forest. The rainforest CRC/Earthwatch protocol manual. Cooperative Research Centre for Tropical Rainforest Ecology and Management. Technical Report Rainforest. CRC Crains

Krebs CJ (1989). Ecological methodology. Harper and Row, New York, USA.

Lawrence KL, Wise DH (2004). Unexpected indirect effect of spiders on the rate of litter disappearance in a deciduous forest. Pedobiologia 48: 149–157.

Lawrence KL, Wise DH (2000). Spider predation on forest-floor Collembola and evidence for indirect effects on decomposition. Pedobiologia 44: 33–39.

Margurran AE (1988). Ecological diversity and its measurement. Princeton University Press, Princeton, New Jersey, USA.

McCoy ED (1990). The distribution of insects along elevational gradients. Oikos 58: 313-322.

Moulder BC, Reichle DE (1972). Significance of spider predation in the energy dynamics of forest-floor arthropod communities. Ecol. Monogr. 42: 473-498.

Niemela J, Langor D, Spence JR (1993). Effects of clear-cut harvesting on boreal ground-beetle assemblages (Coleoptera: Carabidae) in western Canada. Conserv. Biol. 7: 551-556.

Otto C, Svensson BS (1982). Structure of communities of Ground living spiders along altitudinal gradients. Holarctic Ecol. 5: 35-47

Pearce JL, Venier LA (2006). The use of ground beetles Coleoptera: Carabidae and spiders Araneae as bioindicators of sustainable forest management: A review. Ecol. Indic. 6: 780–793.

Pearse A (1946). Observations on the microfauna of the Duke forest. Ecol. Monogr. 16: 127–150.

Platnick NI (2011).The world spider catalog, version 12.0. American Museum of Natural History.

Price PW (1997). Insect Ecology. 3rd ed. Wiley & Sons, New York.

Riechert SE (1981). The consequences of being territorial: spiders, a case study. Am. Nat. 117: 871-892.

Riechert SE, Lockley TC (1984). Spiders as biological control agents. Ann. Rev. Entomol. 29: 299-320.

Rosenzweig ML (1995). Species diversity in space and time. Cambridge, Cambridge University Press.

Russell-Smith A (1999). The Spiders of Mkomazi Game Reserve. In: M. Coe *et al*., Eds., Mkomazi: The Ecology, Biodiversity and Conservation of a Tanzanian Savanna. Royal Geographical Society, London.

Siliwal M, Molur S, Biswas BK. (2009). Indian Spiders (Arachnida: Aranaea): Update checklist 2009. Zoos Plant J. 20(10): 1999-2049.

Skerl KL (1999). Spiders in conservation planning: a survey of US natural heritage programs. J. Insect Conserv. 3:341-347.

Specht HB, Dondale CD (1960). Spider populations in New Jersey apple orchards. J. Econ. Entomol. 53: 810–814.

Uetz, GW (1991). Habitat structure and spider foraging. In: S.S. Bell, E.D. McCoy, H.R. Mushinsky, Eds., Habitat Structure: The physical arrangement of objects in space. Chapman and Hall, London, U.K.

Van Hook RI (1971). Energy and nutrient dynamics of spider and orthopteran populations in a grassland ecosystem. Ecol. Monogr. 41: 1–26.

Werner M, Raffa KF (2000). Effects of forest management practices on the diversity of ground occurring beetles in mixed northern hardwood forests of the Great Lakes region. For. Ecol. Manage. 139: 135-155.

Yen AI (1995). Australian spiders: An opportunity for conservation. Records of the Western Australian Museum Supplement 52: 39-47.

Ziesche T, Roth M (2008). Influence of environmental parameters on small-scale distribution of soil-dwelling spiders in forests: What makes the difference, tree species or microhabitat? Forest Ecol. Manage. 255:738-752.

academicJournals

Vol. 7(3), pp. 87-94, March 2015
DOI: 10.5897/JENE2015.0508
Article Number: 80936F152123
ISSN 2006-9847

http://www.academicjournals.org/JENE

Journal of Ecology and the Natural Environment

Full Length Research Paper

Vegetation regeneration in formerly degraded hilly areas of Rwampara, South Western Uganda

Juliet Kyayesimira[1]* and Julius B. Lejju[2]

[1]Department of Biological Sciences, Kyambogo University, Uganda.
[2]Department of Biology, Mbarara University of Science and Technology, Uganda.

Received 3 February, 2015; Accepted 23 February, 2015

Rwampara hills located in South Western Uganda have long been subjected to intensive degradation due to increased human activities. The hills have been left bare as a result of vegetation clearing for agricultural land, charcoal burning and grazing. In 1998, the National Environmental Management Authority (NEMA) attempted to restore the degraded hilly areas with the aim of establishing the restoration potential. With the cooperation of the local people, NEMA set aside some parts of the hills to allow natural regeneration, while another parts were planted with exotic tree species mainly *Eucalyptus* spp*. and Pinus patula.* This paper presents findings of an assessment on the level of indigenous vegetation regeneration in the three zones namely; restored, planted and areas undergoing degradation due to grazing. The indigenous vegetation was sampled using nested quadrats set along line transects. The results indicate that species richness was different among the three habitat types with the highest number (17 species) recorded in the degraded (grazing) area, followed by the restored area (12 species) and the plantation had the least (10 species). Species density was highest in the restored zone (289.83/ha) and least (80.2/ha) in the plantation zone. The most common indigenous tree species regenerating in all the three study zones were; *Olea europaea* subsp. *africana, Albizia adiathifolia* and *Markhamia lutea.*

Key words: Degraded hills, vegetation regeneration, Western Uganda.

INTRODUCTION

Increased human activities such as agriculture, grazing, firewood collection and charcoal burning aimed at improving livelihoods has caused severe land degradation of marginal lands, especially in hilly areas of western Uganda. Population increase and economic growth are primarily the driving forces behind degradation of these marginal lands (Olson and Berry, 2003).

The Rwampara hills in Western Uganda have a long history of land degradation. Past land use patterns and disturbance regimes have had a profound effect on the abundance, distribution and diversity of vegetation in the area. Due to severe effects of degradation, the area has become prone to agents of erosion. In 1998, the National Environment Management Authority (NEMA) initiated a program to restore the degraded ecosystem of Rwampara hills, with an aim of curbing soil erosion and increase its biological productivity and, local economic benefits and environmental services. Some local farmers volunteered

*Corresponding author. E-mail: kyayejue@gmail.com.

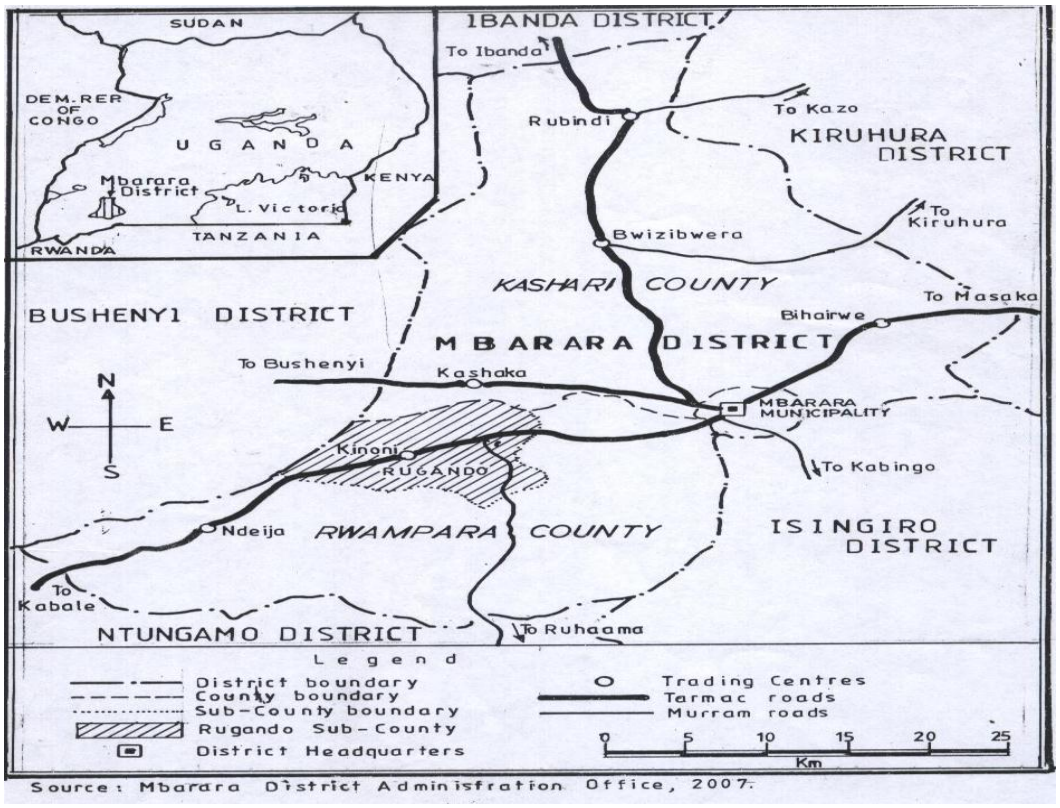

Figure 1. The study area in Rwampara County, South Western Uganda.

portions of their land for the restoration purpose. These portions were set to regenerate naturally, while other parts were planted with eucalyptus and pine. This paper presents the ecological data on a decade of vegetation restoration in the degraded areas of Rwampara hills in western Uganda.

MATERIALS AND METHODS

Study area

Mbarara district in Western Uganda comprises of Rwampara County. The district is located at Latitude:-0.6132; Longitude: 30.6582 (Figure 1). The landscape consists of rolling hills intercepted by long, but shallow valleys with wetlands occurring in the valleys. According to the National Population and Housing Census of 2002, Rwampara County has a population of 132,802 and a land area of 659.8 km^2. The area receives a moderate rainfall throughout the year with an average rainfall of 1200 m and temperatures ranging from 17 to 30°C. Two rainy seasons occur in the area from March to May and September to December, while the dry spells are experienced from December to February and June to August. The relative humidity ranges from 80-90% in the mornings and 48-60% in the evenings throughout the year.

The vegetation in the area consists of ever green and broad leaves, characteristics of medium attitude tropical rain forests. The current vegetation is dominated by indigenous and exotic tree species. The land has been subjected to intensive agricultural activities, mainly banana cultivation and livestock farming.

Vegetation sampling

Vegetation sampling was conducted in the three zones namely; degraded, restored and plantation zones. A stratified random sampling method was applied within the three zones. The principle of stratification was that the vegetation of the area under investigation was divided up before samples are chosen on the basis of major and usually obvious variations within the habitat (Kent and Coker 1996). The reason for this method of stratification was to sample zones of vegetation subject to different gradients and management regimes.

The vegetation was sampled using nested quadrats set along line transects as described in Kent and Coker (1996). The transect lines were set in the three vegetation zones namely; restored zone, degraded zone and plantation zones. A total of 12 line transects, each measuring 100 m long were positioned in such a way that they ran from the bottom of the hill to the top, so as to sample different vegetation starata. Systematic sampling which involved the location of nested sampling points at regular intervals was employed (Kent and Coker, 1996). In each line transect, a series of nested plots were established in an alternating left and right as employed by Kasenene (1987) and Lejju (1999). A series of 15 × 15 m plots were set up at regular intervals of 20 m apart using a measuring tape. Within each plot of 15 × 15m, a series of nested quadrat measuring 10 × 10 m, followed by 5 × 5 m and 2 × 2 m were established to enumerate trees of different size classes that occupy different vegetation strata. Large tree size class measuring ≥ 15 cm dbh (1.3 m) were sampled in 15 × 15 m plot, followed by small trees (dbh 10 -< 15 cm) sampled in 10 m x 10 m plots. Poles (5 – <10 cm, dbh) and saplings (dbh 2 - <5 cm) were sampled in 5 x 5 m plot, whereas seedlings (< 2 cm) were sampled from 1 × 1 m plots.

Table 1. Species richness, R and Shannon Diversity Indices (H) of trees of different size-classes recorded in Restored, Degraded and plantation zones**.**

Study site	Diversity indices	Diameter size-classes (dbh)				
		Seedlings (<2 cm)	Sapling (2-< 5 cm)	Poles (5-<10 cm)	Small tree (10-<15 cm)	Large trees (≥15 cm)
Restored	R	12	12	6	4	1
	H	1.85	1.89	1.15	1.09	0.00
Degraded	R	12	12	7	8	1
	H	2.26	2.51	1.78	1.99	0.00
Plantation	R	10	7	1	0	0
	H	2.07	1.68	0.00	0.00	0.00

*R= Species richness, H = Diversity index.

Species diversity and richness

Plant species diversity was calculated from Shannon's diversity index, $H = -\sum p_i \log_e p_i$ where Pi = is the proportion of each species in the sample (Bibi and Ali, 2013). Species richness, R was calculated as measure of the number of species found in a sample or zone.

Important value index (IVI)

To obtain importance value index, the frequency, density, and dominance of each species was determined in each zone. Then, IVI was calculated as;

Importance value = Relative frequency + Relative density + Relative dominance

Where;
Relative frequency: Number of occurrences of one species as a percentage of the total number of occurrences of all species.
Relative density: Number of individuals of one species as a percentage of the total number of individuals of all species.
Relative basal area (dominance): Total basal area of one species as a percentage of the total basal area of all species.
Absolute density: This was determined by summing up the number of individuals found in each plot and divide by the number of plots. Average species density = (density in plot 1) + (density in plot 2) + (density in plot X) /total number of plots.

RESULTS

Species richness and diversity

Species richness and diversity indices of different diameter size classes in the three vegetation zones are presented in Table 1. The results show that in the restored area, species richness ranged from 1 species for large tree size class ≥ 15 cm dbh to 12 species for seedlings and poles (Table 1). Similarly in the degraded area, species richness ranged from 1 species for large trees to 12 species for seedlings and poles. However, in the plantation zone, the highest number of species (10) was recorded for seedlings and none for small trees and large trees.

The Shannon diversity index, H of restored zone was highest (1.89) in saplings (2-< 5 cm dbh**)** followed by seedlings (1.85) and lowest (0.00) in large trees (≥15 cm, dbh**)**, while in the degraded zone, the H^1 values ranged from 1.78 for poles (5-< 10 cm, dbh) to 2.51 for seedlings (<2 cm dbh). In the plantation zone the diversity index ranged from 1.68 to 2.07.

Among the three vegetation zones, the degraded zone is more diverse (2.51) for saplings than the restored (1.89) and plantation (1.68). Generally, the seedlings (dbh <2 cm) recorded the highest diversity indices, and large trees had the least diversity in all the three study sites.

Tree densities (No/ha) of different size classes

The log density stand curves of different size-classes in plantation, restored and degraded zones are presented in Figure 2. There was a general decrease in log density for all the tree size classes in all the three habitats from seedlings to large trees. In the restored and degraded areas, the log density decrease was gradual, while in the plantation zone, the log density decreased sharply to zero at poles.

Absolute density of tree species in different study zones

The absolute density (No/ha) of tree species recorded in degraded, restored and plantation zones are presented in Table 3. *Markhamia lutea* (had the highest density (1076/ha) in the restored zone followed by *Albizia adiathifolia* (705/ha) and *Olea europaea* subsp. *africana* (600/ha). Within the degraded zone, *Tetrochidium*

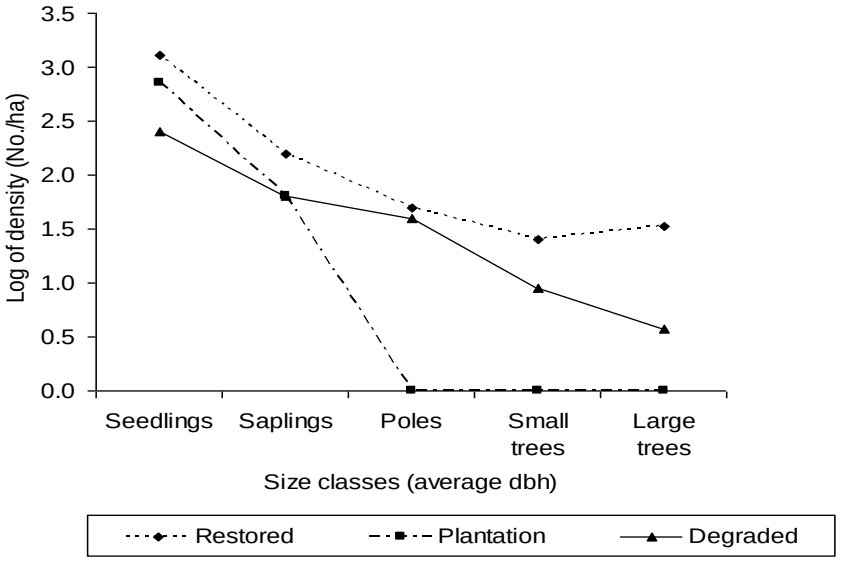

Figure 2. Species area curves showing a cumulative number of plant species recorded in the restored, degraded and plantation zones.

didymostemon had the highest density (64/ha) followed by *Senna didymobotrya* (957/ha) and *Cordia africana* (55/ha). In the plantation zone, *Olea europaea* subsp. *africana* had the highest density (190/ha) followed by *A. adiathifolia* (17/ha) and *Solanecio manii* (117/ha). Three species namely; *O. europaea* subsp. *african, A. adiathifolia* and *M. lutea* occurred in the three zones with *M. lutea* contributing the highest density (38/ha) in the restored zone, while *A. adiathifolia* had the least density (7/ha) recorded in the degraded zone. Generally the restored zone had the highest tree density compared to the plantation and degraded zones (H=17.12, df=2, P=0.000) (Table 2).

Principal component scatter diagram in Figure 3 was used to explain the species density in the restored, plantation and degraded zone. As you move towards the right hand side, there is less disturbance and hence high plant densities while as you move towards the left hand side, there is high disturbance and hence lower densities but many varieties of plant species.

Importance Value Indices (IVI) for tree species

Importance value indices (IVI) calculated from relative densities, relative frequency and relative dominance for all the tree species recorded in the natural, degraded and plantation zones are presented in Table 3. In restored zone, *O. europaea* subsp. *Africana* had the highest importance value (271.2) followed by *A. adiathifolia* (147.1) and *M. lutea* (105.4). Whereas in the degraded zone, *A. adiathifolia* had the highest IVI (127.1) followed by *Croton sylvaticus* (96.8) and *Cordia Africana* (50.3), while in the plantation, *O. europaea* subsp. *africana* had the highest IVI (222.1) followed by *A. adiathifolia* (66.5) and *M. lutea* (47.3).

DISCUSSION

The higher values of species richness recorded in the degraded area in comparison with restored and plantation zones are an indication of high levels of regeneration following disturbance in the degraded hills. The study also indicated that following disturbance, re-growth of new species, which are either from the soil seed store or are dispersed into the site from the outside, occurred efficiently.

Bazzaz (1984) stated that most disturbances create highly heterogeneous habitats that recruit different species and play out different growth scenarios. Some of the agents of disturbances in the study area included fires, overgrazing and cultivation and this caused the creation of gaps. Lamb (1990) found that forests are subject to a number of naturally occurring disturbances that produce a range of different sized gaps (spaces). This led to creation of space for new tree species.

The lower species richness observed in the restored zone compared to the degraded zone could be due to the slow regeneration rates of some species. Studies by Hooper et al. (2004) noted that fire significantly affected species composition and decreased species richness because most species had either their resprouting ability or seed germination inhibited by fire and this could be the case in the restored area. This is in agreement with studies done by Uhl et al. (1988) and Nepstad et al. (1990). Restoration in the area that begun 10 years back after several agents of disturbances, the zone consists of

Table 2. Absolute densities (No/ha) recorded in the restored, degraded and plantation zones.

Species	Restored Zone	Degraded Zone	Plantation zone
Olea europaea subsp. *Africana*	600	12	190
Albizia adiathifolia (Schumach.) W.F. Wight	705	7	162
Markhamia lutea (Benth.) K. Schum	1076	38	110
Syzygium cordatum Hochst.ex Krauss	112	-	76
Acacia hockii De Wild	46	-	-
Peddiea fischeri Engl.	219	-	-
Pittosporum spathicalyx De Wild.	129	-	45
Myriathus holstii Engl.	205	-	-
Bridelia micrantha(Hochst.) Baill	76	-	-
Solanecio manii (Hook.f.) C.Jeffery	217	-	117
Allophylus macrobotrys Gilg.	60	-	-
Olea welwitschii(Knobl.) Gilg& Schellenb	33	-	-
Sapium ellipticum(Hochst. Ex Krauss) Pax	-	31	-
Albizia coriaria Welw.ex Oliv	-	45	-
*Senna didymobotrya (*Fresen.)Irwin & Barneby	-	57	-
Antiaris toxicoria(Rump h.ex Pers.) Lesch.	-	-	29
Polyscias fulva(Hiern) Harms	-	-	21
Cyphomandra batacea F l. Neotrop.Monogr.	-	-	7
Macaranga kilimandscharica Pax	-	-	45
Senna bicapsularis(L.) Roxb	-	21	-
Maes lanceolata Forsk.	-	2	-
Albizia gumefera Welw.ex Oliv	-	26	-
Cordia Africana Burm.f.	-	55	-
Vernonia amygdalina Del.	-	52	-
Erythrina abyssinica Lam. Ex DC	-	48	-
Ficus natelensis Hochst.	-	17	-
Acanthus pubescens(Thomson ex Oliv.) Engl.	-	19	-
Tetrochidiumdidymostemon (Baill.) Pax & K.Hoffm.	-	64	-
Diospyros abyssinica(Hiern) F. White	-	48	-
Croton sylvaticus Hochst.	-	**43**	-
Ficus natelensis Hochst.		17	-
Acanthus pubescens(Thomson ex Oliv.) Eng	-	19	-
Tetrochidiumdidymostemon (Baill.) Pax & K.Hoffm	-	64	-
Diospyros abyssinica(Hiern) F. White	-	48	-
Croton sylvaticus Hochst.		43	
Total	**289.83**	**34.41**	**80.2**

mostly secondary species. Species regenerated from seeds but primary species owed their presence in regeneration to their ability to reproduce vegetatively. Some seeds require fires to break their dormancy and if the rains come soon after, this enables regeneration. Species richness was low in restored zone because some species like *O. europea* subsp. *africana* have a slow growth rate.

However, the low number of species obtained in the plantation zone could be attributed to suppression of indigenous trees by the eucalyptus trees. This agrees with results obtained by Lejju (1999) that eucalyptus suppresses the growth of native species, hence the reason for low species richness.

In general, the regeneration pattern of tree species varied in each study site and human disturbance could have influenced seed dispersal mechanism, fruiting, germination and regeneration of tree species.

The degraded zone was more diverse and showed higher equitability than other areas. The high diversity of indigenous tree species in the lower size classes (seedlings and saplings) for all the three study sites is an indicator of regeneration. Large size classes showed lower diversity and density indicating low survival rate of seedlings into the large size class. This is in agreement with the results obtained by Grubb (1977) and Lejju

Table 3. Importance value indices for tree species recorded in the restored, degraded and plantation zones.

Tree species	Importance value indices		
	Restored zone	Degraded zone	Plantation zone
Olea europaea subsp. africana	271.2	9.3	222.1
Albizia adiathifolia	147.1	127.1	66.5
Markhamia lutea	105.4	27.1	47.3
Syzygium cordatum	12.5	-	34.5
Acacia hockii	6.64	-	-
Peddiea fischeri	20.5	-	-
Pittos*porum spathicalyx*	13.5	-	27.1
Myriathus holstii	19.8	-	-
Bridelia micrantha	8.5	-	-
Solanecio manii	30.6	-	52.1
Allophylus macrobotrys	38.6	-	-
Olea welwitschii	25.7	-	-
Sapium ellipticum	-	35.0	-
Albizia coriaria	-	42.8	-
Senna didymobotrya	-	36.3	-
Antiaris toxicoria	-	-	8.2
Polyscias fulva	-	-	3.34
Cyphomandra batacea	-	-	28.7
Macaranga kilimandscharica	-	-	10.0
Senna bicapsularis	-	13.6	-
Maes lanceolata	-	10.9	-
Albizia gumefera	-	29.4	-
Cordia africana	-	50.3	-
Vernonia amygdalina	-	33.4	-
Erythrina abyssinica	-	62.9	-
Ficus natelensis	-	32.3	-
Acanthus pubescens	-	28.1	-
Tetrochidium didymostemon	-	38.4	-
Diospyros abyssinica	-	26.3	-
Croton sylvaticus	-	96.8	-

(1999) who pointed out that the younger size class is usually numerous compared to the older size class. This is due to the fact that mortality rate is high in early stages of life because of predation, desiccation and competition as well as removal by human activities.

Janzen and Vazquez-Yanes (1978) stated that on tropical mainland, more than 90% of all tree species have more than 50% of their seeds killed by animals and fungi between fruit set and seed germination. Some seeds land in places where the seedlings have no chance of survival and so a few may reach maturity. On the other hand, lower number of large trees recorded in the degraded area could probably be due to selective removal of some trees during harvesting, while the low diversity of large size class trees in the restored area could be due to dominance caused by some species.

Bawa (1983) pointed out that tree species in a tropical rainforest display much variation in timing, duration and frequency of flowering and this could be the case in Rwampara. Species vary considerably in duration of flowering which extends from a few days in some species to several months in others. Lower diversity of large size classes in the plantation zone could be attributed to suppression by eucalyptus and *Pinus patula* in the area. It could be that the gaps are small and so the shade intolerant species begin to die as soon as maturation starts.

Rwampara hilly areashave been influenced by human activities such as agriculture and fire. High abundance of some tree species suggests a form of dispersal and plant utilization. For instance, *O. europea* subsp. *africana, M. lutea and Tetrochidium didymostemon* were highly abundant in the restored, plantation and degraded zones respectively. Plants become established either from the

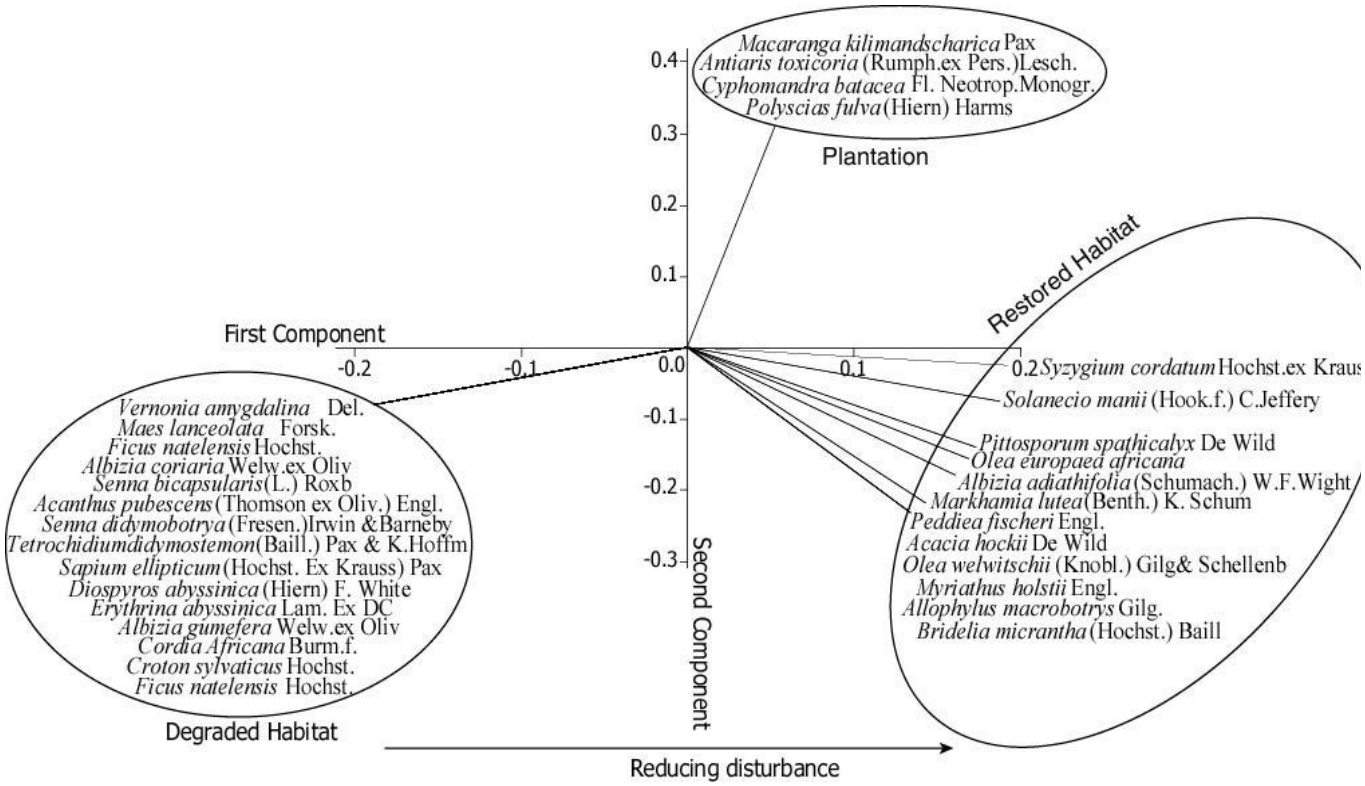

Figure 3. A principal component analysis (PCA) diagrams showing the absolute densities of plant species in the study area.

seedling pool, soil seed store, vegetative re-growth and dispersed seeds. *Olea europea subsp. africana* can regenerate from wildings and seedlings and *M. lutea* from wildings, seedlings and cuttings.

Several tree species like *Sampium ellipticum, M. lutea, Peddiea fischeri* and *Pittosporum spathicalyx*. had several seed or fruit dispersal mechanisms and they may also regenerate from coppice or root suckers apart from wildlings, direct sowing and seedlings.

O. europea subsp. africana and *Albizia adiathifolia* had the lowest densities in the degraded area compared to the restored and plantation areas. *Olea europea subsp*. *africana* is highly used by the local community for firewood, charcoal, medicine, poles, walking sticks, tool handles and environmental purposes such as soil conservation and this could be the reason why it is low in the degraded area. *Olea europea subsp. africana* is also a slow growing tree so once it is harvested; it takes long to re-grow **(**Katende et al., 1995). Currently the restored and plantation zones are restricted from harvesting.

Maesa lanceolata had the lowest density in the degraded area than other species yet it is a fast growing tree. This could be attributed to the rate it is harvested since the local people use it to treat diseases like ulcers, diarrhoea and febrile convulsions in children. Some species like *Olea europea subsp. africana* and *Peddiea fischeri* are slow growing yet are highly diverse in restored and plantation zones. This could be because both restored and plantation zones are restricted from harvesting, hence allowing them time to regenerate.

Polyscias fulva had the lowest density in the plantation zone yet it is a fast growing tree species. The reason for this is that it is highly harvested for firewood, timber, and bee hive making. *Polyscias fulva* is a light demanding species (Omeja et al., 2001) but being in the plantation zone it is shedded and so its growth is suppressed.

Vegetation sampling from the study indicated a high number of indigenous tree species in the lower size-class in all the study sites. Large size class trees had low densities and this could be due to the low survival rate of seedlings into large trees. Hartshorn (1978) and Schulz (1960) have shown that size class distribution of tree diameters of tropical forests show a reverse J-shape or negative exponential distribution which is in agreement with the results of this study.

The high densities of seedlings of exotic species are an indication of higher initial recruitment in the lower size class (Richards, 1966). The fewer numbers of large size-class could be due to the high rate of larger tree harvesting by local people. Lejju (1999) also observed a similar trend of size class distribution in Mgahinga Gorilla National Park. The high densities of seedlings in all the three zones indicated the importance of the presence of propagules in determining the composition of early

successional communities and their establishment.

Conclusion

The regeneration pattern of the indigenous tree species in Rwampara hills varied in each study site because of human disturbance which could have influenced seed dispersal mechanism, fruiting, germination and regeneration of tree species. The indigenous and exotic trees are very essential to the rural people and this was recognized from the resources harvested.

Conflict of interests

The authors did not declare any conflict of interest.

ACKNOWLEDGEMENTS

I thank my supervisor Dr Bunny Julius Lejju for the tireless guidance and support he gave me throughout my study. I am also very grateful to NEMA- Mbarara branch for the assistance rendered during fieldwork.

A vote of thanks goes to my research assistants in Rwampara who assisted me throughout data collection and necessary information to complete the study. I also thank the staff of Biology Department, Mbarara University of Science and Technology.

My sincere thanks go to Nalwanga Rose Mary who guided me in the review of this document.

Lastly, my thanks go to my husband, my parents, brothers, sisters, relatives and friends who gave financial and moral support towards the completion of this study.

REFERENCES

Bawa KS (1983). Patterns of flowering in tropical plants. In: Jones, C.E & Little, R.J (eds). Handbook of experimental pollination Biology. (Van Nostrand and Reinhold Co. New York). pp. 394-410.

Bazzaz FA (1984). Regeneration of Tropical forests: Physiological responses of pioneer and secondary species. In: Gomez-Pompa, A., Whitmore, T.C. & Hadley, M. (eds.). Rainforest Regeneration and management (Vol 6), New Jersey, USA.

Bibi F, Ali Z (2013). Measurement of diversity indices of avian communities at Taunsa barrage wildlife sanctuary, Pakistan. The J. Animal & Plant Sci. 23(2):469-474.

Grubb PJ (1977). The maintenance of species richness in Plant communities: The Importance of the regeneration niche. Biol. Rev. 52: 107 – 145.

Hartshorn GS (1978). Tree falls and tropical forest dynamics. In: P.B. Tomlinson & M. H. Zimmermannn (eds), Tropical trees as Living systems. Cambridge University Press, Cambridge. pp. 617-638.

Hooper E, Legendre P, Condit R (2004) Factors affecting community composition of forest regeneration in deforested, abandoned land in Panama. Ecology 85(12):3313-3326.

Janzen DH, Vazquez-Yanes C (1978). Aspects of Tropical seed ecology of relevance to management of tropical forested wild lands. In. A Gomez-Pompa, T.C. Whitmore and M. Hadley(eds.), Rain Forest Regeneration and Management, UNESCO, Paris. pp. 137-157.

Kasenene JM (1987). The influence of selective logging, felling Intensity and gap size on the regeneration of a tropical moist forest in Kibale forest reserve, Uganda. PhD dissertation, Michigan State University.

Katende AB, Birnie A, Tengrias BO (1995). Useful trees and shrubs for Uganda. Identification propagation & management for agriculture & Pastoral communities. Regional Soil Conservation Unit. Nairobi, Kenya.

Kent M, Coker P (1996). Vegetation Description and Analysis. A practical approach, John Wiley and Sons Ltd.

Lamb D (1990). Exploiting the Tropical Rainforest: An account of pulpwood logging in Papua New Guinea, University of Queensland, Australia.

Lejju BJ (1999). An assessment of the status of exotic plant species and Natural vegetation types of Mgahinga Gorilla National Park South Western Uganda, Msc Dissertation, Makerere University, Kampala.

Nepstad D, Uhl C, Serrao EA (1990). Surmounting barriers to forest regeneration in abandoned, highy degraded pastures: a case study from Paragominas, Para´, Brazil.

Olson J, Berry L (2003). Land degradation in Uganda: its extent and impact. Kampala, Uganda.

Omeja P, Obua J, Cunningham AB (2001) Regeneration, density and size class distribution of tree species used for drum making in Central Uganda. Makerere University, Kampala, Uganda

Richards PW (1966). The tropical Rain forest. Cambridge University Press, Cambridge.

Schulz JP (1960). Ecological studies on rainforest in northern suriname. Meded. Bot. Herb. Rijks. Univ. Utrecht 163:1-267.

Uhl C, Buschbacher R, Serra˜o EAS (1988). Abandoned pastures in eastern Amazonia. I. Patterns of plant succession. J. Ecol. 76:663-681.

Journal of Ecology and The Natural Environment

Related Journals Published by Academic Journals

- *African Journal of Environmental Science and Technology*
- *International Journal of Biodiversity and Conservation*
- *Journal of Yeast and Fungal Research*
- *Journal of Entomology and Nematology*
- *African Journal of Biology and Environment*
- *Journal of Evolutionary Biology Research*

academicJournals