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Perception on fishery trends in Lake Victoria.

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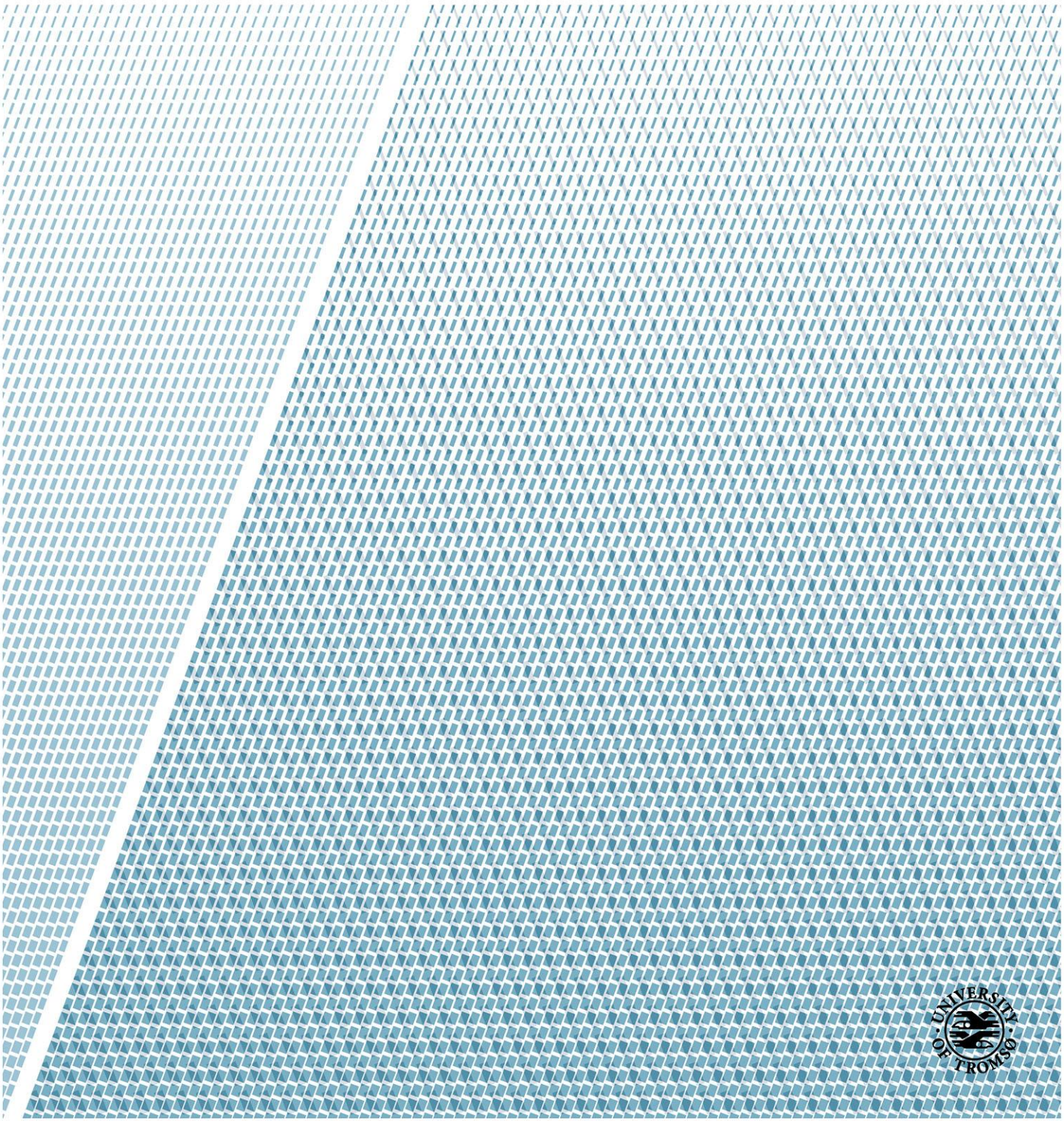
Master thesis in International Fisheries management. NOVEMBER, 2014



Acknowledgement

This work would not have been possible without the assistance and cooperation of many people to whom I am deeply indebted. I thank my supervisor, Jorge Santos for his guidance, encouragement, reading and above all tolerance, which have led to the accomplishment of this study. My heartfelt thanks go to the Norwegian government. I am very grateful for the financial support extended to me for the period of two years. I am also supremely grateful to Jeppe Kolding for the inside knowledge and support in providing data. I also wish to extend my sincere gratitude to all those who helped me during the field study especially NaFRRI management for their great support.

Abstract

Lake Victoria in East Africa provides fishery resources to fishing communities and governments. The dynamics of these fish resources are variable, complex and poorly understood. The perspectives of different scientists, users and stakeholders are in disagreements on the state of Lake Victoria's ecosystem and fisheries, thus creating a problem to constructive discussion regarding the fisheries future. In this study we looked at the social-ecological description of Lake Victoria's system to find out the possible drivers influencing perceptions on changing fish catches and declining stocks. To understand the complexity of the fishery we focused on literature analysis and stakeholder analysis through networks based four themes perceived as drivers (Overfishing, Ecological changes, Environmental changes and Management issues) to find out the relationships among scientist and stakeholders. In addition, a description of the fishery in form of most utilized fishery trends (past and present) and how they have been applied and interpreted by different authors to define the state of fisheries in Lake Victoria. The findings from literature analysis indicate that authors have relationships to most other authors and perceptions in the network, no matter their preference of the perceived drivers. While the stakeholder analysis shows a large number of linkages among the different respondents, confirming the overall homogeneous nature of the responses with regard to the different themes perceived as possible drivers influencing fish catches in Lake Victoria.

Table of contents

List of tables / List of figures / List of plates

List of Tables

List of Figures

List of Plates

1. Introduction

Lake Victoria in East Africa supports a fishing industry for both export and local consumption. The fishery is estimated to produce 1 million tons per annum of which 66.6% is from the Tanzanian part of lake, followed by 18.6% Uganda and 14.8% Kenya (Regional Catch Assessment Survey Synthesis Report 2005-2011). Nowadays, the fishery is predominantly based on three commercial species of Nile perch (*Lates niloticus*), Nile tilapia (*Oreochromis niloticus*) and dagaa *Restrineobola argentea*) (LVFO, 2013). The fishery provides food security, and supports the livelihoods of approximately 3 million people (LVFO, 2009). According to LVFO (2013), there are over 200,000 fishers (20% Kenya, 31% Uganda and 49% Tanzania) and about 600,000 people involved in fish processing and fish meal industries around the lake.

The state of the fishery is of a major concern to the riparian states and there has been a general view that fish catches are declining and that the fishery may be in danger of collapse (LVFO, 2008). The impeding collapse of the fishery was first reported by the factories that process Nile perch (Mkumbo and Marshal, 2014), there were about 15 factories in 1990, rising to 35 in 2005, their numbers fell to 26 in 2008 but increased again to 30 by 2011 (LVFO, 2011). This issue of declining fish catches was recently stressed by the local and international media such as the Nation Media group (NTV Uganda and Kenya), CCTV Africa, Citizen TV, Aljazeera Africa. For instance the New Vision publishing group produced a series of commentaries in 2013 on overfishing and environmental degradation themed “Save Lake Victoria” and further emphasized that Lake Victoria fish stocks had declined. Since then, the state of fisheries in Lake Victoria has raised questions and caused debates between scientists (Munyaho *et al*., 2014), fisheries managers, and fishers and further created tension among the general public and governments that depend on the fishery.

Lake Victoria is faced with mixed understandings and different views about fishery development by both scientist, fisheries managers and the general population on some fisheries aspects hence a need to find out if catches are really declining or not? And

what do we mean by ‘catch’? And secondly, are the main threats overfishing or environmental changes?

It is hypothesized that these different opinions about the state of the fisheries, of the lake as an ecosystem, or, in a broader approach, of the whole ecological and social system, relates to the research interests or understanding of the stakeholders or international experts. A detailed analysis of the background, causes, extent and consequences of different perceptions does not seem to have been performed earlier. Of fundamental interest to such analysis is an understanding of what experience, scientific background or data have most influenced the different perceptions. Can the different perceptions be traced back to the selective utilization of different data; a case of information bias? Alternatively, could it be that different people attach different interpretations to the same information or data; a perception bias?

1.2 The Goal of the study

The goal of this study is to scrutinize different theories and perceptions surrounding Lake Victoria and its fisheries. The analysis used arguments and data from the scientific ecological literature and stakeholders. The aim is to shed light on and understanding the different data/information on the state of fisheries in Lake Victoria. This study puts together the most recent published information as well as stakeholder interviews to understand the different factors, changes and processes affecting the fishery and provide an analysis on the current state of the Lake Victoria.

1.3 Research questions

In order to achieve the goals of this study, the following questions were looked at using data analysis of different conclusions, convictions and perceptions.

1. Are perceptions unanimous among all the stakeholders and scientists?
2. Is the use of data/information selective? Or are perceptions selective?
3. Is the situation in Lake Victoria really catastrophic or open to different interpretation?

4. What are the consequences of different perceptions to management?

1.4 Significance of the study

This study assesses the current status and fisheries exploitation trends based on literatures and stakeholders' perceptions, and confronts these perceptions with some of the most used and recent publications from the lake. The different perceptions may provide enlightenment on how management strategies and priorities should be set in Lake Victoria.

2. The Lake Victoria issues

2.1 Geography and Socio-economy

Lake Victoria is Africa's largest lake, and the world's biggest tropical lake, with a total surface area of 68,800 km^2 and water of volume of 2,760 km^3. The lake has catchment area of 193,000 km^2 which extends to Rwanda and Burundi. The lake is shared by Tanzania (51%), Uganda (43%) and Kenya (6%). Its shoreline is approximately 3,450 km long, whereby 33% is in Tanzania; 51% in Uganda and 16% in Kenya (LVFO, 2013).

Fig. 1 Map of Lake Victoria basin (Kayombo & Jorgensen, 2005).

Lake Victoria is a shallow lake with an average depth of 40 m (Awange & Onganga, 2006), and a maximum depth of 80m (Odada & Olago, 2006). Precipitation is characterized by two main seasons, a dry and a rainy season (Mkumbo, 2002). Annual water temperature variations found in Lake Victoria are small, with averages of 24^0 C surface and 23^0 C on deeper waters. Similarly, the annual air temperature variation reflects the mild climate, not exceeding 25^0 C or less than 19^0 C (Awange & Onganga, 2006). Lake Victoria is considered a closed system (Bootsma & Hecky, 1993) and the variation of limnological parameters reflect a season pattern; variations on the temperature, dissolved oxygen, depths of the thermo and oxycline, chlorophyll *a*, conductivity or water transparency are influenced by the hydrological factors (Mkumbo, 2002).

Lake Victoria fisheries production has an estimated value of more than $550 million and an export value of $260 million (Regional Catch Assessment Survey Synthesis Report 2005-2011). In terms of the national GDP of the bordering countries the fishery contributes to 2% for Kenya, and 3% for both Tanzania and Uganda (World Bank, 2009). In addition, governments earn revenue through licensing fish-processing plants, registration of boats, and issuing fish-dealers licenses and are, therefore, critically important to the economies of the East African countries (LVFO, 2008).

The fishery was commercially based on tilapine specie (i.e. in the tilapia family) targeting local and regional markets before the introduction of the Nile perch in the late 50s and early 60s. However, the fishery became more profitable during the Nile perch boom periods of 80s and 90s to date. The Nile perch fishery has attracted many fishers to the Lake, from 12,000 in the 1980s to 205,249 in 2012 (LVFO, 2013). The fisheries have developed two alternative processing methods and trade markets; the production of fresh and frozen Nile perch has fed export markets; the local domestic industry trades or processes tilapia and dagaa, with fishmeal industry dependent on dagaa and freshwater shrimp (Mkumbo *et al*., 2002; Njiru *et al*., 2005; Budeba and Cowx, 2007).

The fisheries have brought substantial direct and indirect benefits to the region, allowing economic development and improved livelihoods for many people associated with the sector (Crean & Geheb, 2001). Despite the socio-economic incentives derived from the lake, substantial higher incomes have concentrated among a smaller proportion of participants who are involved in the Nile perch fishery (Abila 2000; Yongo *et al*., 2005; Geheb *et al*. 2007). The fishers and local fish mongers have slowly been driven out of fish pricing, marketing and processing activities, with fish factories and their agents tightly controlling these activities, especially in the export Nile perch fishery (Abila, 2000). This has forced some fishers to shift their efforts to the less commercially valued species aimed at the domestic market, such as dagaa, Nile tilapia and haplochromines to earn a living (Abila, 2000).

Four major threats or issues have been generally addressed in the scientific literature with regard to the state of the Lake and its fisheries: ecosystem change, eutrophication, overfishing, and management failure. Because these main topics form the backbone of the present work, a short review of the issues considered is made here.

2.2 Ecosystem change in Lake Victoria

Originally, Lake Victoria supported a multi-species fishery dominated by tilapiine cichlids *Oreochromis esculentus* and *O. variabilis* and an estimated 500 species of the haplochromine cichlid family (Greenwood, 1966; Witte *et al*, 1992). Other species included the native cyprinid, *Rastrineobola argentea*, *Protopterus aethiopicus*, *Bagrus docmak Clarias gariepinus* various *Barbus* species, mormyrid species and *Schilbe intermedius* (Ohywa-0gutu, 1990; Goudswaard *et al*., 2002). In an effort to increase production and add value to the fisheries, the Nile perch (*Lates niloticus*) and Nile tilapia (*oreochromis niloticus*) were deliberately introduced into the fishery from their native ecosystems of Lake Turkan and Lake Albert to convert the haplochromine species into suitable fish for the Nile perch, or to boost the tilapia fishery in case of Nile tilapia (Ogutu-Ohwayo, 1993).

In the early stages of the Nile perch population growth, haplochromines species comprised of about 90% of the Nile perch diet (Ogutu-Ohwayo, 1994), and as a result, the haplochromine stocks declined rapidly from 80% to 1% of the stock biomass composition in the late 1980s (Ogutu-Ohwayo, 1990; Njiru *et al*., 2005) as the Nile perch increased (Ogutu-Ohwayo, 1994). Thus, the Nile perch is believed to have caused the observed mass extinction of haplochromine species (Kaufman, 1992).

The invasion and rapid spread of the alien water hyacinth, *Eichhornia crassipes,* may have affected the lake ecologically by blocking sun light hence causing anoxia, but the major effect was the hindrance of fishing activities as fishers would be stranded and left in the middle of the lake without passage. Water hyacinth first appeared in Lake Victoria in 1989 (Twongo *et al*., 1995) and later disappeared during 1990s after mechanical and manual removal, changes in ecological succession and the application of the weevils *Neochetina eichhorniae* and *N. bruchi* for biological control (Williams *et al*., 2005). More so, the clearance of swamps for human settlement and agriculture around Lake Victoria has reduced marginal vegetation and this has negatively affected recruitment and survival of fish species which depend on the fringing zones during their early stages of development (Njiru *et al*., 2006). It has, for instance, been claimed that the disappearance of water lilies and other aquatic weeds reduced the spawning grounds for *O. esculentus*, while decline of plants such as *Potamogeton pectinatus* and *Ceratophylum demersum* favoured by *T. zillii* drastically reduced its feeding niche (Welcomme, 1967). With regard to future perspectives, the effects of climate change are unpredictable and recent climate models suggest that East Africa will experience increased wet season rainfall with runoff and fresh water availability (Doherty *et al*., 2010). Although this seems beneficial to fisheries, increased rainfall coupled with deforestation and agriculture could lead to severe erosion, siltation, and nutrient runoff, with little beneficial effect to fisheries (Njiru *et al*., 2014).

2.3 Eutrophication

Lake Victoria has experienced increases in subsistence agricultural growth,

deforestation, municipal and industrial effluents, and human encroachment on the shoreline has given rise to historically unprecedented nutrient loadings into the lake (Hecky 1993; Vershuren *et al*., 2002). With current estimates projecting a doubling of the regional human population to 53 million around the lake by the year 2020 (United Nations, 1995), further degradation of the Lake Victoria ecosystem is likely to continue unless effective nutrient management strategies are implemented on a multinational and basin-wide scale.

Lake Victoria has faced increased algal productivity with a corresponding drop in water transparency which was attributed to an increase in anthropogenic nutrient loads or changes in nutrient dynamics within the lake (Ogutu- Ohwayo, 1990). Loss of detritivorous haplochromines is likely to have accelerated an algal production, exacerbating eutrophication, loss of transparency, and deep water hypoxia (Goldschmidt *et al*., 1993). Even though Nile perch are widely considered the main cause for the decline of their main prey, it is generally acknowledged that haplochromine populations were already declining, likely in response to fishing and perhaps also increased eutrophication and the subsequent deterioration of the lake's water quality (Witte *et al*., 1992).

Eutrophication induced loss of deep water oxygen started in the early 1960s, and may have contributed to the 1980s collapse of indigenous fish stocks by eliminating suitable habitats for certain deep-water cichlids (Ogutu-Ohwayo, 1990). Eutrophication has increased over the last century (Verschuren *et al*., 2002), and manifested itself in the presence of more widespread and longer lasting anoxia, fish-kills from the sudden mixing of anoxic water, as well as in the invasion of the introduced water hyacinth in the 1990s (Hecky *et al*., 2010).

Nutrient enrichment of the lake has led to pronounced blooms of algae especially of the toxic blue-greens (Lungayia *et al*., 2000; Mugidde *et al*., 2005) which have led to reduction in dissolved oxygen, at times dipping below 1.9 mgl-1, a level considered

lethal to tolerant cichlid fishes (Mhlanga *et al*., 2006). There has been a loss of about 30-50% of the oxygenated waters volume in Lake Victoria since the 1960s, which has reduced the fish habitat (Mugidde *et al*., 2005). Low dissolved oxygen concentrations and probably phyto-toxins contributed to occasional fish mortality observed in the Nyanza Gulf of Lake Victoria (Ochumba, 1990).

Furthermore, increased stability of stratification, together with higher organic sedimentation to the hypolimnion, has significantly augmented the volume of seasonally anoxic water (Hecky *et al*., 1994) and caused loss of fish habitat and a shift in the benthic invertebrate community toward anoxia-tolerant species (Verschuren *et al*., 2002). Evidence of increasing algal abundance (Hecky and Bugenyi, 1992; Mugidde, 1993) and fish kills raises the possibility of declining oxygen concentrations in the deeper water of the lake. The focus of many discussions has been on the dramatic ecosystem alterations caused by food web changes from ‘‘top-down’’ predation by the introduced Nile perch and overfishing (Goudswaard *et al*., 2008). There is however, a strong evidence that the increased nutrient loading results in a ‘‘bottom-up’’ effect and changes the phytoplankton productivity (Mugidde, 1993; Kolding *et al*., 2008) and community structure (Kling *et al*., 2001).

2.4 Overfishing

The problem of overfishing in Lake Victoria was mentioned as early as 1920s when the first fishery survey was conducted by Graham in 1927-1928 (Kolding *et al*., 2008). The introduction of gill-nets of 5 inch mesh size was believed to have had severe impacts on the Tilapiine stocks in some parts of the lake (Graham, 1929). Commercial fishing on tilapia started when the railroad arrived in Kisumu (Vershuren *et al*., 2002) in the early 20^{th} century (1901). Prior to the Nile perch introduction, Lake Victoria fishery was composed of the native tilapia *(Oreochromis esculentus and Oreochromis variabilis)* (Ogutu- Ohwayo, 1990). There was however, a localized decrease in individual catches in the Winam Gulf of Kenya (Graham, 1929), and may have prompted the introduction of Nile tilapia *(Oreochromis niloticus)* and other tilapiine

species to boost fisheries productivity (Kudhongania and Chitamwebwa, 1995). Overfishing was again mentioned when Ray Beverton visited the lake in 1957 (Beverton, 1959).

The native species were exploited using rudimentary gears such as papyrus seine nets, basket traps, harpoons and hooks (Graham 1929, Muhoozi, 2002); however, with the introduction of nylon gill nets and outboard engines, fishing became efficient which led to a decline in the native species.

Since the mid 1980s, commercial fishing in Lake Victoria has been based on Nile Perch, Nile Tilapia and Dagaa which together make up 85-90% of the catch (Fig 10). The Nile perch boom in the 1980s led to increased exploitation which had a significant impact on societies around the fishery with increased incomes as a result of the high demand from European markets (Balirwa, 2007). The high demand has attracted huge infrastructural growth in form of fish processing plants that has led to an increase in human population and further exerted fishing pressure on the Nile perch (Barilwa, 2007).

The artisanal fishery has developed with multiple types of fishing boats with both propelled and outboard motors which carry a variety of fishing gears, some of which target particular species while others are more general in their selectivity and catch more than one species (LVFO, 2013). The number of fishers has increased from 129,000, with 43,000 boats, in 2000 to 200,000 fishers with 70,000 boats in 2012 (Fig 14). Furthermore, increased use of some non selective gears especially monofilament nets, small mesh-sized multifilament gillnet, beach seine nets and mosquito nets are perceived to negatively influence fish catches (LVFO, 2013; Njiru *et al*., 2014). The recent frame survey by LVFO in 2013, reported an increase in the use of gillnets [multifilament] in the Lake from 650 652 in 2000, to 1 032 948 in 2012.

2.5 Fisheries management in Lake Victoria

The modern management of Lake Victoria dates back to 1908, the year in which the

Fish Protection Ordinance was enacted (Geheb, 1997). The first fish stock assessment in Lake Victoria was conducted in late 1920 by Graham, in 1929, and the second assessment in 1957 by Beverton (Kolding *et al*., 2014). The assessments recommended at regulating the minimum limit of mesh sizes. In 1947, the Lake Victoria Fisheries Services was formed to enforce fisheries laws and regulations (LVFO, 2001). This was later followed East Africa Fresh Water Fisheries Research Organization (EAFFRO) in 1960, which was disbanded when EAC was dissolved in 1977, and later resurrected as the Lake Victoria Fisheries Organization (LVFO) in the 1994 (Fig 2).

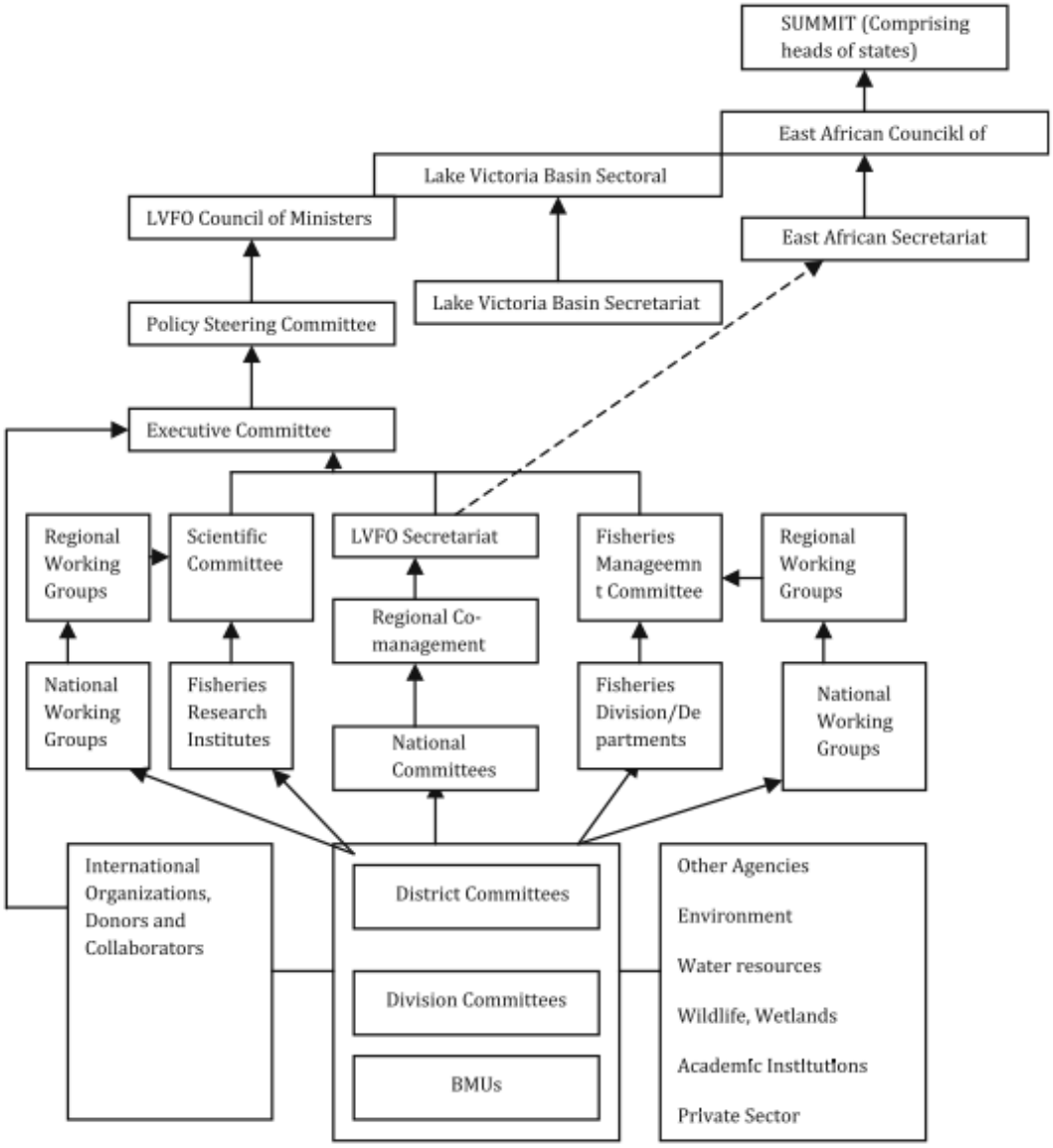


Fig. 2 Management structure of Lake Victoria (LVFO, 2001)

LVFO was created to foster cooperation and collaboration in the management, development and utilization of fisheries in the lake, as well as coordinate research and harmonize management regulations. LVFO is central to the development of coordinated regional activities such as fisheries management plan, regional plans on curbing illegal fishing, unregulated and unreported fishing, fishing capacity and other co-management approaches (LVFO, 2001). LVFO also brings together fisheries departments, national fisheries research institutions and development partners. The Beach Management Units and district fisheries councils are responsible for the harmonious management of the landing sites and enforcement of the fisheries policies at local levels.

The Lake Victoria fisheries management (Fig 2) allows, in theory at least, a bottom-up approach decision making and implementation policies through the decentralized BMUs at the landing sites (LVFO, 2001). However, fisheries management responsibilities still lies within the Ministry of Agriculture, livestock and fisheries in the case of Uganda, Ministry of Natural Resources and Tourism in Tanzania and the Ministry of Agriculture and Rural Development in Kenya that have an upper hand in policy enforcement.

The status of Lake Victoria fisheries is of a major concern to management authorities especially for the Nile perch fishery which is of high economic importance to the riparian states (Balirwa, 2007). The current fisheries management measures only focus on fishing effort of specific species such as Nile perch (Njiru *et al*., 2014). More so, the co-management in form of Beach management unit has failed to live up to its expectations as BMU members are unable to conduct fisheries management activities due to unclear relationships with the higher levels of governance (Lawrence, 2013). The fisheries regime in Lake Victoria has remained open access with unlimited entry and the current management measures seem to be ineffective as non recommended fishing gears are on the raise (LVFO, 2013).

3 Materials and Methods

3.1 Data Collection

To answer the research questions (section 1.3), data were obtained from stakeholder analysis, literature analysis and fishery data series. Stakeholder analysis used field study interviews while literature reviews and fishery data looked at published literature and official statistics respectively. The field study was primarily to capture different views from stakeholders on the current state of the lake and its fisheries particularly on overfishing, environmental changes (eutrophication), ecological changes and fisheries management. The field study was conducted in Uganda and included fishers, fisheries researchers, government fisheries officials, fish dealers, conservationists and journalists.

Secondary data was extracted from the related fishery reports from Lake Victoria Fisheries Organization, published journal articles and other forms of publications, as indicated in the respective contexts.

3.1.1 Literature analysis

The aim of literature analysis was to find a relationship on the current issues surrounding Lake Victoria as perceived and interpreted by different international and local scientists. The literature analysis included systematic reviewing of recent literature (peer-reviewed works) on Lake Victoria. Keywords used in the electronic search included “Lake Victoria”, “Eutrophication”, “Overfishing”, “Ecological changes” and “Management”. These were the priority themes that would encompass much of the perceptions on the state of the fisheries and the ecology of Lake Victoria. Searches were performed in Google Scholar, and only papers published later than the year 2000 and key previous papers that have been frequently cited, were retained for further analysis. To find suitable articles/information under each theme, papers were solely filtered by number of citations received and year of publication. The number of citations was interpreted to indicate the relevance of the article under a particular

theme. A total of 50 most cited and recent articles were selected (Appendix list), and each paper was read and analyzed to judge the focus given by authors to each theme. This was followed by a scoring of the articles according to each of the four themes. New themes raised were often possible to be accommodated within each of the four original categories. For instance, climate change was accommodated under environmental changes (eutrophication) as an influencing factor in the increasing nutrient loads into the lake (Hecky *et al*., 1994).

The literature was perused by only one reader and scored according to the weight that authors gave to each of the four themes identified as the most suitable descriptors: overfishing, eutrophication, ecological changes and management issues. A subjective scale (0-3) was used to classify preference for each topic: 3- Very strong preference, 2- Mentioned as possible secondary cause, 1- Mentioned, 0- Rare or not mentioned at all. The scores given to each article were used to weight the networks/relationships and expected to give a more fine detail of analysis than a simple binary classification (Brick, 2004). For comparison, a second analysis was performed using only binary variables. This was obtained by re-coding all variables with scores less than 3 to zero, emphasizing thereby the main perception of each author(s).

3.1.2 Stakeholder analysis

Stakeholder analysis is a process of systematically gathering and analyzing qualitative information to determine whose interests should be taken into account when developing and/or implementing a program (Schmeer, 1999). Stakeholder analysis can be used to identify the key actors and assess their knowledge, interests, positions, alliances and importance for the issue or project. This information can be used to provide inputs for other analyses such as developing action plans, guide a participatory and consensus-building process (Schmeer, 1999).

According to the World Bank Group (2001), stakeholders are actors with vested interests and can be individuals, organizations, or unorganized groups. These could be

donors, political actors, interest groups, private organizations, NGOs, user/consumers. In the present work, the stakeholders in the fisheries of Lake Victoria were considered to be fishers, fisheries researchers and managers, exporters and factory owners, fisheries conservationists and media houses. These stakeholders involved 6 women from the fisheries research and managers group [3 senior fisheries researchers from LVFO and National fisheries resources research institute, 2 fisheries inspectors from the fisheries department, Ministry of Agriculture, animal and fisheries and 1 lecturer from department of zoology, Makerere University]. The remaining stakeholders were men as shown in the group categories (Table 1).

A purposive sampling method was used in the selection of the stakeholders. Purposive sampling is based on the knowledge of a population and the purpose of the study. It's a form of non-probability sampling where decisions regarding participants to be included in the sample are taken by the researcher, based upon a variety of criteria which may include specialist knowledge of the research issue, or capacity and willingness to participate in the research (Oliver, 2006). All the respondents had knowledge in fisheries and environmental related issues.

The main aim of the stakeholder analysis was to get first hand information on the current issues surrounding Lake Victoria. In-depth interviews were conducted. According to Boyce and Palena (2006), in-depth interviews involve conducting intensive individual interviews to explore their perspectives on a particular idea, program, or situation. In-depth interviews were preferred because they provide much detailed information by offering a complete picture on most of the issues from a small number of respondents.

Stakeholders from different groups with knowledge on the current issues surrounding the lake were identified to be interviewed based on their level of involvement in the lake and fishery. An interview guide was developed with open ended questions and administered to the respondents (Appendix list). Open ended questions allowed

respondents to express their views and no time limit was set. However, questions were designed to keep the interview process in certain topics.

The respondents were clustered into six groups depending on their working environments and area of interest. Stakeholder groups included; Fishers and fish mongers; Fishers' leaders [BMU members and Association of fishers and lake users]; Fisheries officials [managers and fisheries researchers]; Fisheries conservation officers and Environmentalists; Exporters Associations and Factory Owners, and Media groups. To begin with, the different groups were assumed to have homogeneous perceptions given their physical proximity and working conditions. For instance fishers and BMU members are located at landing sites and have similar interests while the rest of the stakeholders tend to have interests that are within their work assignments. Stakeholders' perceptions were summarized in tables per stakeholder group under the following themes; overfishing, environmental degradation, ecological changes and management issues.

Table 1 The number of stakeholders interviewed.

Category	**Composition**	**Number**
Fishers	Fishers and fish mongers	10
Fishers' leaders	BMUs	8
	Association of fishers and lake users	1
Fisheries officials	Ministry of Agriculture, Animal industry and Fisheries	2
	National Fisheries resources and research institute	2
	Lake Victoria Fisheries Organization	2
	Depart of Zoology, Makerere University	1
	District fisheries officers	2
NGO (conservation officer) and Environmentalists	Uganda Fisheries and Fish Conservation association	1
	Ministry of water and Environment	2
Factory owners and exporters' Association	Association of Fish Processors and Exporter	1
	Karmic Foods Uganda Limited	1
Media Groups	New Vision Publishing Group	1
Total		**34**

The available time to perform the field work was one month (24 July- 28 August, 2013) and there were also limitations with regard to resources that constrained travel distance and time. Thus the geographical coverage owing to the limited time and resources, interviews on fishers and their leaders (BMUs) were conducted in four landing sites of Ggaba-Kampala district, Gola-Wakiso district, Massese-Jinja district, and Katosi- Mukono district in Uganda as indicated in figure 3.

Fig. 3 Map of Uganda showing administrative points of data collection (United Nations maps, http://www.ugandamission.net/aboutug/map1.html 20.07.2014).

At every landing site visited, the BMU chairperson would be interviewed first and later help or guide in the next interviews. The interviews were conducted in Luganda

language which in commonly used by fishers in Uganda. The rest of the groups were visited at their respective work places after making an appointment.

Plate 1 Katosi landing site - Mukono district, Uganda

Plate 2 Ggaba landing site - Kampala, Uganda

3.2 Data Analysis

Stakeholders' perceptions were analyzed using network analysis tools which looked at individuals rather than groups. The data consisted of 34 respondents' impressions about issues affecting the lake and fisheries, and were grouped into four categories. The analysis was weighed by the score given to each of the four themes (Ecological

change, Environmental changes, Overfishing, and Management issues). The following criteria were used to score the frequency of citation of any particular theme; 3- Most frequent, 2-Frequent, 1-Mentioned, 0-Not mentioned. A network analysis of the individual data was presented in thematic networks and network plots to show the linkages between respondents, and whether or not there was an association between the professional group of the respondent and the related theme of interest.

Network analysis is an interdisciplinary methodology developed mainly by sociologists and researchers in social psychology in the 1960s and 1970s (Scott, 2000). Network analysis is a statistical analysis of networks of relations among actors usually represented graphically in form of nodes and edges (Wasserman and Faust, 1994). A network is a set of nodes connected by a set of ties, the edges. The nodes can be anything; individuals, teams, organizations, concepts, patents. In a network, ties connect pairs of nodes and can be directed [potentially one-directional] or undirected [as in being physically proximate] and can be dichotomous [present or absent] or weighted [measured on a scale, as in strength of friendship] (Allen, 1983). All ties are weighted or have values, even dichotomous relations have binary values [either the tie exist and is assigned a value of 1 or it doesn't and is assigned a value of 0] (Allen, 1983).

According to Kaid (1989), network analysis follows similar analytical processes of formulating the research questions to be answered, selecting the sample to be analyzed, defining the categories to be applied, outlining the coding process, implementing the coding process, determining trustworthiness, and analyzing the results of the coding process. The success of the analysis depends greatly on the coding process which organizes data into categories (Weber, 1990).

While the coding and interpretation of results was performed by the author, fit of the networks to the observations was performed by Jorge Santos (University of Tromsø). Calculation and visualization of networks and communities within networks was

made in the R-package igraph 0.7.0 (Csardi *et al*., 2014. Package 'igraph: Network analysis and visualization) using the walk trap algorithm (Pascal Pons and Matthieus Latapy, 2006).

The network analysis was presented in thematic networks and network plots using the Fruchterman-Reingold projection by Jorge Santos (University of Tromsø). The walktrap procedure defines a hierarchical community structure that can also be presented in the form of dendrograms. A dendrogram is a visual representation of structured data with individual spots arranged along the bottom (Total Lab, 2013) or simply a branching diagram that represents the relationships of similarity among a group of entities (Michael & Smith, 2012). The height of the branch points indicates how similar or different they are from each other: the greater the height, the greater the difference. We can use a dendrogram to represent the relationships between any kinds of entities as long as we can measure their similarity to each other (Michael & Smith, 2012). Therefore a dendrogram guides us where to look more closely, and provides independent support or contradiction for various hypotheses about similarity and difference in this study.

4 Results

4.1 Literature analysis in Lake Victoria

4.1.1 Thematic networks

The analysis showed the relationship between authors and the stated causes of prime concern to explain the state of the lake and fisheries. The network plot (Fig 4) indicates separation of some groups of authors in the network, but also looks extensively interconnected. Most authors tend to mention all the four themes as possible drivers influencing changes in fish catches. There is a high degree of connectance among authors and this explains why there are many arrows or linkages in the network (Fig 4). The two major groups consist of authors that generally favour the view that the problem with the changing individual fish catches is related to the

fishing and its management and the other environmental (anthropogenic) causes. Authors that emphasized the influence of over fishing and management issues are indicated in blue circles in the network while authors with red circles pointed out environmental related factors. The top of the network has authors who mostly pointed out overfishing and management problems or with little special issues influencing fisheries in Lake Victoria.

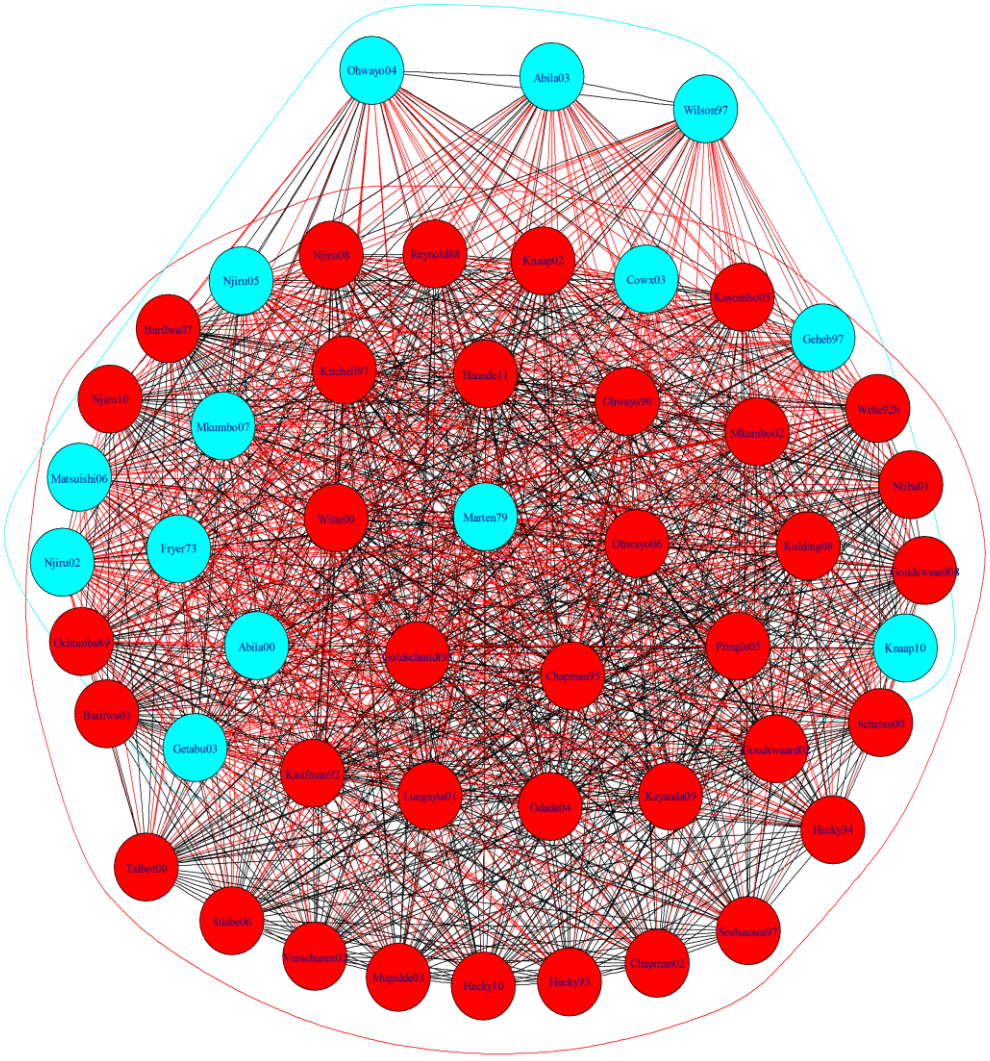


Fig. 4 Network plot showing authors' relationships within the network

The groups do not separate completely because an author rarely gives only one score. Normally several issues are mentioned as relevant (scores 0, 1 and 2), but only one is stressed (level 3). This means authors have relationships (even if weak) to most other

authors and perceptions in the network, no matter their preference. That is why there are so many links in the network graph (Fig 4). Authors at the outer edges normally have scored zeroes in one or more variables. One can say that they are more "extremists" or focused in their opinions or preferences. Authors at the center of the network are those that tended to give some scores to everything, even if low scores. Therefore the distance between authors at the periphery is large. In this case the diameter of the network is 8 (steps between the most extreme authors).

In case of a dendrogram analysis, the groups are further disaggregated into authors that highlight four types of argumentation: overfishing, management, eutrophication and ecological change. The dendrogram (Fig 5) shows a considerable overlap between authors that perceive overfishing and management issues as the main drivers influencing fish stocks. However, there is little overlap between authors who perceived eutrophication and ecological changes to be the influencing forces in fisheries dynamics in the lake.

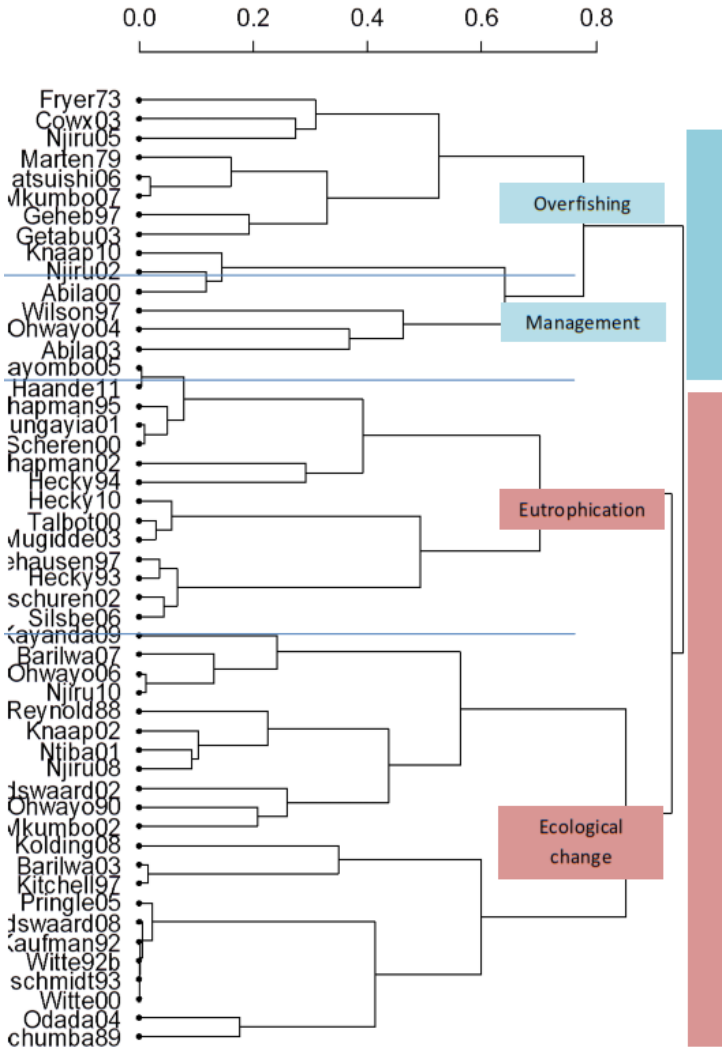


Fig. 5 Dendrogram showing author relationships on 4 major themes: Overfishing Management issues, Ecological changes and Eutrophication

In the dendrogram (Fig 5) the scale at the top indicates distance (max distance =1). This means that two groups that branch earlier (close to 1) have very strongly divergent opinions or preferences. On the contrary, authors that are very close to each other and branch at a distance close to zero, often have scored exactly the same on the 4 variables, and have thereby shown very similar perceptions. Authors that score high on every issue or have no clear preferences score in the middle of the tree.

An alternative analysis was performed with the literature data after re-coding of the [0-3] scores into binary [0.1] scores where the score 1 (positive) was only given to the

highest ranked topic(s) by each author. This greatly emphasized the contrasts among authors and defined three marked communities: eutrophication, overfishing-fisheries management (which have many authors with communalities), and ecological change. In between these communities, there are two minor groups: one has three authors that have scored high in all the four issues, and the other group has two authors that have scored highly in three issues, but omitted the importance of eutrophication (Fig 6). The diameter of network, i.e. the longest separation among authors, clearly declined, from 8 to 2: no matter their main beliefs no author is separated from another author by more than two steps. The modularity of the network also increased from 0.06 to 0.39, reflecting the formation of clear clusters with regard to the main perceptions.

The dendrogram (Fig 7) shows a substantial separation with slight overlap among authors who stressed eutrophication, followed by authors who favour ecological factors. In case of overfishing and fisheries management issues, there is a closer association among authors who preferred either of these issues to be influencing changes in individual catches in Lake Victoria.

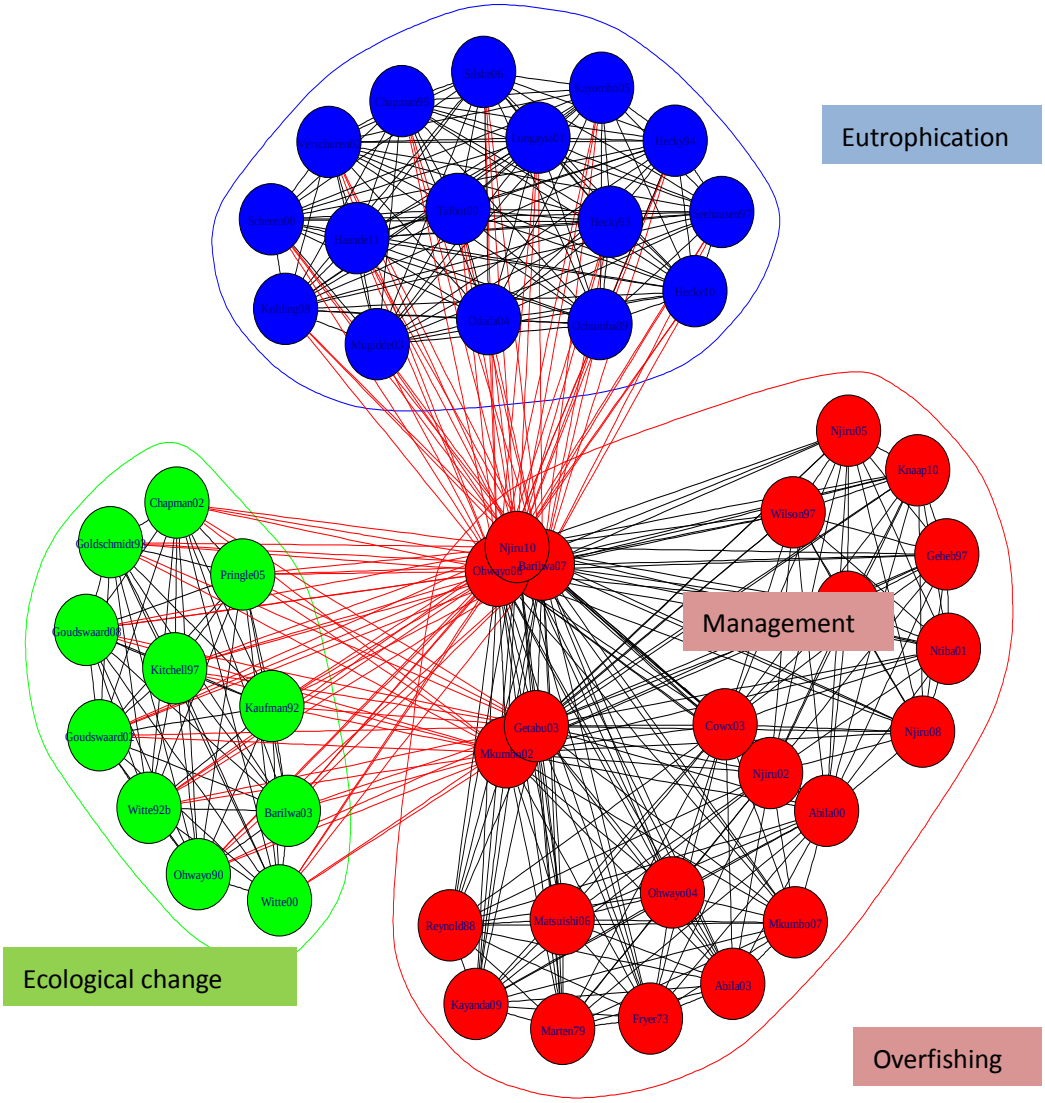


Fig. 6 Network plot analysis for each author within the network.

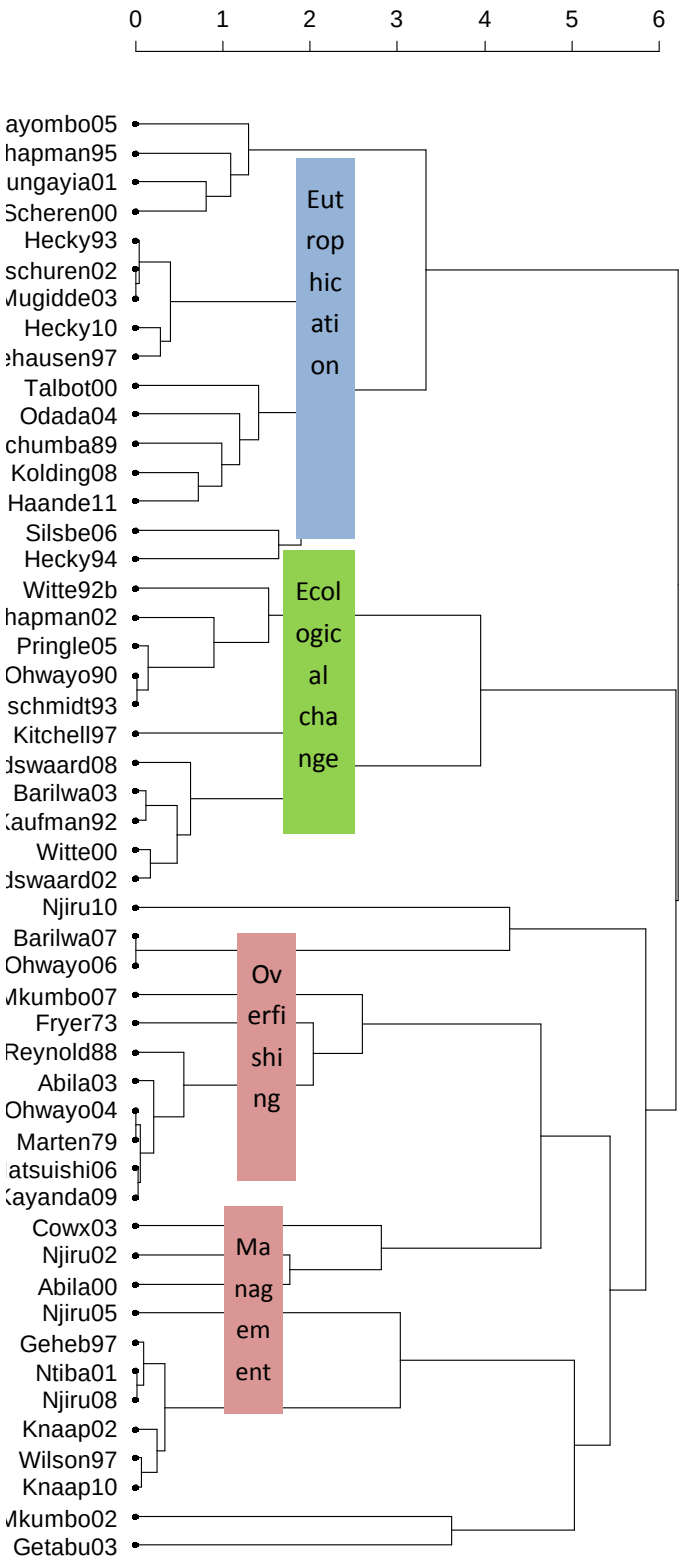


Fig. 7 Dendrogram for each author within the network.

4.2 The underlying fishery statistics

Data selection for assessing the status and exploitation of fishery resources in Lake Victoria has been inconsistent and fragmented among many authors (Cowx *et al*., 2003). Information on landings, fishing effort and fish stocks were taken from the different literature sources as the most used data sets and recent long data series in Lake Victoria. According to Kolding *et al*., 2005, the main problem throughout the history of Lake Victoria was the availability of comprehensive data sets that authors could agree upon. Lake Victoria fishery was compounded with scattered and incomplete statistics and nobody really knew the 'big picture' until after 2005. There were no fully agreed long-term time series available and this can be one of the reasons why there are so many different views on the development of the lake as authors presented little and fragmented series.

4.2.1 The fish trends in Lake Victoria

The landing data sets in figures 8 and 9 are among the most utilized by authors in Lake Victoria depending on their different research subjects. These involve some authors surveyed in the literature analysis in section 4.1. The datasets were utilized by authors such as Cowx *et al*., 2003; Njiru *et al*., 2005 who are categorized under the 'management' theme in the literature analysis while Cowx *et al*., 2003 overlapped to the 'overfishing' theme. Other authors that favour the overfishing perception included Matsuishi *et al*., 2006; Mkumbo *et al*., 2007 while Barilwa *et al*., 2003 is categorized under the 'ecological change' theme. However, these may not be the only authors that have utilized these landing datasets as some of fishery data/statistics come from the Lake Victoria Fisheries Organization.

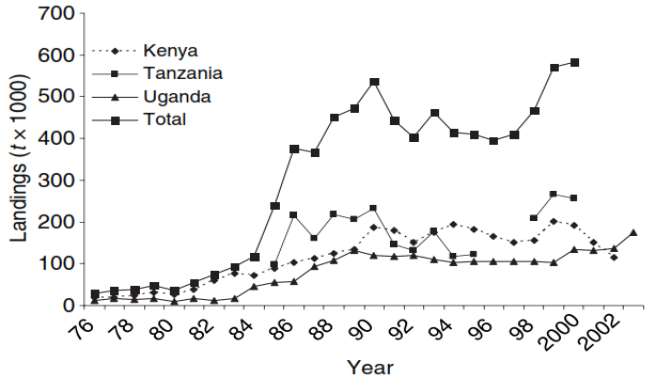
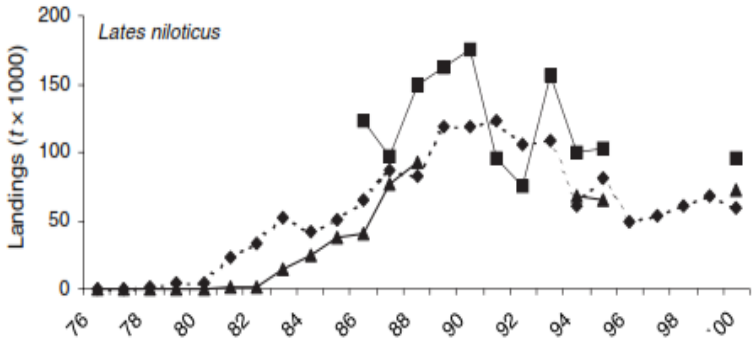


Fig. 8 Trends in Landings (t) of major fish species in the riparian countries of Lake Victoria (◆Kenya; ■Tanzania; ▲Uganda) in the period of 1976-2000. (Cowx *et al.*, 2003).

Total fish landings in the three riparian states of Lake Victoria until 2003 is shown in figure 8, and figure 9 shows species composition. In Kenya, total fish landings increased from about 19 000t tons in 1977 to approximately 220,000t tons in 1992 due to increases in the contribution of Nile perch. In 2002, catches declined to less than 120,000t tons largely due to reduced catches of Nile perch (60,000t tons). In Uganda, landings increased from 11 000t tons in 1977 to 120,000t tons in the early 1990s with high Nile perch contribution. In Tanzanian, landings increased from 72,000t tons in 1983 to 231,000t tons in 1990, again due to landings of Nile perch increasing from 274 tons in 1981 to 175,000t tons in 1990.



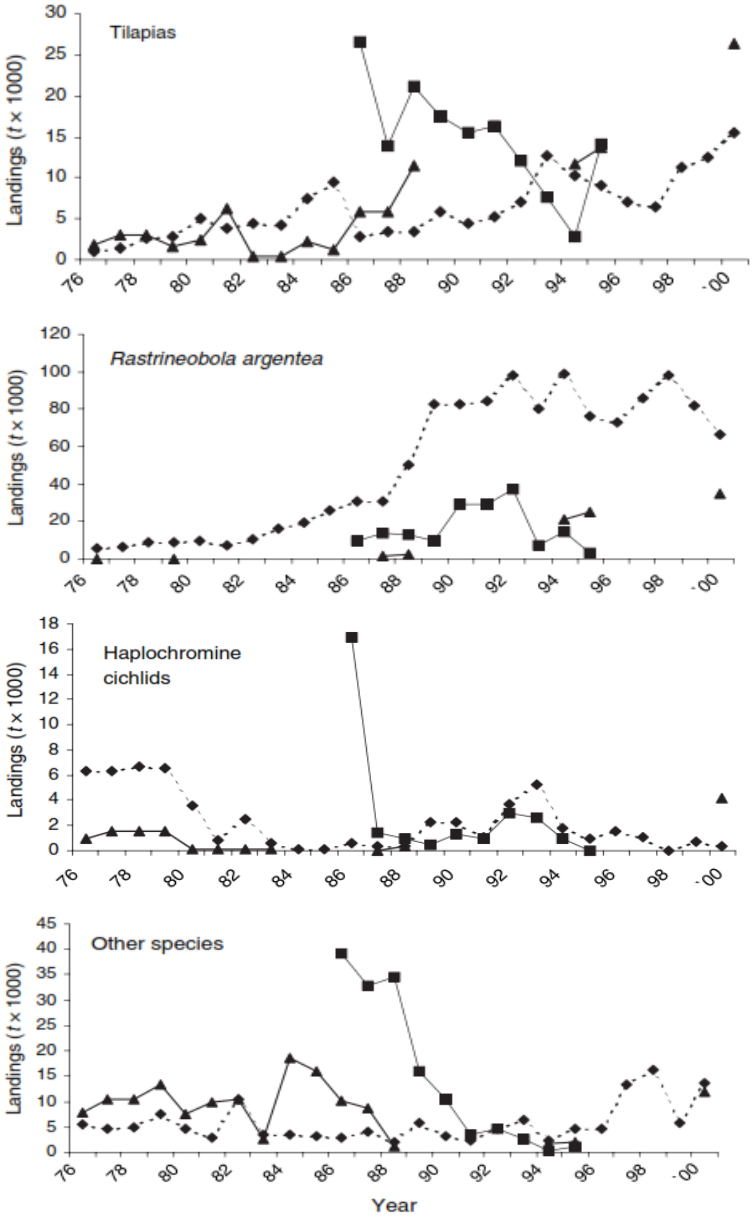


Fig. 9 Trends in Landings (thousand tons) of major fish species and species groups in the riparian countries of Lake Victoria (◆Kenya; ■Tanzania; ▲Uganda) in the period of 1976-2000. (Cowx *et al*., 2003).

From the datasets in Fig 9, there is an increase in landings for most species, particularly Nile Perch, Tilapia and Dagaa, from the mid 1970's to 2000, despite the annual or periodic fluctuations. As for Haplochromines and Others, the situation is more unclear as these series were, at the time, incomplete, with a good deal of missing data. It seems that the total catch of Haplochromine was reduced from about 6t tons to <1t ton in Kenya, but increased from 1000t ton to 4000t ton in Uganda. Catch of other

species was very variable and the data from Tanzania largely missing, but the total landings in the other two countries seemed to remain at about 10,000t tons throughout, despite many fluctuations. These species have always been small in the catches, and have been apparently been largely replaced in the landings by the other three dominant species.

The recent catch dataset (Fig 11) utilized by Kolding *et al*., 2014 shows historical coverage with four different stages in the fishery from the 1959 to 2010. This gives a clearer view and indicates all fishing phases involved in the fishery. The dataset indicates that in the first phase; pre-1980s, total annual catches were stable estimated at 100, 000 tons. In the second stage from 1980-1990, there was an exponential growth of over 350,000 tons in total annual catches recorded during this period. The third phase from 1990 to 2003 also recorded stable total annual catches of around 500,000 tons. In the last phase; 2003 to 2010, the total catches increased sharply to about 1 million tons per annum. This can be partly explained by the expansion of the dagaa fishery coupled with the re-emerging of the haplochromines in 2006. Lake Victoria currently has a total annual fish catch of over 1 million tons with the Nile perch averaging 250,000 tons per year generating an estimated US$300 million in export revenue and supporting the livelihoods of over 200,000 active fishers and other activities involved in the fisheries sector (LVFO, 2013).

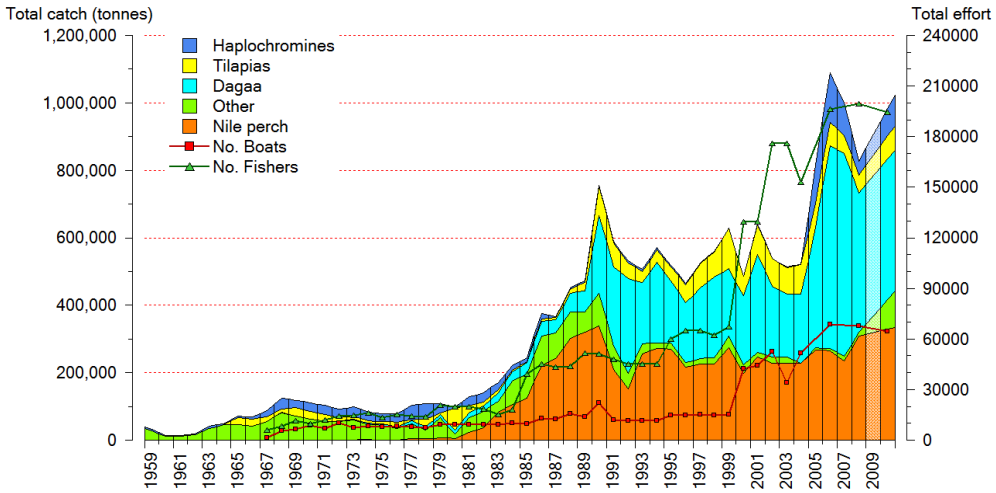


Fig. 10 Total annual catches (tons) with superimposed effort in Lake Victoria 1959-2010 grouped into 5 main groups. (Kolding *et al*., 2014; Hecky *et al*., 2010).

4.2.2 Effort trends in Lake Victoria

Fishing effort in Lake Victoria is based on national frame survey which dates back to 1967. However, since early 2000, regional frame surveys are conducted by LVFO on a biennial basis with support from EU and World Bank (LVFO, 2013).

According to Matsuishi *et al*., (2006), based on frame surveys conducted in 1998, 2000 and 2002, effort in terms of boats and fishers doubled between 1990 and 2000 (from about 5000 to 15,500 in Tanzania and 8000 to 15,500 in Uganda). There was further effort increase between 2000 and 2002 in Tanzania and, to a lesser extent, in Uganda (Fig 11).

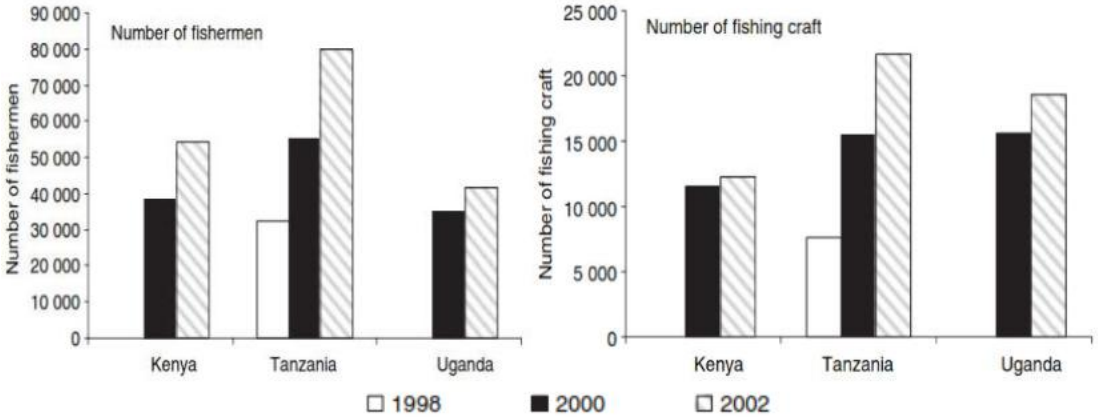


Fig. 11 Changes in number of fishers and fishing craft in Lake Victoria in between 1998 and 2002. (Based on LVFO, 2004).

According to Matsuishi *et al*., (2006), the catch-per-unit-effort in the Nile perch fishery has declined from about 80 kg/boat/day to around 45 kg per boat day and under this scenario of increased fishing effort, these authors suggest that the fisheries are unsustainable and will decline in the long term. They further reported that fishing methods have been introduced or modified to maintain the CPUE and this has led to increased fishing effort for Nile perch, especially with smaller mesh-sized nets which

have resulted into high number of juveniles being captured.

Another fishery data set (Fig 12), utilized by Njiru *et al*., 2008, themed under 'management' in the literature analysis, argued that fishing effort started to increase in 2000 with number of fishers and crafts doubling before a slight decline. However, there was a sharp increase in both fishers and crafts recorded since 2004 up to 2006 probably due to high fish demand for export or lack of jobs in other sectors.

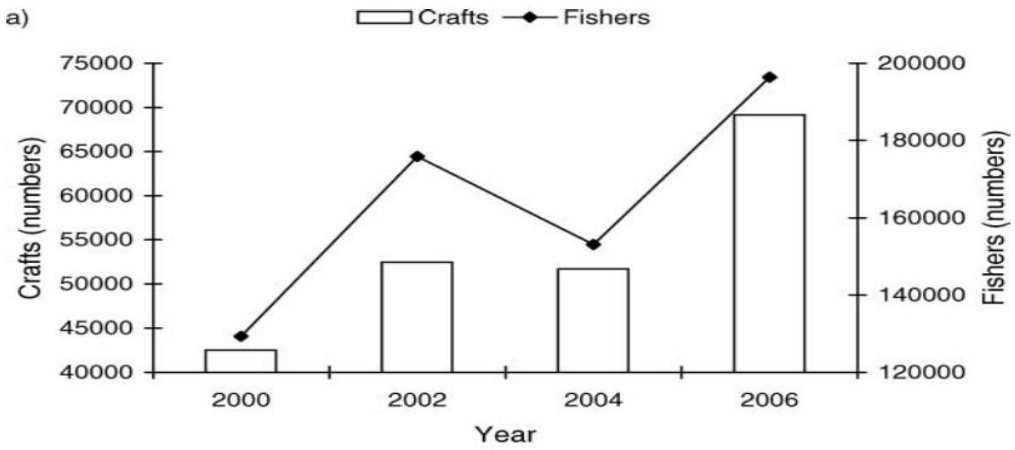


Fig. 12 Capacity trends in Lake Victoria, (a) fishers and fishing gears. (Njiru *et al*., 2008).

According to Njiru *et al*., (2008), fishers have resorted to the use of cast netting, smaller-mesh-sized gillnets nets and beach seines to maintain catches although the stocks are possibly also declining. However, there appears to be a continuous decline in catch per unit effort (CPUE) as the recommended gears are unprofitable. Despite the increase in effort and the use of illegal gears that target immature fish, the Nile perch fishery has shown remarkable resilience.

More updated information and data series (Fig 13) indicate that fishing effort showed a clear change in trend from 1988 onwards, when the rate of increase in numbers of boats and fishers accelerated with a reduction of fishers per boat from 4 to 3 people. Since 2006, the number of fishers and boats has stabilized at around 200,000 and 120,000 respectively. However, in terms of average catch rates for the total fishery,

the catch per fisher in the last decade is higher than before the Nile perch boom in the 1970s.

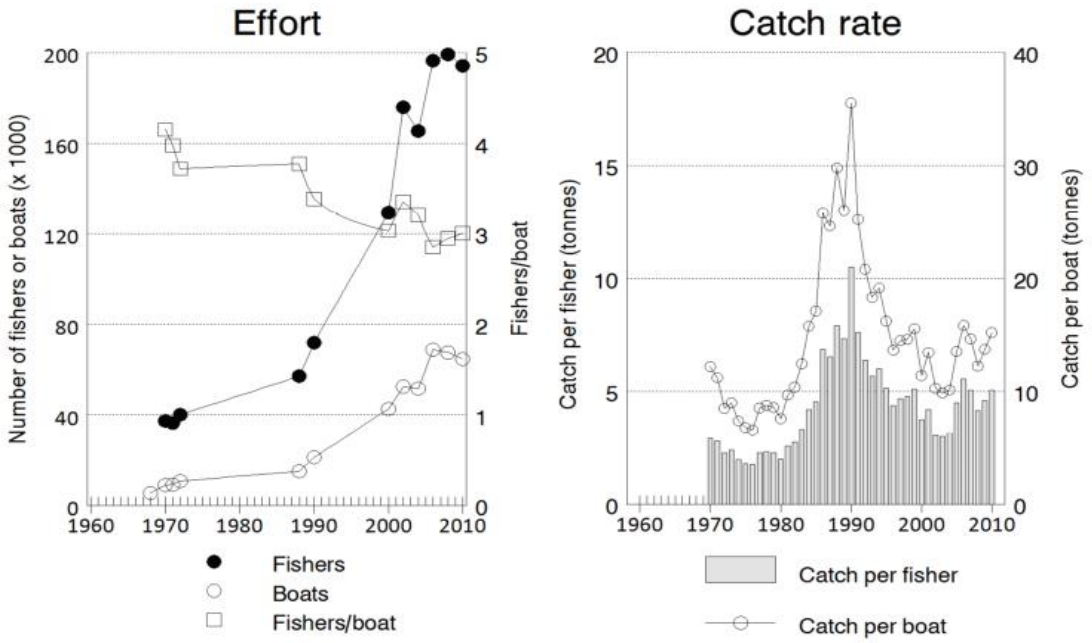


Fig. 13 Overall effort (number of fishers, boats and fishers per boat) and annual catch rates (tons per unit of effort-boat or fisher) in Lake Victoria 1968-2010. Over this period the fishing effort in terms of fishers and boats increased fivefold (Kolding *et al*., 2014) and (LVFO, 2010).

Based on the data in figure 13, there is a strong increase in the overall catch per unit trends indicated during the 1980 to 90 period when the Nile perch populations were booming. The average annual catch rate was stable at around 2.3 ± 0.75 tons per fisher prior to the Nile perch boom, when it rapidly increased to an all-time high of 10.5 tons in 1990. Since then catch rates have decreased to around 3.6 tons in the early 2000s. From 2005 onwards catch rates increased again to 4.9 ± 1.1 tons per fisher. This variability in annual catch rates reflects high dynamics of the fish stocks and shifting fishing patterns (Kolding *et al*., 2014). The number of fishers per boat has decreased from around 4 in the 1960s to 3 in recent years.

According to the most recent data series from LVFO, 2013 (Fig 14) indicate that growth in effort in terms of fishers and boats has stabilized since 2006. On country

level, Tanzania has the highest effort with an average of 100,000 fishers and 26000 fishing crafts, and the number of fishermen still seems to be in the rise. Uganda with about 60,000 fishers and 24000 fishing crafts and Kenya with 40,000 fishers and 14000 fishing crafts since 2006 seemed to have achieved a more stable stage of effort.

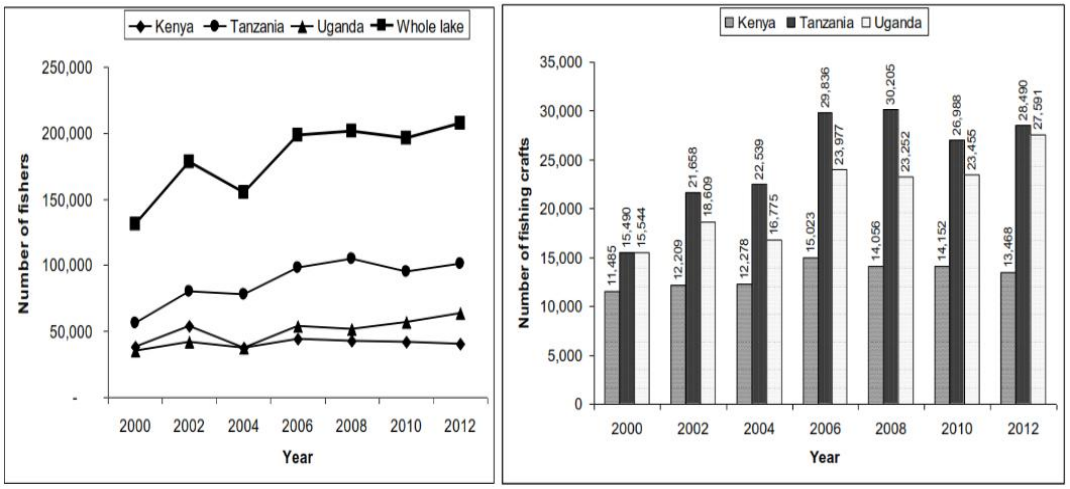


Fig. 14 Distribution of fishers and fishing craft in Lake Victoria between 2000 and 2012. (LVFO, 2013).

4.2.3 Fish stock trends in Lake Victoria

Fish stock assessment in Lake Victoria was by bottom trawl surveys since 1969, and has been supplemented by hydro acoustic surveys since 1999 to estimate the biomass (Nile perch and dagaa). Based on the acoustic estimates (Fig 15), the total measured biomass of fish in the lake is relatively stable at 2.1 million tons (Kayanda *et al*., 2010) while the biomass of *Rastrineobola argentea* had increased with an estimated average of over 1million between 2005 -2008 (Fig 15b). According to the acoustic estimates, the Nile perch biomass declined from 1.9 million tons in 1999 to about 200,000 tons in 2008 (Fig 15a). This data series was utilized by Kayanda *et al*., 2009: categorized under the ‘management’ theme in the literature analysis.

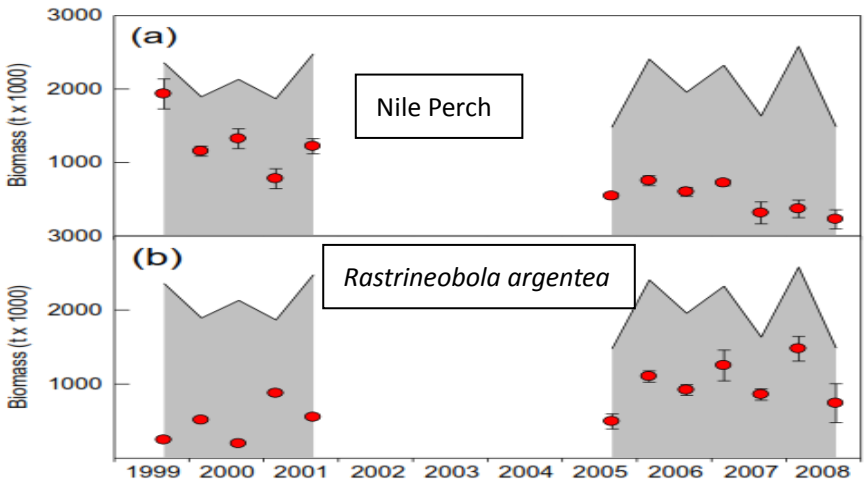


Fig. 15 Changes in the biomass of (a) Nile perch and (b) *Rastrineobola argentea* (dagaa) in Lake Victoria, 1999-2008. as measured with hydro-acoustic surveys. [Grey shading = total biomass, red points = species biomass (±standard deviation)]. No surveys were carried out between August 2001 and August 2005. Acoustic surveys carried out from 1999-2001 (Getabu *et al*., 2003: Tumwebaze *et al*., 2007) and from 2005-2008.

Based on data from the bottom trawl surveys (Fig 16), utilized by Kolding *et al*., 2008, the demersal community of Lake Victoria is currently dominated by three species of Nile Perch, Tilapia, dagaa and the re-emerging Haplochromine. The haplochromine formed a very small share of the total composition in the 1980-1990's, particularly in Uganda (data for Kenya not available). Before the Nile perch boom in early 1980s, the haplochromines dominated the community with over 90 % of the total demersal biomass.

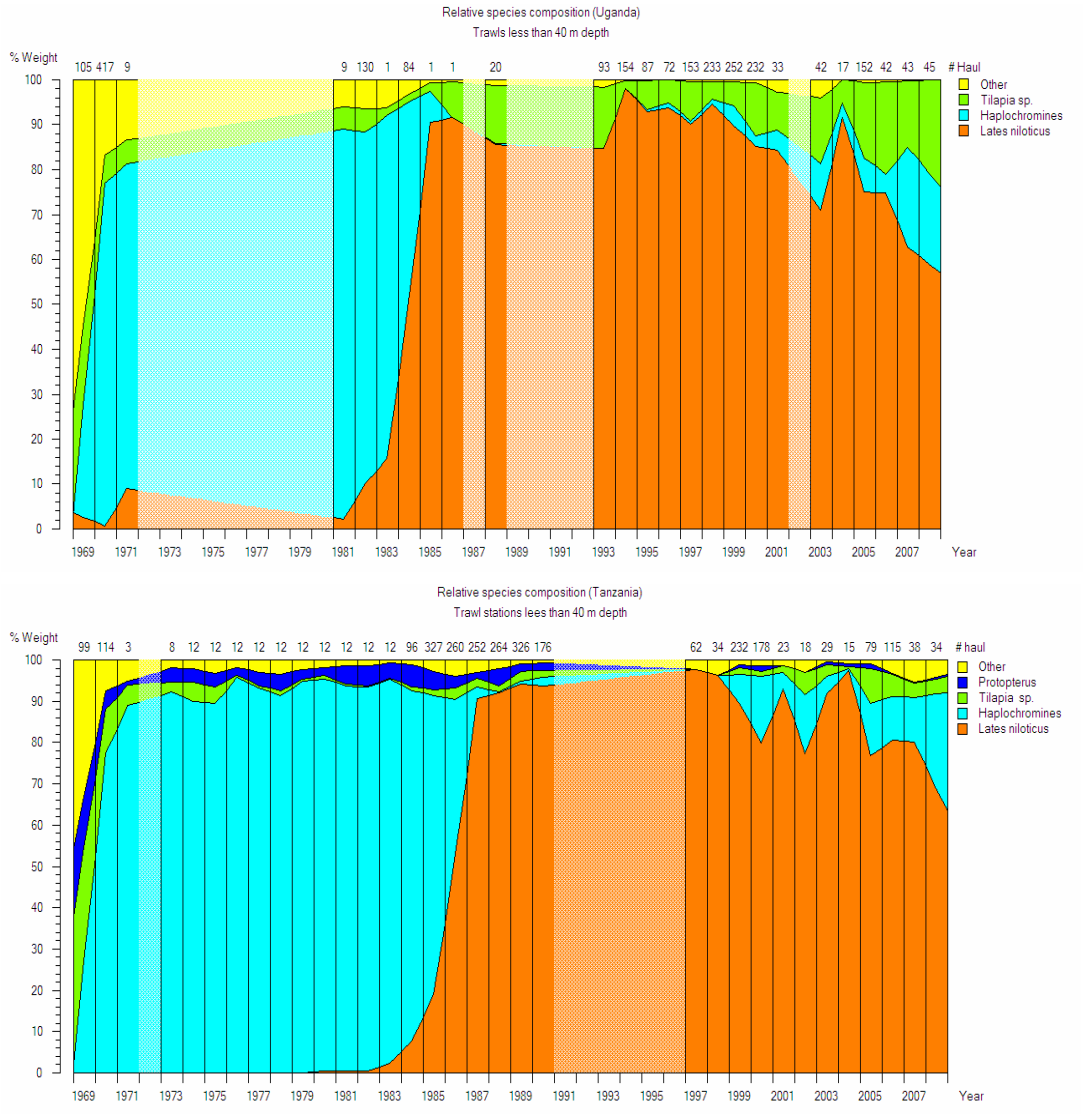


Fig. 16 Relative species composition by percentage weight in standardized experimental bottom trawl surveys in Uganda (top) and Tanzania (bottom) between 1969 and 2008. Years with no surveys are interpolated (light colors) (Kolding *et al.*, 2008).

4.3 Stakeholder analysis

4.3.1 Stakeholder group analysis

Stakeholders with diverse interests/opinions on the issues affecting Lake Victoria and its fisheries were interviewed in this study. Stakeholders included individuals who are involved in the day to day fishing activities, fisheries management and research, business and media groups in order to get a wide perspective on the current events surrounding fisheries in the lake.

Table 2 Summary of stakeholder group perception with stakeholders divided by occupational group. With respect to overfishing the responses were further interpreted in terms of processes [activities happening in the lake] and drivers [influencing events leading to actions or processes]

Groups	**Overfishing**	**Environmental changes**	**Ecological changes**	**Management issues**
Fishers and fish mongers	**Processes:** ↑ -Illegal fishing gears and practices ↑ -Many fishers ↑ -Capture of immature fish **Drivers:** ↑ -Open access ↓ -High poverty levels ↓ -Price fluctuations ↑ -High fish demand for export	↓ -Pollution ↓ -Wetland degradation	↓ -extreme weather conditions ↓ -Water hyacinth affect transportation ↓ -receding water levels	↑ -Political interference ↓ -Weak laws and policies ↑ -Corruption and bribery ↑ -Lack of enforcement ↑ -lack of government support
Fishers' leaders (BMU members, Association of fishers and lake users	**Processes:** ↑ -Many fishers ↑ -Illegal fishing gears and practices ↑ -Capture of Immature fish **Drivers:** ↑ -Open access ↓ -Price fluctuation ↑ -High fish demand for export	↑ -Wetland degradation ↑ -Pollution ↓ -Silting of the lake ↑ -deforestation	↓ -Extinction of fish species	↑ -Lack of government support ↑ -corruption and bribery ↑ -Lack of monitoring and enforcement ↑ -Weak laws and policies ↓ -Political interference
Fisheries officials (managers, and fisheries researchers	**Processes:** ↑ -Illegal fishing gears and fishing practices ↑ -Immature fish ↑ -Many fishers ↑ -Many factories	↑ -Pollution from increasing human population ↓ -Localized eutrophication ↓ -Sand mining	↓ -Climate change ↓ -Re-emerging of haplochromines	↑ -Lack of monitoring and enforcement ↑ -Unreliable data ↓ -Political interference ↑ -Weak laws and policies

	Drivers: ↓ -Price fluctuation ↑ -High demand for fish exports ↑ -Open access			↓ -Corruption and bribery ↓ -Lack of harmonization
Fisheries conservationists and Environmentalists	**Processes:** ↑ -Many fishers ↑ -Illegal fishing gears and practices ↑ -Capture of immature fish **Drivers** ↓ -High poverty levels ↓ -Open access	↑ -Siltation and soil erosion ↑ -Pollution from industrial wastes ↑ -Wetland degradation ↑ -Deforestation ↓ -Sand mining	↓ -Climate changes with prolonged drought and flooding ↓ -Extinction of fish species	↑ -weak laws and policies ↑ -Lack of monitoring and enforcement ↑ -Lack of government support ↓ -Unreliable data ↑ -Corruption and bribery
Exporter association and factory owners	**Processes** ↑ -Use of illegal fishing gears and methods ↑ -Many fishers ↑ -Capture of immature fish **Drivers:** ↑ -Price fluctuations	↑ -Sand mining ↑ -Industrial pollution	↓ -Climate change affected lake ecosystem ↑ -Decline in fish sizes	↑ -Lack of laws and policies ↑ -Lack of government support ↑ -Lack of monitoring and enforcement ↓ -No functioning institutions ↑ -Unreliable data
Media groups	**Processes:** ↑ -Many fishers ↑ -Use of illegal fishing gear and practices ↑ -Capture of immature fish **Drivers:** ↑ -High demand for fish exports ↓ -Open access	↑ -Pollution from domestic and industrial discharges ↑ -Degradation of wetlands		↑ -Lack of government support ↑ -Lack of lack of monitoring and enforcement ↑ -Weak laws and policies

Symbols: frequency of occurrence of statement **1-** ↑ [Most frequent] 2-↓ [Least frequent]

Fishers and fish mongers: Overfishing is perceived as the use of illegal fishing gears and practices, many fishers and fishing of immature fish, and viewed as the main factor influencing individual fish catches. Fishers claimed that high poverty levels are driving the use illegal gears in order to maintain their catch. More so, fishers highlighted awareness on the current wetland degradation which has destroyed spawning grounds for the Nile Tilapia. On the ecological aspects, some fishers were concerned with the extreme weather conditions affecting their fishing operations. On fisheries management decisions they reported experiencing political interference with poor decision making policies, corruption and bribery from fisheries officials, and a general lack of strong monitoring and enforcement.

Fishers' leaders (BMU members and Association of fishers and lake users: Overfishing in Lake Victoria is perceived as the main driver influencing individual fish catches in the Lake Victoria. Fishers' leaders stated that there are many fishers in the fishery using illegal gears and fishing of immature fish. The leaders further expressed their concerns on the rate of wetland degradation, pollution and deforestation; however, these were not stressed as the main threats to the changing individual fish catches. On ecological related issues, the leaders talked about the disappearance of some indigenous fish species [*Labeo* sp., *Mormyrus* sp., *Barbus* sp. and *Bagrus docmak* sp] which used to be common in the lake. However, much emphasis was pointed at the situation of weak fisheries management policies, lack of monitoring and enforcement, corruption and bribery, and lack of government will are perceived to be the main causes of problems affecting Lake Victoria.

Fisheries managers and scientists: Fisheries officials also put emphasis on overfishing especially the use of illegal gears, involving many fishers and the fishing on immature fish as the major factor influencing individual fish catches. Fisheries officials also acknowledged an increase in pollution levels from the increasing human population coupled with the effects of climate likely to influence fish distribution. The management system still lacks monitoring and enforcement mechanisms to tackle issues related with use of illegal fishing gears and capture of immature fish, and there is further lack of

harmonization among the fisheries departments to address some of the issues holistically, as well the unavailability of reliable/credible fisheries data to support fisheries management decisions.

Fisheries conservation officers and Environmentalists: This group was also much concerned with the increasing use illegal gears and fishers involved in the fishery. The group also stressed that Lake Victoria watershed has witnessed increasing industrial pollution, wetland degradation and deforestation together with changes in climate characterized prolonged drought which may pose serious threats to fisheries. The continued illegal practices were highlighted to be caused by poor fisheries policies, lack of monitoring and enforcement, corruption and bribery by BMUs and District fisheries officers.

Exporters' Association and factory owners: Again, overfishing was fronted as a major factor influencing individual fish catches. The issue of overfishing was claimed to be driven by increasing prices and high fish demand for the Nile perch on the international market. This driver influences fishers to the use illegal gears and fish undersized fish for export to the regional markets which is likely to affect catches. Ecologically, the average size of the Nile perch was reported to have declined [55cm to 25cm] in recent years. Also the effects of climate change have been observed with receding water levels which was experienced during the 2005/2006 drought events within the East African region. Management failures were associated with lack of government support, weak laws and policies and lack of monitoring and enforcement were stated to be the main factors affecting fisheries management decisions in Lake Victoria.

Media groups: This group was poorly represented in the samples (N = 1), but the respondent reiterated that overfishing characterized by many fishers, use of illegal fishing gears and capture of immature fish is the main threat causing changing individual catches. Other issues pointed by this respondent included; environmental degradation in form of pollution from domestic and industrial discharges together with wetland reclamation for agriculture and human settlement around the lake. Lastly, poor governance fisheries system associated with weak fisheries laws and policies, lack of monitoring and

enforcement and lack of government support were highlighted to be facilitating illegal fishing practices in Lake Victoria.

4.3.2 Stakeholder network analysis

Stakeholder analysis utilized the use of networks analysis to understand individual perceptions on the issues surrounding Lake Victoria. According to this analysis on the stakeholders, the thematic network was relatively homogeneous, with many or most respondents mentioning most of the themes (overfishing, environmental changes, ecological changes and management concerns). The difference was in the way they emphasized each theme. Therefore, the dendrogram (Fig 18) shows relatively small distances (0.3) between the two main branches (overfishing and management issues). In general these branches corresponded to the respondents that emphasized mostly Overfishing (top) and those that most often mentioned Management Issues (bottom). Respondents that also gave some weight to environmental or ecological issues tended to come from overfishing group (top group).

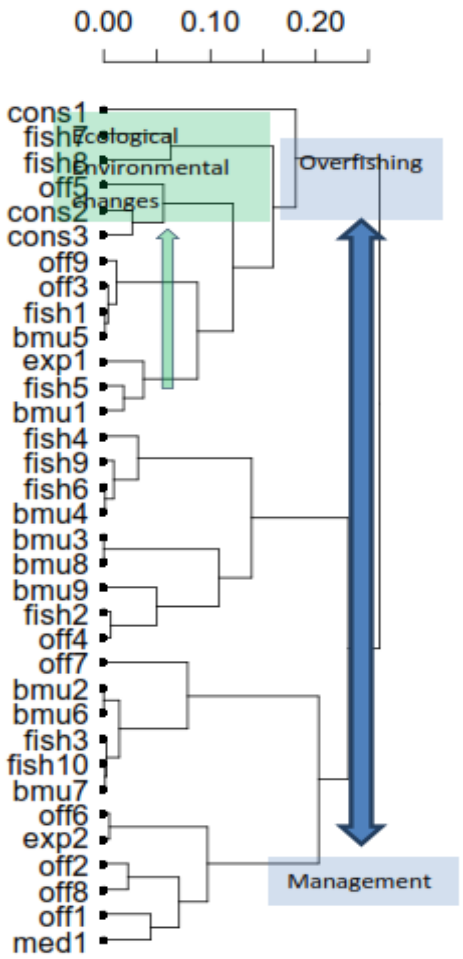


Fig. 17 Stakeholder relationships and themes.

Defination of symbols

- fish [Fisher and fish mongers]
- cons [Conservation officers and Environmentalists]
- bmu [Beach management units and Association of Fishers and lake users]
- off [Fishery officials (Mangers and Fisheries researchers)]
- expt [Exporters Association and Factory owners]
- med [Media groups]

In general, fishermen were among those that emphasized overfishing, together with conservation representatives who stressed environmental and ecological issues as also important. Although the distinction was not very sharp, BMU leaders and fishery administrators tended to be more inclined to stress Management Issues. Exporters and

media seemed to be more inclined to Management issues as well.

The network plot (Fig 19) shows the large number of linkages among the different respondents, confirming the overall homogeneous nature of the responses with regard to the different themes. Stakeholders expressed their opinions on the issues affecting individual fish catches and almost all the groups mentioned or talked about the themes (overfishing, environmental changes, ecological changes and management issues). This is why the plot network has many links between groups. The groups in green circles gave some (moderate) emphasis to Ecological Change or Eutrophication. In general respondents weighted most Overfishing or Fisheries Management issues.

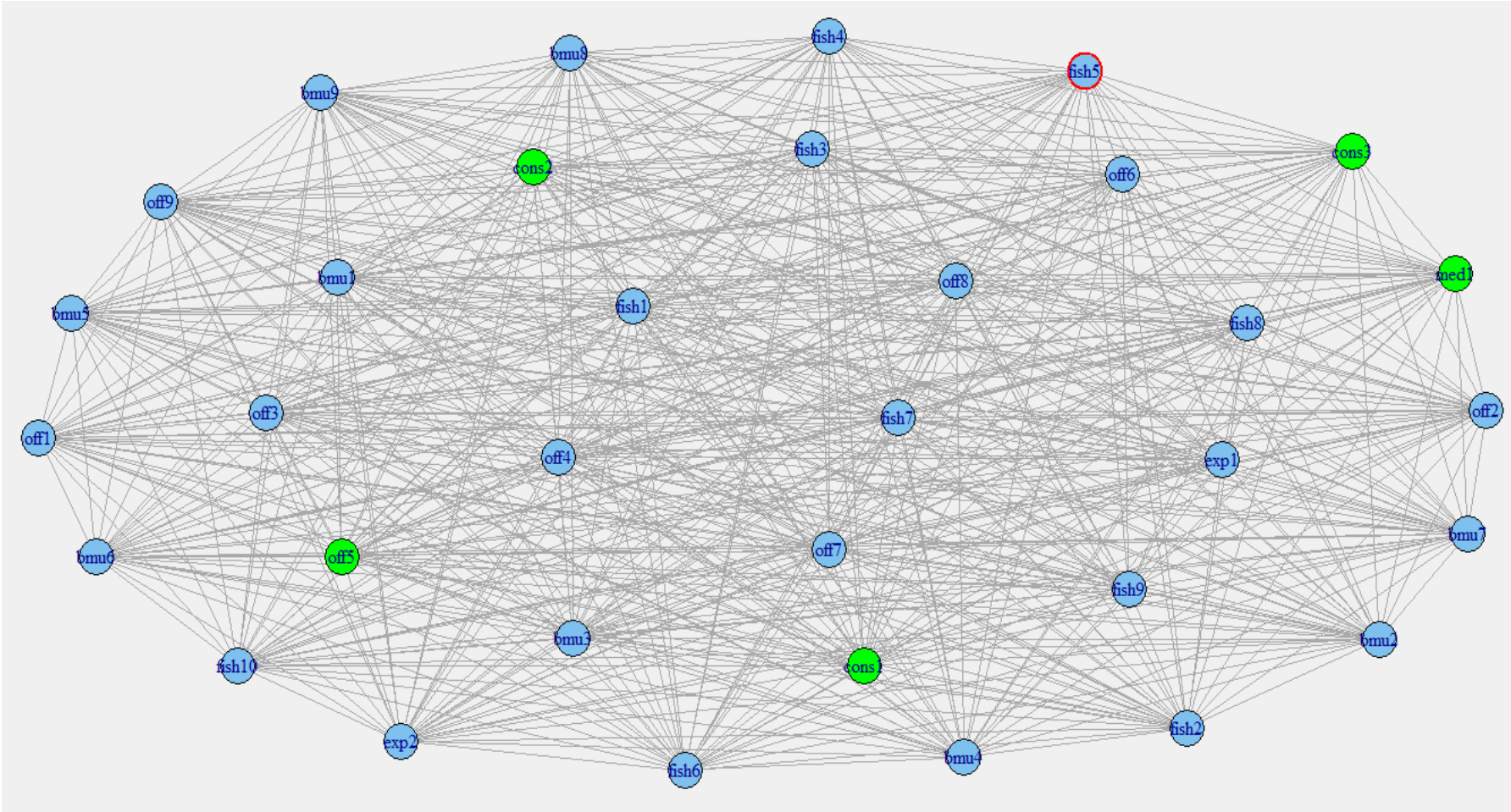


Fig. 18 Network of stakeholders and their perceptions

5. Discussion

Different approaches and analyses were employed in an attempt to study and understand the various perceptions about the trends in fish catches, the present state of fisheries, and the possible background of these views. The data for these analyses was information taken from both published accounts, mostly written by academics (international or at regional level), and interviews from a sample of different fishery stakeholders in Uganda. Thus, not only the preconditions and background of the informants, but also their (physical and emotional) distance to life in the lake itself, varied widely and it's interesting to understand this variation.

The Lake Victoria is nowadays an object of global concern, as reflected by its regular appearance in the international and local media such as BBC news, Aljazeera African, CCTV Africa, Citizen TV Kenya, NTV Uganda and Kenya, Urban TV Uganda and local news papers such as Daily Monitor and the New Vision group (Reference list). Other appearances have been in form of films or video clips and documentaries e.g. the "Deadly Catch", "Big fry-small catch", "Winners and losers of commercial fishing", "Scramble for fish", "Turning the tide in Lake Victoria", "Troubled waters in Lake Victoria" (Reference list). The method utilized to analyze the information from different sources was similar, however, and relied on text analysis of both written reports and transcribed oral interviews. Categorization of the perceptions of each individual source was followed by network analysis of the coded data. Network analysis has become an important tool for understanding of complex relationships in many disciplines since its development in social sciences. Here it was used to make a graphic representation of the complex network of perceptions in the international literature and among the stakeholders.

Whilst network analysis can help us visualize the distances and the clusters of opinions, there are limitations to it, particularly during data collection, analysis and selection of the different parameters. The use of network analysis is liable to misinterpretations due to omissions and assumptions as significant information may

have been left out, and as a result the conclusions drawn are questionable (Muller, 2010). When using network analysis, boundaries of relationships are often very hard to identify by researchers due to sampling errors [including or excluding certain factors] which may require the use of artificially imposed definition that might not reflect the reality of the social network at all (Scott, 2000). The use of networks also does not automatically guarantee a network tie or positive interaction even when common characteristics do exist, this may be because of indiscriminate presentation of research subjects as networks (Hafner-Burton *et al*., 2009).

The sampling strategy for the literature utilized in the present study may arguably be selectively biased, as only the most cited papers were chosen and reviewed/read. Thus the selection may have omitted new and original contributions and perceptions on the state and causes of change in Lake Victoria. This would bias the analysis towards mainstream perceptions. However, during the search phase, attention was paid to the possible occurrence of novel perceptions, and themes like climate change were easily accommodated within the broader topic of ecological change. Furthermore, the coding process is likely to simplify the original data and introduce subjectivity.

More so, the field study focused on a small percentage of the population by concentrating on the Ugandan side of the lake. All the views presented are based on experiences in Uganda and excludes views from Kenya and Tanzania. The network analysis of stakeholders was performed based on field data (interviews) conducted by the researcher which may be biased or questionable. All in all, the success of the analysis depends greatly on the coding process which organizes data into categories (Weber, 1990). All these potential limitations must be taken into account in the interpretation of the findings.

5.1 Facts and perceptions in Lake Victoria

The current state of fisheries in Lake Victoria has generated varying opinions among researchers, fisheries managers and the general public on whether fish catches

(individual/total) have declined or not and what are the possible influencing drivers associated with such changes. The different arguments have been elaborated in some of the most recent literature; [e.g. Kolding *et al*., 2008; 2014; Sitoki *et al*. 2010; Matsuishi *et al*., 2006; Njiru *et al*., 2014; Mkumbo and Marshall, 2014; Munyaho *et al*., 2014]. This study looked at stakeholders' perception and published data to understand the different opinions, and their groundings, on the status fish stocks in Lake Victoria. The fisheries situation in Lake Victoria seems not straightforward because of different contradictory statements which require careful analysis.

5.1.1 Are the perceptions unanimous among all stakeholders and scientists?

The perception on the state of Lake Victoria is at the moment driven by different opinions. This scenario has generated debates in scientific literature on the state of fisheries in Lake Victoria (Matsuishi *et al*., 2006; Sitoki *et al*. 2010). The current state of the fishery debates seems to be split into two factions; those in favour of overfishing and the other for eutophication (Munyaho *et al*., 2014). The split in opinion has been further portrayed by Mkumbo and Marshall, (2014) in the recent literature where it is stated that overfishing in the lake has been supported by other authors; [Simonit & Perrings 2005; Marshall and Mkumbo, 2011; Getabu *et al*., 2003; Matsuishi *et al*. 2006; Mkumbo *et al*., 2007; Njiru *et al*., 2007]. However, the issue of overfishing has been disputed by Kolding *et al*., 2008, who argued that eutrophication is the main threat and that there was no evidence of overfishing in Nile perch stocks (Mkumbo and Marshall, 2014).

Based on the stakeholders' investigation, the network analysis shows homogeneity among the groups (Fig 18) and tends to be much inclined to perceive overfishing and management issues as more important than eutrophication and ecological factors to be the drivers influencing changes in individual catches. The issues of overfishing and management concerns are also widely portrayed by the stakeholder perceptions (Table 2), where fish density in the lake, as reflected in individual catch rates, is perceived to be mainly driven by overfishing which again is manifested in the use of illegal fishing

gears and practices, excess number of fishers, as well as capture of immature fish. The stakeholder analysis reported a poor management system that is heavily infested with corruption tendencies among fisheries administrators, lack of government support to facilitate monitoring activities, and unreliable data to support management priorities.

The literature analysis suggests a strong split in the academic community (Fig 4). A cluster of authors clearly favour overfishing and eutrophication as main drivers while another cluster considers ecological changes that may be associated with the introduction of the Nile perch (Ohywa-0gutu, 1990). Although most authors favour one particular driver, they still point to the other issues as possible drivers influencing changes in individual fish catches. It is therefore not clear if this is a true conviction or used as strategy to hedge against failed predictions of the favoured mechanism. However, it may be that all authors have correct arguments, but this happens against a background of an apparent increase in landings for most the species (Fig 10) and a stable trend for the Nile perch, which is the pinnacle of the fishery, and even increasing levels of Haplochromines, which were deemed to be the losing part in the ecological changes. Based on the total catch data alone, the fishery indicates an upward trend as opposed to a decline commonly reported to, and, thereby, generally perceived by the public.

5.1.2 Is the use of data/information selective? Or are perceptions selective?

In the last decade, there have been fluctuations in catches which sparked different ideas between scientists (Matsuishi *et al*., 2006). Lake Victoria fishery is regarded as one of the most studied fresh water ecosystems (Kolding *et al*., 2014), and these studies by both local and international researchers have generated mixed reactions due to the different conclusions and different methods. We therefore need to understand why authors have different opinions; may be because they used different data sets, or they interpreted the same data sources differently. For instance, some reports have suggested that the abundance of Nile Perch stocks in Lake Victoria from the early 1990s to 2005 have not changed and no signs of fishing (decrease in abundance) are

evident (Kolding *et al*., 2008). However, based on Munyaho *et al*., (2014), Nile perch stocks have changed but trends are often clouded by methods of monitoring. Despite the various research studies, the data give different results (Kolding *et al*., 2014), and this could partly explain why there are different opinions on the status of the fishery and the driving forces influencing individual fish catches.

Most of the fisheries data in Lake Victoria give different opinions on the status of the fishery (Kolding *et al*., 2014). This can be portrayed in figures 11 and 12 utilized by Matsuishi *et al*., 2006 and Njiru *et al*., 2008; 2010 respectively which give isolated short-term series (Fig 12) and sometimes from different disciplines, while the long term trends are rarely updated and very few studies give a holistic perspective on the status of the stocks, the fishery and the lake ecosystem (Kolding *et al*., 2005). In such scenarios, different interpretations are made which could lead to misunderstandings due to the choice of data used.

Furthermore, there is a limitation on the use of hydro acoustic survey, as some species that live in shallow (<10-20m) deep, including the Nile tilapia, may not be easily detected (Njiru *et al*., 2014). This results on a downward bias of the estimates of fish abundance. In such a case, biomasses may even be considerably higher than normally stated, irrespective of the increasing or decreasing trends. Also the dataset in figure 16 shows only percentage of species composition in the swept-area surveys which may be treacherous as there should be a lots of Nile perch left. The selective use of data in Lake Victoria by different authors has created arguments between scientists and fisheries managers on the possible factors influencing changes in individual fish catches in Lake Victoria.

5.1.3 Is the situation in Lake Victoria really catastrophic?

Lake Victoria contributes significantly to the economic growth of the East African countries (LVFO, 2011). The fishery is currently viewed in terms of the Nile perch performance by the majority of the population and this belief has caused general

public to think that total catches are declining but it's instead the individual catches (Fig 13) and total catches are increasing (Fig 10). Although the Nile perch is main species in terms of commercial value (Balirwa, 2007), there are other species such as Nile Tilapia, dagaa which are also of significant value (Abila, 2000). Lake Victoria fishery is undergoing a transition associated with intense exploitation and ecosystem change, especially eutrophication (Balirwa *et al*. 2003). Despite numerous changes, the fishery shows a steady increase in total catches with the Nile perch maintaining stable catches over the past two decades (Fig 10), estimated at around 200,000 tons per year. More so, progress has been witnessed in other species such as dagaa which have attracted regional trade from South Sudan, DR Congo, Burundi and local markets (Abila 2000). Biologically, the Nile perch is considered to be highly fecund with over 16million eggs for a mature Nile perch, manifesting itself by a high abundance of juvenile fish and therefore not likely to be threatened by fishing pressure in the near future. It is further believed that the major concern is not the availability of Nile perch but the lack of large individuals because the processors may not process any fish smaller than the legal slot Size of 50 cm TL (Mkumbo and Marshall, 2014).

The recent regional frame survey by LVFO shows a slight increase in number of fishers and fishing crafts in 2012 (Fig 14). However such an increase does not seem to result in any declines in the annual fish catches as total annual catches have increased between the 2003-2010 periods (Fig 10). There is still a linear correlation between total catch and number of fishers (Fig 19). If there had been overfishing we should have seen a decline (in the dome-shaped model).

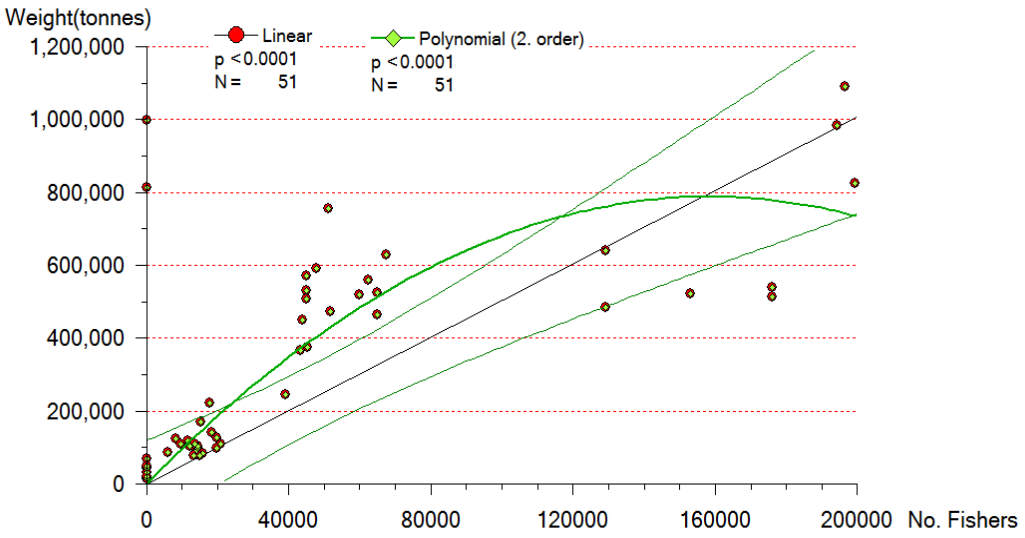


Fig. 19 Total catches and total effort in Lake Victoria

For instance the Tilapia fishery is thriving with little or no reported declines and the re-appearance of haplochromine species (Fig 10) indicate how other fish species have increased in the lake. However, factory owners and fishers have reported a decline in the size of Nile perch (Mkumbo and Marshall, 2014) which has been interpreted as a signal of decline in fish stocks.

Furthermore, there is a general belief that the Nile perch biomass has declined due to overfishing as reflected by the increased biomass of its major prey species, dagaa and the haplochromines (Munyaho *et al.*,2014); and that decreased predation pressure was responsible for haplochromine resurgence in Lake Victoria (Witte *et al.*, 2007). However, the resurgence of haplochromines may not be simply linked to a general decrease in Nile perch, but reflects a decrease in the numbers of large fish because haplochromines were their main food (Mkumbo and Marshall, 2014).

The issues on changing individual fish catches may have been misinterpreted by some stakeholders such as media groups and thereby misleading the general public. For instance media reports have not highlighted the fisheries performance especially on the published long term trends on the total catch which shows an increase trends (Fig

10). Lake Victoria may be experiencing some challenges in terms of individual fish catches, as catch rates per boat have decreased in the last decade (Fig 13). This is mostly caused by the fast expanding number of fishers who are attracted to the fishery, particularly in Tanzania; however, these changes have only been experienced in the Nile perch fishery. This may be the major cause of conflict, with possible reflections in the whole basin. The problem here is that there are many fishers involved especially in the Nile perch fishery which has influenced a decrease in individual catches. In other words, there may be too many fishers sharing the same catch. Otherwise fishers would no longer be involved in fishery if the situation was catastrophic.

5.1.4 What are the consequences of different perceptions to management?

Effective fisheries management requires a unison approach across the whole lake with a shared vision on the best possible management options depending on the issue at hand. In the case of Lake Victoria, there are number of conflicting issues and interests that complicate fisheries management (Nunan, 2014). Therefore one has to consider each scenario independently for best management option as issues are perceived differently by both fishers, scientists, fisheries managers and the public. For instance, the majority of the stakeholders consider overfishing as the main driver influencing individual fish catches. Accordingly, overfishing in Lake Victoria is perceived to be associated with use of illegal fishing gears, capture of immature fish and many fishers involved in the lake. Under such circumstances, management options should focus on instituting fishery policy that enables fishers to maximize profits from their smaller catches, or boosting of processing sectors and encourage fishers to engage in alternative occupations.

Other authors and stakeholders singled out the issue of lack of management mechanisms. For instance the current fisheries management plan for the period 2009-2014 focused more on fisheries management rather than institutional development (LVFO, 2008), as the plans were more suited for industrial marine

fisheries than the artisanal fisheries (Njiru *et al*., 2014). Another management failure is the recognition of the "top-down" instead of the "bottom-up" management approach as indicated in LVFO management structure (Fig 2). In addition, management failure in the lake is perceived to involve corruption practices among the fisheries officials, lack of government support to facilitate fisheries activities like reducing the prices of recommended fishing gears, weak fisheries policies and political interference in the fisheries sector. Such challenges can be addressed by instituting and promoting transparency among the fisheries officials, establishment of cooperatives and reviving co-management systems where fishers manage and feel a sense of ownership of the resource, and enforcing local based monitoring activities to manage fisheries in Lake Victoria. This can help reducing conflicts within communities and between communities and fisheries authorities.

In case of ecological factors influencing fish catch changes as a result of the Nile perch, then the management option can be by subsidizing the Nile perch fishery by fishing out all the mature fish. Alternatively, management should call for a holistic approach that involves principle of an ecosystem based fisheries management program. This includes food webs, trophic structure, complex population dynamics, and numerous predatory and competitive interactions, and their contributions to the structure and functioning of ecosystems (Fowler *et al*., 2013). More so, fisheries management can adopt the ecosystem approach to fisheries as suggested by Kolding *et al*., 2008 by incorporating limnological and ecological factors into the fisheries management plan. However, the problem with ecosystem approach to fisheries is that nobody has agreed on how the ecosystem should look like such as many Nile perch, few or many haplochromines, few, or clear water productive, although everybody talks about ecosystem approach to fisheries, it's still un defined.

Finally, if eutrophication is the major concern to fisheries, management option is to reduce all sorts of nutrient input starting from the watershed at wide lake scale through farming practices that do not require fertilizer use, treatment of industrial

wastes and conserving wetland and other type of vegetation on lake shores such as planting of trees. Furthermore, the removal nutrient can be done by shifting fishing to species in the lower food chain in order to accelerate the removal of carbon production (Kolding *et al*., 2008).

6. Conclusions

The Lake Victoria has been in the spotlight due to changing and divergent perceptions on fishery trends which has generated arguments and caused confusion among general public and attracted international attention. Different media groups both local and international have published reports about the declining fish stocks in Lake Victoria and the imminent collapse of the whole fishery. The media further reported an increase human activities threatening Lake Victoria with increased pollution levels which have affected the water quality and fisheries. However, issues of declining individual fish catches have been much publicized. Lake Victoria is currently perceived as a failed fishery with declining fish stocks despite increasing total catches and the enormous and critical economic support it offers to the fishing communities and riparian states.

Lake Victoria fisheries management has been faced with short-term data and contradictory statements from different researchers/authors involved in the lake. This study has presented the varying information emanating from Lake Victoria fisheries sectors, authors and highlighted insights on the possible drivers influencing changing individual fish caches and decline in stocks as perceived by the different researchers/authors. More so, there seems to be mismatches or poor understanding between what is presented publically and the actual fishery data records as researchers have analyzed the issues differently, and this has led to misunderstandings on the exact factors affecting fisheries in the lake. Part of the discrepancies can be further explained, where by groups of researchers and stakeholders are focusing on totally different aspects and values, using different types of fisheries data to support their claims, intentionally or not, and ultimately interpreting different trends from the same

sets of data to state their understanding of the fisheries issues in the lake.

The perceptions on the current state of fish stocks in Lake Victoria are based on different sources of information, and a general poor understanding of what is expected when a fishery develops, either from the fishers or the scientific monitoring (catch data and hydro acoustics). It is therefore difficult to point out the possible drivers influencing individual fish catches and the declining stocks based on varying results from researchers for effective fisheries management in Lake Victoria.

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Appendix

1. Interview guide for the stakeholder analysis in Lake Victoria, Uganda.

1) What are some of the issues affecting Lake Victoria and its fisheries?
2) How is the state of fisheries in Lake Victoria in terms of catches?
3) Have the fish catches increased or declined? And why?
4) What do you think are the main reasons for the outcry among the fishers and the public?
5) What are the indicators for the given reasons?
6) What do you think about the current media reports, scientists and other stakeholders on the state of Lake Victoria and fisheries? Is the reporting genuine or biased to some extent?

2. Some of the plates taken during the field study in Lake Victoria, Uganda.

Plate I: Impounded immature Nile perch and big Nile perch fish ready for sale.

Plate II: Trucks waiting for fish at katosi landing site in Mukono district, Uganda

Plate 5: Middle men distributing ice to fishers for long night fishing trips at Katosi

landing site

Plate III: Nile perch swim bladder

Plate IV: Ggaba landing site- Kampala District

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