

**LAKE FISHERY SUSTAINABILITY: A SOCIO-ECOLOGICAL SYSTEM THINKING
AND APPROACH**

A LITERATURE REVIEW

Richard A Nyiawung
Department of Geography, Environment and Geomatics,
University of Guelph, Canada

October 2019



***Disclaimer:** This literature review was not peer-reviewed by the NRDN and does not necessarily reflect the position of the RPLC, the NRDN co-leads or their institutions.*

Table of Contents

| | |
|---|------------------|
| <i>ABSTRACT</i> | <i>1</i> |
| <i>1.0 Introduction</i> | <i>2</i> |
| 1.1 Why this Research? | 3 |
| 1.2 Research Questions..... | 4 |
| <i>2.0 Literature Review</i> | <i>4</i> |
| 2.1 The Great Lakes of Canada..... | 4 |
| 2.2 The African Great Lake | 5 |
| 2.3 Lake Fisheries Sustainability Challenges..... | 6 |
| 2.4 Indigenous knowledge and Adaptive management of fisheries | 7 |
| 2.4 Current Knowledge Gaps..... | 8 |
| <i>3.0 Conceptual Framework</i> | <i>9</i> |
| 3.1 Socio-ecological Systems, Knowledge and Sustainability..... | 9 |
| 3.2 Institutions and Common-pool Resources | 10 |
| <i>5.0 Expected Outcomes</i> | <i>11</i> |
| <i>6.0 Research Significance</i> | <i>12</i> |
| <i>7.0 Beneficiaries of the research</i> | <i>12</i> |
| <i>References</i> | <i>13</i> |

ABSTRACT

Lake-based fisheries play a significant role in terms of food security, livelihoods, culture, and well-being of the millions of people who rely on the resource for varying purposes. Many local and indigenous coastal communities have for several generations lived and depended on fishing as their principal economic activity and have passed down their fishing knowledge, skills and expertise over time. However, with considerable effects from environmental change, human anthropogenic activities, and mismanagement, lake-based fishery resources are rapidly depleting and deterioration at rates that might not satisfy and meet the demands of our growing population. With such a scenario, issues of complex food systems, livelihood, employment and sustainability of the resource remains a challenge and problem within these communities. This paper provides a schematic literature review of the Great Lakes of Canada and the African Great Lakes local fishing communities as a complex and changing socio-ecological system and landscape. An understanding of how people are using their local fishery, how it interacts with other aspects of their food system and security, and how this relates to the human/ecology and sustainability of their practices is very important. The paper creates a foundational and socio-systematic thinking approach for the complex analysis of the socio-ecological system of lake-based fishing communities and to further understand challenges within this system and its contribution to the global debate on adaptation, sustainability and the effects on livelihood, food security and well-being of communities depending on the resource.

1.0 Introduction

Factsheet of the United Nations Ocean Conference – 2017 shows that almost 2.4 billion people (approximately 40% of the world's population) live and have access to the coast (United Nations, 2017, p. 1). Amongst this, the Great Lakes of Canada (constituting – Lake Superior, Lake Huron, Lake Michigan, Lake Erie and Lake Ontario) has a population of approximately 8.5 million Canadian living around the Canadian portion of the Lake (Canadian Geographic, 2019:2). The African Great Lakes, on the other hand, constituting of Lake Victoria, Lake Tanganyika, Lake Malawi, Lake Albert, Lake Kivu and Lake Edward, has a population of approximately 107 million people (www.cs.mcgill.ca). Fishing for several decades remains a principal activity, way of life and livelihood source for communities who have access to the resource and its coastline. Whether be it either coastal lake-based communities in North America or Sub-Saharan Africa, the attachment of fishers and their communities to fishing activities significantly shapes the socio-ecological system of these lakes, and food security, and their livelihood. Locally caught seafood has the potential to address food security problems within many coastal communities as their diets constitute a reasonable portion of fish or fisheries products (Loring, Gerlach & Harrison, 2013:15). However, as many scholars (e.g., Brinson; Lee & Rountree, 2011; Paolisso, 2007) argue, fisheries are usually absent on the agenda for most food security forums and debates, although, through actions of food activists and movements, current trends and discussions on the potential of seafood in addressing food security has been on the rise. The recent 2018 State of Food Security and Nutrition world report shows that more people keep going hungry with a ratio of about one in nine people being hungry/malnourished (FAO, IFAD, UNICEF, WFP and WHO, 2018). With such challenges in food and nutrition, and with about 40% of the world's population living around or having access to the coast, it is unarguable that fisheries and seafood are vital in addressing food insecurity as it constitutes a significant component of various local community food systems especially of rural indigenous communities around the world.

Predominantly, small-scale artisanal fisheries (SSF) especially lake-base or from other coastal fisheries sources contributes and provides a significant production amount to the world's seafood that we consume or use for varying purposes and economic activities with almost half as much quantity as commercial or industrial fisheries (Sharma, 2011). That is to say, there are enormous potentials for SSF in terms of employment, income generation and as a food source for the thousands who depend on it. However, although there exist these potentials, issues of overfishing, illegal, unregulated and undocumented fishing (IUU), amongst other challenges have impacted the sustainability of fisheries and a constant decline in fish stock globally (See Godfray et al., 2010; Pauly, Watson & Alder. 2005). Contending issues of sustainability and the current trends of vulnerabilities to climate change effects has been a complex challenge for most researchers or policymakers to quintessentially discuss fisheries and seafood as a significant resource that could be dependable or to resolve some of the food insecurity issues (Loring, Gerlach & Harrison, 2013; Hilborn et al., 2015). Since the 1980s, there has been a constant decline of global fisheries stocks due to overexploitation, the use of more complex and advanced technologies for fishing, and poor management. The sustainability of the resource is at risk (Hilborn et al., 2001). Critical scholars (e.g., Worm et al., 2006; Clausen & Clark, 2005) argue that poor management and governance are the root causes of these deteriorating fisheries stocks.

The last decades have witnessed the introduction of several international and national policies on the management of fisheries resources and market-focused initiatives. Many governments, especially those in the global south, for example, prioritize the option of privatization as a means to ensure proper management of the resource by those they consider having the required expertise and resources and can afford to pay and access the resources (Béné & Friend, 2009). On the other hand, fishery management is confronted with the proliferation of market-based mechanisms through eco-certification to ensure the sustainability of the resource through price premiums for sustainable practices. Through fisheries certification, fisheries stakeholders enter into and follow the certification procedures and guidelines by established organizations (mostly private and NGO led) to achieve their ecolabel and chain of custody and the garnering of price premiums as a reward mechanism (see for example the Marine Stewardship Council). But as Foley and McCay, 2014 argue, this market-based approach to fisheries management sets in new rules and new forms of ‘privatize property rights’ to a common-pool resource like fisheries. That said, the issue of access to fisheries resources and fishery enclosure has brought in a significant challenge for communities who own the resources and now been deprived of their collective rights and management of their fisheries. However, the precedent amongst other issues such as overfishing and degrading fish stocks sets as a point of departure for this project as to how this contributes or affects community food systems, sustainability and food security of communities who are attached to their fisheries for their livelihood.

Great Lake fisheries (the Great Lakes of Canada and the African Great Lakes in this context) have experienced significant stock depletion from overfishing, alongside a drop in the lake's size and capacity over the years (Ogutu-Ohwayo et al., 1997). Pressures from commercial or local fishers have resulted in overexploitation of the resource as fishing is a significant economic activity for many of the inhabitants (See Jamu et al., 2011). The varieties of fish species serve as a vital food source for many coastal inhabitants and constitute a significant component of the food systems for the increasing human population around the Lakes. Overfishing and demand for the resource have resulted in drastic reduction and even depletion of the ecosystem of some lake fisheries species. Undoubtedly, the depletion of fish stocks in these areas has a direct impact on the people whose generation has lived and depend on these resources for food (food systems), socio-ecological aspects (culture and traditional knowledge as well as their economic activity). The sustainability of Lake fisheries is essential. It sets a good foundation for human-ecology interaction and analysis with the use of not only scientific knowledge but also local/traditional knowledge.

1.1 Why this Research?

Lake fisheries, as outlined above, is a natural resource with enormous potential. From the attachment of people to their environment, fishing plays a vital role in enhancing social cohesion as it connects communities and as knowledge on how to use and manage the resources goes down from one generation to the next. Fishing serves as an essential economic activity, income generation and, most importantly, a significant part of their community food system as it serves as a food source for the millions of people who depend on it. This research aims to contribute to the burgeoning body of literature on adaptation, resilience, and sustainable livelihood challenges faced by small-scale fishing households and their communities. They are challenged and exposed not only to declining fisheries stocks but also limitations to their fishing activities,

access to the resource and access to market opportunities, which has been monopolized in most cases by larger corporations (Hébert, 2014). For better continuity, the sustainability of the resource is very crucial and strongly depends on how much we know and implement both traditional and scientific knowledge in the management of this resource. Those affected and whose generation has lived and depended on these resources are key stakeholders in these processes. Their food system, food choices income, and livelihood all depend on the resources and directly reflects on the well-being of the people. A research focus on coastal fishing communities around the Great lakes will help explore the various sources of household income, food choices, and how they are currently doing to curb the challenges of sustainability.

1.2 Research Questions

Our understanding of how lake fisheries shape and define the food system of fishing communities and how it affects aspects of their livelihood and well-being is very important as environment and societies keep changing. The focus on people who depend on fishing as their principal economic activity, and their access rights to the resource creates a broader understanding of the socio-ecological dynamics within lake fisheries systems. A major consideration will be on how the people are coping with the issues of depleting fish stocks and the ecosystem and how these have impacted their lives. This leads to the following research questions:

- a. How are communities adapting to environmental changes?
- b. How do these changes affect their livelihood (food security, employment etc.)? and
- c. What are some of the policies or fishery governance mechanisms within these coastal communities?

2.0 Literature Review

The burgeoning body of literature on environmental change and how it affects other aspects such as food security and livelihood has begun to include discussions and debates on the significant contribution of fisheries especially small-scale as an essential component of community food systems and its importance to local livelihood and well-being. Although contend with issues of overexploitation and stock depletion, the sustainability of the resources remains very crucial for the billions of persons and communities depending on it. This section critically discusses the current trends and gaps in the available literature on Lake fisheries, Lake fisheries sustainability and the nexus between fishing, sustainability, and food security.

2.1 The Great Lakes of Canada

Located in North America, the Great Lakes of Canada constitutes part of the Laurentian Great Lakes bordering both the United States and Canada. It comprises of five major lakes namely Lake Superior, Lake Michigan, Lake Heron, Lake Erie, and Lake Ontario. The Great Lakes are made up of more than 179 fish species which have been harvested for several century/decades by the native inhabitants of the area and the later arrivals of Europeans who settled in the area (Coon, 1999). However, Regier et al. (1999) posit that overfishing in the area from

indigenous/aboriginal activities, local or commercial fishing of fish for food amongst other recreational fisheries activities has impacted tremendously of the depletion of fish species and severe threats to its natural ecosystem. Aboriginal inhabitants have been inhabitants of these Lakes for so many years, where fishing constitutes their way of life and their attachment to fishing for various cultural purposes and also as a significant component of their food system especially as family food, although more subsistence nature (Liuson, 1997; Cleland, 1982). Fish equally serves as a commercial commodity that could be exchanged for other goods and services within the community. Access right was strictly locally controlled by various native bands and local management communities until the late 1990s when commercial fishers, through government policies, started fishing in the area (See Jewiss, 1992 in Regier et al., 1999).

Unarguably, as Whillans and Berkes (1989) noted, the introduction of commercial fishers and their sophisticated fishing gear and technology has worsened the issues of overfishing in the Great Lakes and numerous conflicts and fishing rights. Liuson (1997) outlines that “Aboriginal fisheries are found on all of the Canadian Great Lakes except Lake Erie. There are two First Nations fisheries on Lake Ontario, two on Lake Heron, and five on Lake Superior” (p.3). The indigenous inhabitants’ fishing activities are mostly subsistence and fish are used chiefly for family consumptions and other cultural/traditional activities depending on the species and the ceremonial event (Berkes, 1990). These claims on the attachment of coastal communities to fishing espouse the arguments on the importance of fishing/fisheries to the community food systems of its residents and how it assists in addressing food security issues and livelihood. But, relatedly, there are also licensed commercial local Aboriginal fishers who operate commercially, although recently, their numbers are comparatively meagre to the number of native licensed commercial fishers working in the area and who account more to total fish harvest per year (Legg, 1994 in Liuson, 1997).

2.2 The African Great Lake

The African Great lakes comprise of Lake Victoria, Lake Tanganyika, Lake Malawi, Lake Albert, Lake Kivu and Lake Edward and have a total population of about 107 million people living and depending on the resource (Ogutu-Ohwayo et al., 1997). Many countries in Africa have access to these lakes, and the lakes, over the years, have witnessed increase exploitation from an increasing human population. Lake Malawi, for example, is amongst the deepest lakes in Africa and constitutes more than 700 fish species. Like most of the other Great Lakes, the African Great Lakes has enormous fishery resources that serve as a source of dietary proteins for most of the inhabitants around the lakes. Fishing equally contributes to the livelihood of many Africans who have direct access to the resource (Hara & Njaya, 2016). Sustainability of the African Great Lake fisheries, just like those in North America since the 1970s, remains a significant challenge (Ogutu-Ohwayo et al., 1997). There is a drastic decline in fish stock as catch volumes keep declining while the population demanding the resource keeps growing. The market value of most of the African Great lakes'lakes' essential species has been on a decline, and the stocks are rapidly declining compared to three decades back (Hara & Njaya, 2016). Considering the attachment of the people in this area (especially the rural communities) to fishing as their source of livelihood, most lake fisheries are open access, which acts as safety nets for most of its resource-poor inhabitants (See Jul-Larsen et al., 2003). The management of the resource to ensure its sustainability is very critical

too for the short and long run, especially with the rapidly growing population that depends on the resource for their livelihood.

Many scholars have advanced in their various scholarship discourses on the different type of management system that operates for these lakes (e.g., Hara & Njaya, 2016; Njaya, Donda & Béné, 2012). Whether right based management or co-management, each governance options have both advantages and disadvantages. For example, co-management within the fisheries context, advocates for management of the fisheries between the government and organized fishing groups/communities based on equal power-sharing agreements or the terms ascribed to both parties (Sen & Nielsen, 1996). Right based management on the other hand outlines the provision for exclusive use and management rights of fisheries by a fishers' group or group of fishers which by law gives them the legal right and power over their fishing activities for their own benefits, through forms of individual transferable quotas (ITQs) etc. (Sumaila, 2010). However, within the context of developing countries, these management options outlines above are usually challenged with inadequate financing, lack of appropriate technology and expertise and pressures from international donors who most at times dictate best management options or procedures (Njaya, Donda & Béné, 2012). African Great Lakes, amongst the many other lakes in the world, suffers from weak management systems and the continued effects of anthropogenic human activities on these lakes as the human population keeps increasing (Jamu et al., 2011). With such a scenario, the depletion of the lakes directly affects the millions of people who depend on it for their livelihood.

2.3 Lake Fisheries Sustainability Challenges

The sustainability of most lake fisheries remains at stake. Growing populations and failures in agricultural land to meet productivity expectations have exerted enormous external pressures from new entrants to lake fisheries resources, amongst other issues such as over-fishing and poor management (Geheb & Binns, 1997). Such constraints on fisheries arise from numerous reasons, that is, just one reason, the quest to meet household income, dietary protein needs and sustainable livelihood by those living around the lake (Cohen & Foale, 2013). For example, most of the fish (cichlid) species in Africa's Great Lakes are going extinct and experiencing a drastic decline in catch volume from the usual overexploitation and the overtime introduction of invasive fish species (Witte et al., 1992). Relatedly, the Great Lakes of North America are equally going through similar trends of stock depletion and overexploitation and the presence of parasitic or invasive species (Ogutu-Ohwayo et al., 1997; Liuson, 1997). This can be seen by the introduction of industrial fishing trawls in Lake Malawi since the 1970s has exacerbated the decline of cichlids species as they are being harvested and used in fish trade (Turner, 1977 in Ogutu-Ohwayo et al., 1997). Espousing this claim, Alimoso et al. (1990) equally argue that the introduction of these industrial trawls in the lake has accounted massively for the depletion and degradation of the habitat of other fish species such as catfishes.

On the part of Africa's Great Lakes, growing human population and human activities possess a severe threat to the sustainability of its lake fisheries resources and clean water sources. There has been a rapidly growing community around the lakes, which has more than doubled the population size in the early 1980s (Cohen et al., 2016). Human activities such as farming and livestock rearing have aided in the pollution of the lake, including the increasing number of fishers

that depend on the lake for their daily subsistence. As Ogutu-Ohwayo et al., 1997 noted, most of Africa's Great lakes, which constituted a rural setting, are rapidly changing to urban centers with substantial commercial and tourism activities taking place, owing to its economic potentials. The Great Lakes of Canada, on the other hand, is equally faced with similar trends in sticks depletion and fish habitat degradation (See Liuson, 1997). The entrants of European fishers in the lake and the provision and open access to commercial licenses and commercial fishing with sophisticated technology and tools have increased the external pressures on the lake's ecosystem from overfishing. Many species in most of the lakes have witnessed drastic physiological changes or extinction (Johnson, Ross & McCullough, 2000). Also, the pollution of the lake by industrial wastes, recreational activities amongst others has consistently increased concerns on its sustainability (Rabe, 1997). First Nations or the indigenous people in the area are usually excluded from the management decisions of the lake, failing to take into consideration their local traditional knowledge on how they have been using the resource (See Beckford et al., 2010).

2.4 Indigenous knowledge and Adaptive management of fisheries

Unarguably, pressures or stresses on natural resources, especially from the effects of climate change, are often felt directly by small communities at various levels, that is, economic, social or environmental (Khattabi & Jobbins, 2011). These stresses for small-scale fishery communities, for example, has been on the increase and continuously increases the vulnerability and more impoverished living conditions and livelihoods for the many small-scale fishers who depend on the resource. In sustaining their livelihood and the culture of fishing, many local indigenous fishing communities, through the use of Traditional Ecological Knowledge (TEK), are taking innovative measures on how to effectively manage their fisheries adaptively to the numerous existing challenges (Berkes, Colding & Folke, 2000). TEK has been very instrumental in the management of resources within complicated situations ranging from conservation of biodiversity, ecological processes and the establishment of protected areas (Johannes, 1998; Gadgil, Berkes & Folke, 1993). Many contemporary scholarly publications have outlined different definitions and importance of TEK in resource management. Most prominently, Berkes, Colding & Folke (2000), TEK is "a cumulative body of knowledge, practice, and belief, evolving by adaptive process and handed down through generations by cultural transmission and relationship between humans and the environment" (p.1245)

TEK constitutes some aspects of adaptive management together with other rigorous scientific methods and processes for fishery management. Considering the rapid deterioration and decline of fisheries resources, adaptive management through the reduction in the fish catch is assumed to allow recovery of stocks and enable an increase in productive fish sizes (Ben-Hasan, Al-Husaini, & Walters, 2017). However, many scholars (for example, Pauly, Hilborn & Branch, 2013; Hutchings, 2000) argue that there is no clear evidence as to how the reduction in fishing can facilitate stock recovery. Although with such critics, management through complete fishing enclosure amongst others has helped improve the health and sustainability of fisheries (Pauly, Hilborn & Branch, 2013). TEK, as an option for adaptive management, has been very instrumental in the management and use of fisheries resources, especially as knowledge and techniques, are being passed down for several generations. Berkes (1989) posits that the incorporation of 'local social mechanism' through local institutions is a key distinctive difference between TEK adaptive management from the usual conventional or scientific methods.

The establishment of local institutions that promotes the sharing of local knowledge within communities is an effective way to engage local people into the management of the resources that sustain their livelihood. Here, local institutions are regulated by recognized leaders who set rules and mechanisms in which resources are used in the community, and several generations uphold these principles. Berkes, Colding, and Folke (2000, p.1253), in their issue, summarise the use of TEK in resource management to follow the following procedures usually overlooked by the conventional methods. These include: (1) the use of ecological knowledge through monitoring of changes in the ecosystem, species protection, habitat and the control of harvest; (2) Species management through resource rotation and succession management; (3) incorporation of social mechanism for resource management through the establishment of local institutions and leadership, local rules and regulations and the transition of knowledge from one generation to the other. Overall, adaptive management through the use of TEK for fisheries management deals with the use of local institutions, leadership (social mechanisms) and the use of local knowledge for the better use of fisheries resources that ensures its sustainability and the enhancement of better livelihood amongst people in a particular community. However, state policies and regulations may also interplay to shape the way local people use the resource and the involvement of commercial fishers, too, which increases the complex nature in the management of the resource.

2.4 Current Knowledge Gaps

Fishing and gaming serve as a way of life, community activity, family food source and livelihood for many indigenous (aboriginal) populations around the world such as those in the North of North America (See Loring & Gerlach, 2015; Loring Gerlach & Harrison, 2013). Their community food systems and healthy living are highly dependent on their attachment to the coast for various socio-cultural and economic reasons. Unarguably, the same goes for many local indigenous communities living around lake fisheries. The Great Lakes of Canada, including those of the African Great Lakes, comprises of several indigenous community settlers who have lived their lives from generation to generation in the same area. Fishing activities equally forms part of their culture, household food source, amongst others. However, for decades now, debates on the sustainability of lake fisheries resources have been on the rise with many commissions and legislative bodies created to ensure sustainable use and management of the lakes (e.g. The Great Lakes Fishery Commission; The Lake Victoria Basin Commission). Many fish species are becoming extinct, habitats degraded, overfishing from commercial fishers and a rising population depending on fish as a primary protein source raise so many issues. That said, little is known as to how these current trends affect or interact with the human-ecology and food systems of these communities, their access to healthy food, specifically locally-caught fish, and the ongoing management options. We know so much about the various conventional methods of fisheries management and policies. Still, little is known or been advocated for on the relevance of local traditional knowledge in the management of natural resources. Summarily, this research will explore and contribute to the current body of literature on the community food system and explore how traditional knowledge can be useful in ensuring the substantiality of lake fisheries resources, especially for inhabitants around the Great Lakes.

3.0 Theoretical Framework

There do exist a plethora of related theoretical approaches often used by many scholars in their discourse on natural resources management and resource use. The theoretical debates such as Berkes, Folke and Colding (2000) on ecological and traditional systems/knowledge for resource management; Ostrom and North (1991) on new institutions and common-pool resources are some related examples.

3.1 Socio-ecological Systems, Knowledge and Sustainability

Berkes, Folke and Colding (2000) in their book on *Linking social and ecological systems* debate explicitly the importance of utilizing and including humans through local or traditional knowledge sharing in resource management discourses rather than just relying on scientific propositions or findings. They succinctly articulate how social and ecological systems linkages approach to resource management are a more plausible and sustainable approach. Berkes, Folke, and Colding (2000) define “social systems are systems that deal with property rights, land and resource tenure systems, systems of knowledge pertinent to environment and resources, and world views and ethics concerning environment and resources, while ecological system refers to the natural environment or ecosystems” (p.4). The inclusion of humans is the major aspect underpinning their theoretical debates on resource management. The role of humans within this context implies their local or traditional knowledge, which they have learned and has been passed down to them from generation to generation. The oft-quoted contribution of local people in resource management is usually construed on the type of knowledge and information they possess about a particular ecosystem they live in, which is commonly referred to in many scholarly works as traditional ecological knowledge (TEK) (Warren, Slikkerveer & Brokensha, 1995).

Ruddle et al. (1992), in their issue, use Fiji ‘Vanua’ concept to elaborate the interrelations between human-nature (social systems) with land, water, and the environment as a single and unified unit of interactions and relationships. Relatedly, debates on how institutions shape the governance of common-property rights and access through social, economic and political organizations rely on the understanding of the relationship between humans (social groups) and the carrying capacity of the ecosystem around them (Berkes et al., 2000). However, from a more ecological economics perspective, natural resources have been commodified and a price attached to it (natural capital), although there are several debates as to how these assists in the management of the resource (Costanza, 2006). Contextualizing the human factor, Berkes, Folke, and Gadgil (1994) argue that there should be another component known as cultural capital since humans create and operate institutions that govern these natural resources. Constant changes in the ecosystem over time, however, makes it more difficult to accurately predict or provide room for researchers to speak confidently on a particular socio-ecological context and dynamism (See Hilborn & Ludwig, 1993). Unpredicted and overexploitation of resources within an ecosystem equally makes it harder to discuss changes and current trends in the area accurately. Considering such a scenario of unpredictability, scholars (Walters, 1986) have posited adaptive management as a tool or strategy that handles such situations and examines the relationship between humans and the ecosystem as they all evolve and change over time. To Holling (1978), policies regarding resource management can be constructed as a continuous experiment in which policymakers keep learning, with the quest to find out how people in the different environments do depend on the available

institutions and social setting. Lee (2001) articulates this system as an adaptive management strategy that relies on feedback from individual actions and their environment and one that shapes policy decisions depending on the sustainability of the resource.

Conceptualizing the interaction between social and ecological systems for a resilient and sustainable natural resources management, Berkes, Folke and Colding (2000:16) categories this relationship into four broad concepts, that is an ecosystem, people and technology, local knowledge and property rights institutions. First, ecosystem analysis deals with the more general discussions on either the physical or biological characteristics of a particular environment (lake fisheries in this context). Physical characteristics entail the various variations in the seasonal temperatures or fishing seasons in the areas, while the biological relates to the productivity of the lake, species interaction and their growth patterns, which are their biotic and abiotic considerations (See Holling et al., 1995). Notwithstanding, as Folke, Holling, and Perrings, 1996 noted, there are other living organisms aside from fisheries that live within this ecosystem and equally contribute to the functionality of a proper food chain in the system. Thus, biodiversity consideration is significant for sustainability. However, as earlier explained, ecosystems are open to variability and unpredictable situations, which makes it very difficult for new analysis and making definite conclusions.

Second, people and technology constitute and describe the social system and the level of technology being in the area for fishing activities. The social network goes beyond individual characterization but to the total number of people who make up a small community or social group (this could be tribal groups, district, or even a region). The size of the community, depending on the case, influences the use of technology. Small-scale inshore fishing communities will employ smaller technology for the exploitation of fisheries and within a certain surface area compared to a larger-scale offshore fishing community. Therefore, the type of technology being used directly relates to the sustainability of the resource and how resources are being used within the community. Third, local knowledge in its entity embodies a vital component of any sustainable natural resources management system, especially for a resource like fisheries. Local indigenous fishers, whether in Canada or Africa, do have local knowledge in the management of the resources which have often pass on this knowledge from one generation to the next. They possess what many scholars describe as traditional knowledge, which refers to how local communities use cultural methods in the management of their natural resources. Finally, property rights institutions deal with various ways in which established institutions manage resources. These range from state property rights regulated by government or private property rights governed by the market/neoliberal principles and the rising trends of co-management regimes where communities have the powers to manage their resources in a form for common property right management system. The latter system is the focus within this context as all the rights and management responsibilities are on the people themselves who define and set the fishery rules. However, as scholars argue, each of these management regimes comes with its pros and cons in resource management.

3.2 Institutions and Common-pool Resources

Theoretical debates on natural resources management (fisheries in this context) have elaborated through the lens of new institutional economics (NIE) and the common-pool resource's

dimensions. This theoretical approach critically examines the mainstream discourse on how individuals and institutions interact together for the management of a common resource. Major scholars on this front, for example, North (1991) and Ostrom (1990), have discoursed extensively how aspects of institutions, self-interest, and elements of property rights facilitate or makes complex the governance of natural resources. To North (1991), “institutions are the humanly devised constraints that structure political, economic and social interactions through either informal constraint (customs, codes of conduct) or formal rules (property rights, and laws)” (p.97). Institutions act as rule-setters in shaping human interactions and assist in defining economic activities within societies through various choice set for production cost, and reward mechanisms (Hall, 1997). Procedures for incentives are instituted and enforced through the use of different instruments by these institutions in the economy in a manner that directs economic growth amongst other microeconomic parameters.

However, the state is crucial in the enforcement of individual contracts and their effectiveness in negotiation processes, depending on the type of trade, be it at the local or capital markets. In capital markets, as North explains, the security of property rights through systems that avoid the seizure of property or controlled access, especially for the common is paramount no matter how these properties are acquired (North, 1991, p. 101). Unlike the state, institutional enforcement could either be through self-enforcing standards or the involvement of third-party. The state should regulate third-party participation in principle through its political structure and how these established structures provided room for better enforcement of contracts and property rights in such economies (Clague et al., 1999). North (1991) debates the arguments by Williamson (1985) that the concept of NIE should be a combination of “not only a theory of property rights and their evolution but a theory of the political process, a theory of state, and of the way in which the institutional structure of the state and its individuals specify and enforce property rights” (p.233)

Generally, NIE is position in the manner in which political and economic institutions define the choice set for humans, the changes in this choice set with time and the availability of alternatives guided by political decisions and property rights for the people. Further, Alchian and Demsetz (1972) see individuals forming organizations as means to get more rewards from their different expertise and division of labour either voluntarily or by force depending on the terms of the agreement or exchange; thus, organizations are a combination of several individual contracts. However, this organization within the institutional framework can be perceived as either creating channels for maximizing outcomes or the misappropriation of resources and creating changes in property rights depending on the political structure governed by the state and on the different individualistic interests.

5.0 Expected Outcomes

The question of whether people/communities living around the Great Lakes, have access to healthy food, specifically locally-caught fish, and how this shape their food system is an important issue to be looked upon. It is expected that with declining fish stock, depleted fish habitats, increases in commercial fishing and an increasing human population affect the sustainability and capacity for these lakes to meet its expectations, especially those of local inhabitants. With such challenges, it will not be surprising to see the food systems and food options of these locals being affected or compromised. Although environmental shocks from climate

change, over-fishing directly affects lake fisheries sustainability and productivity, access rights to this resource and the various management options are important factors defining the sustainability of the resource and how it can continue to serve those depending on the resource in the future. Unfortunately, rising demand for fish for family food or as an economic activity that contributes to household income continues to increase while productivity keeps falling. Various management methods are proposed through rigorous scientific findings, but the sustainability of the resource remains at stake. However, considering the long line of generations who have to live in these coastal communities and are attached to the lakes not only for fishing but for other socio-cultural activities, assumable local traditional knowledge, if appropriately integrated, could provide a workable solution on how to better manage lake resources. It is equally expected that limited access to the fisheries and limited harvest quantities directly relate to household incomes, especially for families who rely on fishing as their primary economic activities. With limited incomes, family food options become a challenge and could also affect their health and well-being. That said, the study should be an open dialogue for sustainable ways in which the fisheries resources productivity could be maximized; the incorporation and acknowledgment of traditional knowledge is an appropriate management option. An objective criterion will be to properly understand their food sources and opportunities, especially for household who depend on fishing.

6.0 Research Significance

The global discourse on fish stock depletion, overfishing, illegal unregulated and undocumented (IUU) fishing, always focuses on how it affects the GDP of countries, its effects on licensed commercial fishers amongst many others. However, the debates, including even those of the recently held Blue Economy Conference, failed to pay particular attention to how these are affecting the food systems, health and well-being of small-scale fishing (SSF) communities who live and depend on fishing for their livelihood. This research seeks to explore and assess how communities are reacting to environmental changes, their various food choices/options, the availability of healthy locally-caught fish and the household incomes for the many SSF communities who are attached and depend on fisheries resources for numerous reasons (both socio-cultural and livelihood). An understanding of the human-ecology, their food system will help provide evidence that speaks to issues of sustainability, food security and healthy living within these communities and as to how interventions and stakeholder's involvement could be well coordinated. Another key significance of this research is to raise and bring out the debates on how local traditional knowledge possessed by the local communities could be a significant and integral part of a sustainable fishery management system. Understanding and incorporating the traditions of these people within the countries is the first step to any sustainable management plan in the area. Summarily, this study will help generate evidence for programmatic and policy actions that will strengthen community food systems and lake fishery sustainability, which will ultimately be important in solving the global and continuous challenges of food insecurity, hunger, and malnutrition around the world.

7.0 Beneficiaries of the research

Currently, there does exist little or no scientific literature within lake fisheries discourses that comparatively examines issues of food security and lake fisheries sustainability and management for communities living in both the global north and global south. Although

variation does exist in terms of institutional, political, development and social qualities, the attachment of these local and indigenous communities to fishing as a source of their livelihood, culture and the passing down of knowledge between several generations are similar. With such considerations, this research will benefit the scientific community, fishing communities, NGOs and governments directly. Especially from an international development perspective, many lessons could be learned by both cases on how local communities can advance sustainable fishing practices, food security, and livelihood issues in a changing climate and society. The research hopes to commence a north-south scholarly and policy discourses on aspects of food systems and local knowledge amongst these similar groups of persons with cultural and livelihood attachments to fishing.

References

- Alchian, A. A., & Demsetz, H. (1972). Production, information costs, and economic organization. *The American economic review*, 62(5), 777-795.
- Alimoso, S. B., Magasa, J. H., & Van Zalinge, N. (1990). Exploitation and management of fish resources in Lake Malawi. *Fisheries of the African Great Lakes*, 83-95.
- Beckford, C. L., Jacobs, C., Williams, N., & Nahdee, R. (2010). Aboriginal environmental wisdom, stewardship, and sustainability: lessons from the Walpole Island First Nations, Ontario, Canada. *The journal of environmental education*, 41(4), 239-248.
- Béné, C., & Friend, R. M. (2009). Water, poverty and inland fisheries: lessons from Africa and Asia. *Water International*, 34(1), 47-61.
- Ben-Hasan, A., Al-Husaini, M., & Walters, C. (2017). Adaptive management of declining fisheries: When is it worth trying to rebuild stocks through fishery regulation? *Marine Policy*, 85, 107-113.
- Berkes, F. (1989). *Common property resources. Ecology and community-based sustainable development*. Belhaven Press with the International Union for Conservation of Nature and Natural Resources.
- Berkes, F. (1990). Native subsistence fisheries: a synthesis of harvest studies in Canada. *Arctic*, 35-42.
- Berkes, F., Colding, J., & Folke, C. (2000). Rediscovery of traditional ecological knowledge as adaptive management. *Ecological applications*, 10(5), 1251-1262.
- Berkes, F., Folke, C., & Colding, J. (Eds.). (2000). *Linking social and ecological systems: management practices and social mechanisms for building resilience*. Cambridge University Press.
- Berkes, F., Folke, C., & Gadgil, M. (1994). Traditional ecological knowledge, biodiversity, resilience and sustainability. In *Biodiversity conservation* (pp. 269-287). Springer, Dordrecht.
- Brinson, A., Lee, M. Y., & Rountree, B. (2011). Direct marketing strategies: the rise of community supported fishery programs. *Marine Policy*, 35(4), 542-548.
- Canadian Geographic (2019). Watersheds. Available at http://www.canadiangeographic.com/atlas/themes.aspx?id=watersheds&sub=watersheds_flow_thegreatlakes&lang=En, last accessed on 18/10/2019

- Clague, C., Keefer, P., Knack, S., & Olson, M. (1999). Contract-intensive money: contract enforcement, property rights, and economic performance. *Journal of economic growth*, 4(2), 185-211.
- Clausen, R., & Clark, B. (2005). The metabolic rift and marine ecology: An analysis of the ocean crisis within capitalist production. *Organization & Environment*, 18(4), 422-444.
- Cleland, C. E. (1982). The inland shore fishery of the northern Great Lakes: its development and importance in prehistory. *American Antiquity*, 47(4), 761-784.
- Cohen, P. J., & Foale, S. J. (2013). Sustaining small-scale fisheries with periodically harvested marine reserves. *Marine Policy*, 37, 278-287.
- Cohen, A. S., Gergurich, E. L., Kraemer, B. M., McGlue, M. M., McIntyre, P. B., Russell, J. M., ... & Swarzenski, P. W. (2016). Climate warming reduces fish production and benthic habitat in Lake Tanganyika, one of the most biodiverse freshwater ecosystems. *Proceedings of the National Academy of Sciences*, 113(34), 9563-9568.
- Coon, T. G. (1999). Ichthyofauna of the Great Lakes basin. *Great Lakes fisheries policy and management a binational perspective*. Edited by WW Taylor and CP Ferreri. Mich. State Univ. Press, East Lansing, MI, 55-72.
- Costanza, R. (2006). Nature: ecosystems without commodifying them. *Nature*, 443(7113), 749.
- FAO, IFAD, UNICEF, WFP and WHO. 2018. The State of Food Security and Nutrition in the World 2018. Building climate resilience for food security and nutrition. Rome, FAO. Licence: CC BY-NC-SA 3.0 IGO.
- Foley, P., & McCay, B. (2014). Certifying the commons: eco-certification, privatization, and collective action. *Ecology and Society*, 19(3).
- Folke, C., Holling, C. S., & Perrings, C. (1996). Biological diversity, ecosystems, and the human scale. *Ecological applications*, 6(4), 1018-1024.
- Gadgil, M., Berkes, F., & Folke, C. (1993). Indigenous knowledge for biodiversity conservation. *Ambio*, 151-156.
- Geheb, K., & Binns, T. (1997). 'FISHING FARMERS' OR 'FARMING FISHERMEN'? THE QUEST FOR HOUSEHOLD INCOME AND NUTRITIONAL SECURITY ON THE KENYAN SHORES OF LAKE VICTORIA. *African Affairs*, 96(382), 73-93.
- Godfray, H. C. J., Beddington, J. R., Crute, I. R., Haddad, L., Lawrence, D., Muir, J. F., ... & Toulmin, C. (2010). Food security: the challenge of feeding 9 billion people. *science*, 327(5967), 812-818.
- Hall, P. A. (1997). The role of interests, institutions, and ideas in the comparative political economy of the industrialized nations. *Comparative politics: Rationality, culture, and structure*, 174-207.
- Hara, M., & Njaya, F. (2016). Between a rock and a hard place: The need for and challenges to implementation of Rights Based Fisheries Management in small-scale fisheries of southern Lake Malawi. *Fisheries Research*, 174, 10-18.

- Hébert, K. (2014). The matter of market devices: Economic transformation in a southwest Alaskan salmon fishery. *Geoforum*, 53, 21-30.
- Hilborn, R., & Ludwig, D. (1993). The limits of applied ecological research. *Ecological Applications*, 3(4), 550-552.
- Hilborn, R., Fulton, E. A., Green, B. S., Hartmann, K., Tracey, S. R., & Watson, R. A. (2015). When is a fishery sustainable? *Canadian Journal of Fisheries and Aquatic Sciences*, 72(9), 1433-1441.
- Hilborn, R., Maguire, J. J., Parma, A. M., & Rosenberg, A. A. (2001). The precautionary approach and risk management: can they increase the probability of successes in fishery management? *Canadian Journal of Fisheries and Aquatic Sciences*, 58(1), 99-107.
- Holling, C. S. (1978). *Adaptive environmental assessment and management*. John Wiley & Sons.
- Holling, C. S., Gunderson, L. H., & Light, S. (1995). *Barriers and Bridges to the Renewal of Ecosystems*. New York: Columbia University Press.
- Hutchings, J. A. (2000). Collapse and recovery of marine fishes. *Nature*, 406(6798), 882.
- Jamu D, Banda M, Njaya F, Hecky R. 2011 Challenges to sustainable management of the lakes. *J. Great Lakes Res.* 37, 3–14. (doi: 10.1016/j.jglr.2010.11.017)
- Jewiss, T., 1992. Oral pact included hunting, fishing rights. *Peterborough Examiner*, Peterborough, ON, 1992 (July 24) B4.
- Johannes, R. E. (1998). The case for data-less marine resource management: examples from tropical nearshore finfisheries. *Trends in Ecology & Evolution*, 13(6), 243-246.
- Johnson, J. H., Ross, R. M., & McCullough, R. D. (2002). Little Galloo Island, Lake Ontario: a review of nine years of double-crested cormorant diet and fish consumption information. *Journal of Great Lakes Research*, 28(2), 182-192.
- Jul-Larsen, J. Kolding, R. Overa, J. R. Nielsen and P. A. M. van Zwieten (eds.). (2003). Management, co-management or no management? Major dilemmas in southern African freshwater fisheries. FAO Fisheries Technical Paper 462/1 & 2. Rome.
- Khatabi, A., & Jobbins, G. (2011). Vulnerability and adaptation of traditional fisheries to climate change. *World Small-scale Fisheries: Contemporary Visions*, 63.
- Lee, K. N. (2001). Appraising adaptive management. *Biological diversity: Balancing interests through adaptive collaborative management*, 1-26.
- Liuson, E. (1997). The Allocation of Commercial Fishing Rights within the Great Lakes, June 1997. *En ligne*: [http://www. environnementprobe. org/EnviroProbe/pubs/ev538. htm](http://www.environnementprobe.org/EnviroProbe/pubs/ev538.htm) (consulté le 30 mars 2006).
- Loring, P. A., & Gerlach, S. C. (2015). Searching for progress on food security in the North American North: a research synthesis and meta-analysis of the peer-reviewed literature. *Arctic*, 380-392.

- Loring, P. A., Gerlach, S. C., & Harrison, H. L. (2013). Seafood as local food: Food security and locally caught seafood on Alaska's Kenai Peninsula. *Journal of Agriculture, Food Systems, and Community Development*, 3(3), 13-30.
- Njaya, F., Donda, S., & Béné, C. (2012). Analysis of power in fisheries co-management: Experiences from Malawi. *Society & Natural Resources*, 25(7), 652-666.
- North, D. C. (1990). Institutions and a transaction-cost theory of exchange. *Perspectives on positive political economy*, 182, 191.
- North, D. C. (1991). Institutions. *Journal of economic perspectives*, 5(1), 97-112.
- Ogutu-Ohwayo, R., Hecky, R. E., Cohen, A. S., & Kaufman, L. (1997). Human impacts on the African great lakes. *Environmental Biology of Fishes*, 50(2), 117-131.
- Ostrom, E. (1990). *Governing the Commons: The Evolution of Institutions for Collective Action* (Cambridge University Press, New York)
- Paolisso, M. (2007). Cultural models and cultural consensus of Chesapeake Bay blue crab and oyster fisheries. *NAPA Bulletin*, 28(1), 123-135.
- Pauly, D., Hilborn, R., & Branch, T. A. (2013). Fisheries: does catch reflect abundance? *Nature*, 494(7437), 303.
- Pauly, D., Watson, R., & Alder, J. (2005). Global trends in world fisheries: impacts on marine ecosystems and food security. *Philosophical Transactions of the Royal Society B: Biological Sciences*, 360(1453), 5-12.
- Rabe, B. G. (1997). The politics of sustainable development: Impediments to pollution prevention and policy integration in Canada. *Canadian public administration*, 40(3), 415-435.
- Regier, H. A., Whillans, T. H., Christie, W. J., & Bocking, S. A. (1999). Over-fishing in the Great Lakes: the context and history of the controversy. *Aquatic Ecosystem Health & Management*, 2(3), 239-248.
- Ruddle, K., Hviding, E., & Johannes, R. E. (1992). Marine resources management in the context of customary tenure. *Marine Resource Economics*, 7(4), 249-273.
- Schlager, E., & Ostrom, E. (1992). Property-rights regimes and natural resources: a conceptual analysis. *Land economics*, 249-262.
- Sen, S., and J. R. Nielsen. 1996. Fisheries co-management: A comparative analysis. *Mar. Policy* 20(5):405–418.
- Sharma, C. (2011). Securing economic, social and cultural rights of small-scale and artisanal fisher workers and fishing communities. *Maritime Studies*, 10(2), 41-62.
- Sumaila, U. R. (2010). A cautionary note on individual transferable quotas. *Ecology and Society*, 15(3).

- United Nations (2017): The Ocean Conference - Factsheet, New York, 5-9 June 2017. Accessed on 16/02/2019 from <https://www.un.org/sustainabledevelopment/wp-content/uploads/2017/05/Ocean-fact-sheet-package.pdf>
- Walters, C. J. (1986). *Adaptive management of renewable resources*. Macmillan Publishers Ltd.
- Warren, D. M., Slikkerveer, L. J., & Brokensha, D. (1995). *The cultural dimension of development: Indigenous knowledge systems*. Intermediate Technology Publications Ltd (ITP).
- Williamson, O. E. (1985). Reflections on the new institutional economics. *Zeitschrift für die gesamte Staatswissenschaft/Journal of Institutional and Theoretical Economics*, (H. 1), 187-195.
- Whillans, T. H., & Berkes, F. (1986). Use and abuse, conflict and harmony: The Great Lakes fishery in transition. *Alternatives*, 13(3), 10-18.
- Worm, B., Barbier, E. B., Beaumont, N., Duffy, J. E., Folke, C., Halpern, B. S., ... & Sala, E. (2006). Impacts of biodiversity loss on ocean ecosystem services. *science*, 314(5800), 787-790.