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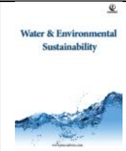

Research paper

Environmentally Induced Alternative Livelihood Strategies among the Artisanal Fishers of the Kainji Lake Basin, Nigeria

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A R T I C l E I N F O

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A B S T R A C T

Living in poverty-driven communities suffering from food insecurity that is escalated as a result of sub-standard exploitation, fishery resources, and other environmental challenges, small-scale Nigerian artisanal fishers have dominated the fisheries sub-sector. Sadly, environmental changes have reduced Kainji Lake's inflow levels from 393,369m/cu3 in 1994 to 307,231m/cu3 in 2011, accordingly reducing the fish yield by 24025 metric tons in the same period, which has put innumerable Nigerian beneficiaries livelihood at serious risk. The study aimed to devise and propose an adaptive strategy model using the concept of sustainable livelihoods approach. This study mainly depended on distributing questionnaires among thirty fishing communities as the data collection method and provided supplementary data from officials. The results indicated that a set of four livelihood activities yields optimum outcomes. This paper also discusses its implications.

Introduction

Environmental difficulties and mismanagement most severely harm fisheries operating on a small-scale. Worldwide, the supporting ecosystems have been poorly managed, and the overexploitation of fishery resources, aquatic contamination, and habitat destruction impose an estimated over $50 billion annual loss on the global economy (Tafida and Galtima 2016), jeopardizing about 8% of the global population, based on (Béné 2004, Allison, Adger et al. 2005), more than 520 million people, to whom fishery and aquaculture bring family and economic stability and food security. Developing countries are where the majority of such people live in horrible economic conditions.

Nigeria harbors many artificially-made lakes with national and regional importance, and the Kainji Lake is not an exception as it provides good economic and environmental support, especially for the riparian communities. Built mainly for hydroelectricity generation, the Kainji Lake has also had irrigational, navigational, and fishing-related applications. The Kainji Lake's rainfall and discharge patterns have undergone drastic changes during the years. Today, these new patterns are a huge source of concern for entities and beneficiaries of Kanji Lake, particularly the fishery sector, since these changes reduce yield and the locals' income, aggravating the fishers' already frustrating economic conditions by subjecting them to episodes of unemployment and poverty. Some have suggested that any improvement in the fishers' economic status requires rethinking accepted theories, approaches, sustainability definitions, and the evaluative indexes of managers' performance. The development and expansion of an adaptive and flexible strategy through the diversity of livelihood portfolios is a critical step to properly managing these impacts (Ellis 1999, Béné 2006, Tafida and Galtima 2016). Policymakers and decision-makers in different fields, including ecology, social sciences, have long reached an agreement stressing the cruciality of incorporating flexibility, resilience, and adaptability into the management of fisheries in Nigeria (Carpenter, Walker et al. 2001, Walker, Carpenter et al. 2002). More formally, resilience analysis suggests stressing mechanisms and proposing that support systems should address uneasiness and shocks and address uncertainty and risks. Accordingly, resilience by definition seems significantly fruitful for managing small-scale fisheries. Hence, the study becomes imperative to inform policy on the implications of the decline in fisheries following the hydrological regime's variation. The goal is to investigate the impacts of changes in hydro-climatic variables on fishing and the fishers' livelihoods and devise an adaptive strategy model for viable livelihood among the artisanal fishers.

The Study Area And Methods

A. The Study Area

Created in the late 1960s following the completion of the Dam at New Bussa, Kainji Lake was selected as the site of this study, located between longitude 90 50' -100 55' N and latitude 40 43' – 40 45' E. Kainji Lake is the largest artificial lake on Earth. The Nigerian government planned to use the Dam to generate clean hydroelectric power and boost local and national prosperity and bring economic development, although the impounded water provided Nigerians with new, unintended economic opportunities, especially for the Nigerian fishers. Kainji Lake principally relies on River Niger as its water source. The local rivers around the lake basin and Fouta Djallon highlands feed River Niger. Maximum 54.9 m deep with an area of 1,250 km^2, Kanji Lake, extends to 136.8 km upstream of the Yelwa area. Its water represents an annual fluctuation between 10-11 km, and its widest point is 24.1 km. Its surface temperature ranges from 23 to 31 C^o and has a catchment area of 1.6 × 10 km2 (Williams and Rota 2011). This river has two flood regimes; the black floods and the white floods. Niger's source and catchment water go on a 4,183 km journey to the Lake six months later, draining Timbuktu's Swamp along the way, causing it to lose 65% of its volume to evaporation and infiltration. After depositing in three swampy areas, the water regains its clarity, looking black from afar on its arrival at the Lake; thus, it is called the black flood, which occurs between December and March, and recedes in May-August when the white flood takes over. Every year, the white flood occurs between August and November. The high silt and mud content it flushes make it look milky and unclear. Reaching the peak around September, the white flood is significantly more voluminous than the black flood. It has a peak discharge of 4,000 cubic meters per second and levels down to 1,500 m^3/s in November when the black flood takes over again (Tafida and Galtima 2016). About 297 villages and camps whose residents' livelihoods solely rely on fishing and one temporary fishing camp around the lake basin and the Islands have been documented (Abiobun and Niworu 2004).

B. The Nation's Socio-Economic Background

Relevant research on the Lake basin indicated the people's socio-economic characteristics as most fishers belonged to the Sarkawa sub-tribe of the Kebbi Hausa and (Ayanda and Alamu 1991) illustrates other tribes: Laru *Gungawa*, *Lopawa*, and *Nupes.* The *Hausa* and *Nupe* tribes are dedicated fishers and recently turned to farming, husbandry, and small-scale trading. (Hollowed, Kim et al. 2013, Tafida and Galtima 2016). Based on (Ayanda and Alamu 1991), the Hausa's monopolized the occupation due to their long attachment. Other full-time fishers include *Zabarmawa*coming from Mali and Niger Republics. Conventionally, fishers can also have other income sources, such as farming, animal husbandry, and traditional and local crafts such as pottery, mat weaving, gear/craft making, and servicing (Alamu and Mdaihli 1995, Mohanty, Mohanty et al. 2010).

C. Data, Sampling Technique, and Analysis

This research used stratified sampling technique to collect micro-level data from 259 households in 30 fishing villages around the Lake Basin while relying on primary and secondary data sources, besides drawing elements through simple random sampling. The research selected two periods for data collection: January to February and August to September, during which two distinct water flow regimes (high and low) occurred. Resulting in the abundance and fish shortage, these regimes and dry and rainy seasons are concurrent to seize seasonality and variability regarding income and spendings. For secondary and missing data collection, the study used the cooperation of NIFFR and extrapolation. Descriptive statistics was used by comparing means of different livelihood enterprise combinations. The study approximated each livelihood enterprise combination based on this formula:

$$\bar{Y}i, \dots, n = \frac{\sum_{i=1}^{k} Yi}{n}$$

enterprises *i* to *k* where k is the total number of enterprises a household is engaged in, $\bar{Y}_{i,\dots,n}$ is the enterprise's income from *n*, and *I* is the total number of households with the given livelihood enterprise combination.

Table 1. Anomalies of the water inflow and outflow in Kainji Lake 1994-2011.

Year	Condition	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Water level	Inflow	380	385	370	360	520	550	390	455	355	445	350	390	400	470	501	435	440	375
	Outflow	501	320	330	275	400	540	350	410	295	400	305	360	380	385	390	395	400	405

Results and Discussion

A. Hydro-Climatic Variations in the Kainji Lake Basin

Over the years, the River Niger, as Lake Kainji's major water source, has experienced two critical hydrological changes. The interannual inflow and outflow changes in Lake Kainji have been observed for 18 years from 1994 to 2011. As presented by Table 1, results indicated high annual inflow (upstream) variability, which subsequently reflects the year-to-year variation in the outflow (downstream); discharge is mainly a function of rainfall and upstream inflow. These variations straightly influence the aquatic habitat and, thereby, its efficiency. Many factors can cancel potential benefits, including river fishes' decreased spawning success due to higher river flows in the wet season, decreased fish survivability in lower dry season flows, losing habitat to new construction projects, and other human activities. Variations of precipitation and evaporation in inland waters' hydrology influence fish reproduction, growth, and mortality, based on (Allison, Adger et al. 2005). This corroborated the report of (Center 2007), as observed in Lake Mwemu and Lake Turkama, where the Lake's low level reduces fishing success, indicating that water level largely determines stock fluctuation. Generally, a fishery's efficiency is inextricably intertwined with ecosystems' health and defectless functionality, which are integral elements of a fishery's dependency on the ecosystem for food, habitat, and even pollen and seed dispersal (Roessig, Woodley et al. 2004).

The data related to rainfall is regular hydrological data collected in the lake basin. Kainji Lake demonstrated significant rainfall pattern variations since 1994, as represented in Fig. 1, with an average of 1043.18mm, and minimum rainfall of 735.3 mm and a maximum of 1349.8 mm, respectively, measured in 2002 in 1998. Between the two extremes, the rainfall represented a monthly variation pattern between years, representing annual and lasting variability. In any case, variability in rainfall alters water levels and physio-chemical parameters, directly affecting fish yield. Low water level slows down or blocks navigation; however, since nutrients and pollutants concentration will increase, water quality issues are expected be increase in low-discharge periods (Gerlak, Varady et al. 2011). Decreased fish yield remains fishers' one of the main vulnerability sources. Hence, the presumably hydrological pattern changes critically influence both fish and food production and residents' livelihoods, requiring urgent attention.

Similarly, Fig. 2 illustrates high-temperature variability in random years. The maximum temperature of 41.220C was recorded in 1999, while the minimum of 36.410C was observed in 2007, with an average of 38.20C. Famously, fishers are so vulnerable to intense temperature variations (Bell, Johnson et al. 2011). Higher temperatures can reduce wild fish stocks' availability by damaging water quality, escalating mortality in the dry season, introducing new predators and pathogens, and causing variations in the food abundance available to fishery species (Center 2007). Because of the fishes' inclination to live close to their tolerance limits of a range of factors; thus, increased temperature and acidity, lower dissolved oxygen, and salinity changes can result in damaging impacts (Girmaw 2019).

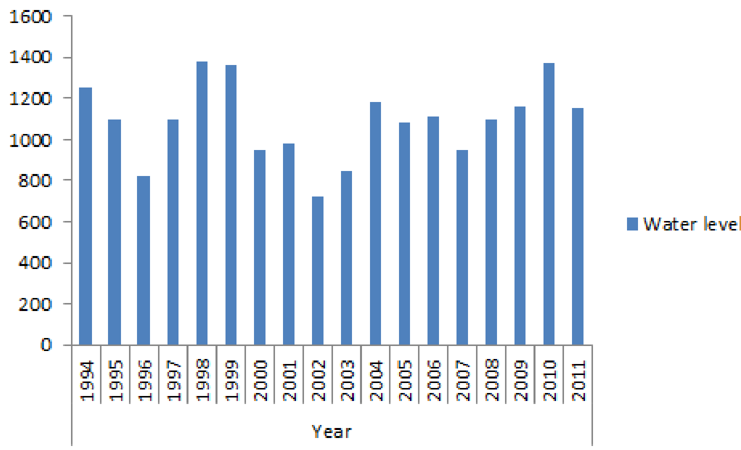

Fig. 1. Anomalies of the annual rainfall in Kainji Lake 1994-2011.

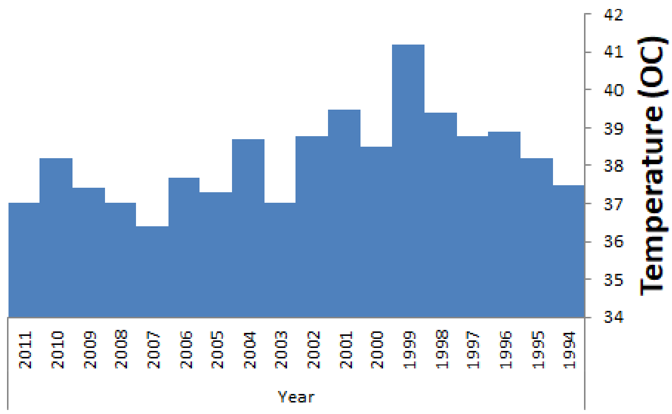

Fig. 2. Temperature variability 1994-2011.

B. Effects of Hydro-Climatic Changes on Fish Yield

Fig. 3 illustrates the variations in fish yield over the years. The yield variation worryingly descended in 2002 from 38,346 metric tons to 11,315 tons in 1996 and to just about 3,476 tons in 2011. This is due to variability in inflow, outflow and rainfall, and temperature and may be due to poor management practices such as overexploitation and application of troublesome fishing methods in the area. Nevertheless, the low water level is still the most critical factor with the strongest negative influence on fish yields. Also, climatic parameters, such as temperature, precipitation, and fishing efficiency, are closely intertwined since, for instance, intense temperature fluctuations reduce the water level, which, in turn, changes spawning and recruitment of native fish species and also reduces water quality by lowering production photosynthesis capacity balance. Similarly, water level and quality variations impact fish reproductive patterns and migratory routes, while rainfall variations influence fish reproduction, growth, and mortality, leading to lower fish production and income, higher food vulnerability, and adverse health conditions. Based on [20], mean rainfall variations and possible increases in seasonal and annual variability and extremes are potentially the most critical factors that result in changes in inland fisheries, greatly influencing public livelihood, especially considering the population growth in the basin area and Nigeria at large.

B. Impacts of Hydro-Climatic Changes on Fish Yield

Fig. 3 demonstrates fish yield variations changes occurred over the years. The variation in the yield showed an alarming drop from 38,346 metric tons in 1996 to 11,315 tons in 2002 and to just about 3,476 tons in 2011. This is as a result of variability in inflow, outflow and rainfall and temperaure and may be due to poor management practices such as, over exploitation, application of obnoxious fishing methods in the area. However, among all the attributes that contribute to low fish yiled, low water level remains the most critical factor. Strong linkages exist between changes in climatic parameters such as temperature, rainfall and fisheries productivity. Extreme temperature and changes in precipitation lead to lower water level. Meanwhile, lower water level alters spawning and recruitment of endemic fish species and also, lead to lower quality due to reduced productivity capacity of photosynthesis balance. Changes in water level and quality affects fish reproductive patterns and migratory routes while precipitation changes affects fish reproduction, growth and mortality. Generally, this will lead to low yield and by implication low income, food insecurity and poor health among others. According to (Tafida and Galtima 2016) changes in precipitation averages and potential increases in seasonal and annual variability and extremes are likely to be the most significant drivers of changes in inland fisheries. This has a great effect on livelihoods of the people, particulary looking at the population increase in the basin area and the Nigeria at large.

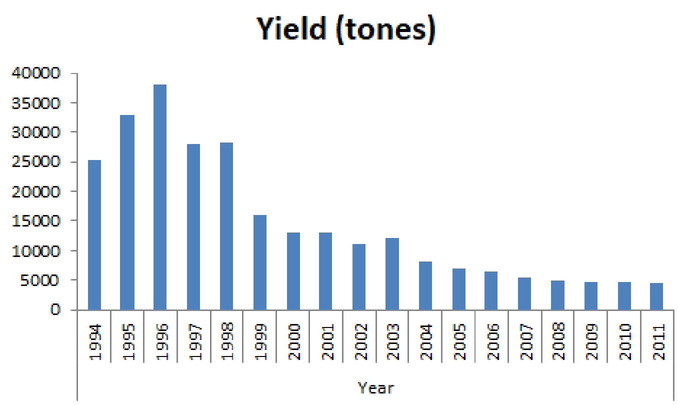

Fig. 3. Fish yield in the study area 1994-2011.

C. Adaptation and Coping Strategy Model

The environmental changes due to rainfall variability in and water inflow and outflow to Lake Kainji and its resulting depletion in fish yield over the years has made fishers adapt to specific ecological, social, and economic systems to be able to tolerate the unpleasant influences of different variations and use opportunities based on the accessible assets to build other livelihood activities. Hence, this research devised a model for the most profitable livelihood strategies adopted. The model analyzed the positive impact of each livelihood activity on their general income. The results indicated that non-fishing enterprises' income is increasingly gaining a more prominent share in the fishing communities' overall income in Kainji Lake. From Fig. 4, fish-related activities, including fishing and fish processing, contribute up to 68.8% of the total income (44.9% for fishing and 23.9% for fish processing). Other non-fishing activities like farming are the next most critical supplementary income source of households with 15.8% of the total income, followed by animal husbandry with 12.4 %. The least contributing non-fishing livelihood activity was trading with only 3.1%. This result is similar to a study in the Zambezi Floodplain, which indicated that in most cases, inland fisheries generated more cash for households than animal husbandry and, in some cases, more than crop production [22]. While most majority the Kainji Lake basin fishers are reacting to fisheries resource variations by diversifying, most communities represent similar trends, which can be attributed to having similar resources available for farming and cultural affiliation of the people in skills related to animal husbandry. Nevertheless, as essentially non-finishing livelihood activities, trading and other servicing activities are extensively spreading across the fishing communities (Tafida and Galtima 2016), reported that all household members' raised earnings were such as the main route out of poverty. The main aim of diversifying the locals' livelihood is to eliminate the element of seasonality's impacts on their income sources, including fishing, enabling them to switch their income source to other activities if seasonal changes require so. This way, households become less vulnerable and ensure their families' welfare.

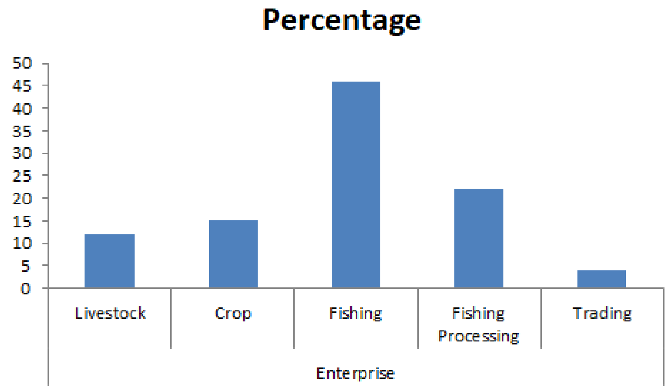

Fig. 4. Contribution of various activities to the overall income.

D. Best Activity Combination Model

The study identified five groups of different enterprise combinations in the fishing communities and then subjected them to descriptive statistics compared with the mean of each livelihood activity combination's income. The result indicated the higher income of fishing households combining four enterprises, with a mean of N 6227.42, followed by five enterprises with a mean income of N 3955.31. The group with the lowest income involves those with only two activities (see Table 2). Hence, it is suggested that fishers start four to five enterprises rather than two, allowing them to put less effort into fishing and thereby conserve the current resources for generations to come. This model's significance for the mentioned combinations is based on addressing two issues; improving the actors' income and well-being and providing fisheries with resource sustainability through exempting fishers from limitless fishing efforts and the simplification of their livelihood activities, thereby overcoming the fisheries' resource management challenges that have been around for long. Diversification is a critical way for the effective and viable adaptation; if people have more generating, processing, and producing options, they will be less likely to be directly hit by adverse implications of climate change since some options give communities a safe path to survive (Tafida and Galtima 2016). Needless to say, more options mean environmental changes may encourage some activities. Based on (Béné 2004), adaptation is an active set of strategies and actions taken by individuals in response to or expecting the change to improve or keep their well-being.

Table 2: Livelihood Enterprise Combination (Descriptive Statistics)

	N	Minimum	Maximum	Sum	Mean	Std. Deciation
Mean income from hh with one enterprise	248	0.00	288000	535200	2158	20387
Mean income from hh with two enterprises	248	0.00	37352	424257	1710	6277
Mean income from hh with three enterprises	248	0.00	20459	629537	2538	3865
mean income from hh with four enterprises	248	0.00	48400	1544400	6227	8114
mean income from hh with five enterprises	248	0.00	194818	980918	3955	20244
Valid N (list wise)	248					

hh=household

Conclusion

Everyone's lives, including the fishers, in the value chain, who are main beneficiaries, have been more or less influenced by climate change, a phenomenon whose implications also encompass the aquatic habitat and fishery resources. In addition to the ecological problems detected, management issues, such as overexploitation, and contamination, complicated the issues by impacting the annual fish yield negatively and spoiling other economic advantages, hence the subsequent falling of fishers into financial difficulties. The livelihood strategies model currently in operation aims to consolidate the fishing communities' adaptive strategy to forestall ecological vulnerability and enhance their socio-economic welfare. Policies aiming to boost Nigerian fisheries development should regard ecological and management aspects to achieve greater sustainability.

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