Thesis for the Degree of Master of Fisheries Science

Vulnerability of Fishing Communities to Environmental Changes on Lake Lagdo, Cameroon

by

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카메룬 Lagdo 호수의 환경변화에 취약한 어촌사회에 대한 연구

Advisor: Prof. Andrew C.M. Baio

by

Yaka Laure-Ephigenie

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Acronyms and Abbreviations

CDHS or EDSC-V:	Cameroonian Demographic and Health Survey
CDPM:	Mission for Development of Artisanal Maritime Fishing;
CNFZV:	National Center for Zootechnical and Veterinary Training;
CRHOL:	Limbe Halieutic and Oceanographic Research Center;
DAEPIA:	District of the Livestock, Fisheries and Animal Industries;
DIRPEC:	Fisheries and Aquaculture Directorate;
DSCE:	Growth and Employment Strategy Paper;
FAO:	Food and Agriculture Organization;
MIDEPECAM:	Fund for Development of Maritime Fishing;
MEADEN:	Mission for the Development of the Northern Province;
MINEPDED:	Ministry of Environment, Protection of Nature, and Sustainable Development;
MINEPIA:	Ministry of Livestock, Fisheries and Animal Industries;
MINFI:	Ministry of Finance;
MINRESI:	Ministry of Scientific Research and Innovation;
MINTRANS:	Ministry of Transport;
PCD:	Council Development Plan;
PRODEL:	Livestock Development Project;
ILO	International Labour Organization;
INS:	National Institute of Statistics;
UNDP:	United Nations Development Program;

UNCLOS:	United Nations Convention on the Law of the Sea;
UNESCO:	United Nations Educational, Scientific and Cultural Organization;
WASH:	Water, Sanitation, and Hygiene;
WHO:	World Health Organization

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Abstract

With a production of 335,158 tons, Cameroonian fisheries represent 3% of the GDP, employing about 200000 people. However, environmental changes are adversely impacting water availability as observed on Lake Lagdo, where Lake surface area has observably shrunken due to siltation and evapotranspiration. The impact of such environment changes on the sustainable livelihoods of fishing communities is palpable. Thus, the study set out to determine the impact of Lake siltation and shrinking on the livelihoods of the fishing community especially from their own perspective and how they are coping or otherwise. The sustainable livelihoods framework was applied to assess main causes and impacts of the vulnerability context as well as existing or developing opportunities/strategies for surviving the vulnerabilities. Field study for primary data collection used semi-structured questionnaire interviews, focus group discussions and field observational research whereas; secondary information was sourced from Ministries, Departments and Agencies including scholarly articles from the internet. The findings show that siltation and lake shrinkage pose a serious threat to the fisheries on Lake Lagdo. Due to an estimated annual sedimentation of 40 800 000 m^3, the reservoir volume has decreased by 0.9 percent. The catches have decreased from 20,000 tons in 1990 to just 9,600 tons in 2020 and the once common fish species, such as *Dasyatis garouaensis*, have disappeared. The threat of these environmental changes to the fisheries has a knock-on effect on livelihoods by reducing fisheries income by 69.67%. Economic diversification involving engaging in Agriculture (66.7%); Petty trading (11.9%) and Cattle rearing (14.7%), is an

important strategy adopted to cope with the environmental changes. The hypothesis that Lake shrinking and siltation have no effect on the livelihoods of the fishing communities along Lake Lagdo is therefore rejected. Reforestation of the lake banks to reduce erosion; enhanced access to viable alternative livelihoods; dredging operation on the lake to restore lake carry capacity and restocking to restore biodiversity; are the key recommendations of the study.

Keywords: Fishing Communities; Lake Lagdo; Livelihoods; Shrinking; Siltation; Vulnerability.

1. INTRODUCTION

1.0. Background

1.1. Country Economic and Social Context

1.1.1. Geographic Location

Cameroon is located in Western Central Africa, with a triangle form that stretches from 2° N to 12° 30'N and between 9° 30'E and 16°00'E. It is bordered to the north by Chad, to the east by the Central African Republic, to the south by Equatorial Guinea, Gabon, and the Republic of Congo, and to the west by Nigeria (Figure 1). Population of Cameroon is estimated at 25.8 million people in 2019 (World Bank, 2020) with a total land area of about 475440 km2. Administratively, the country is divided into 10 Regions with more than 250 different ethnic and language groups. French and English are the official languages. Cameroon's coastal plain extends inland from the Atlantic Ocean (Gulf of Guinea) to the edge of a plateau. Tropical rain forest dominates the low southern plateau that rises from the coastal plain. Western Cameroon is a complex chain of mountains, hills, and plateau stretching from Mont Cameroon (4095 meters above sea level) to Lake Chad at the northern part of the country. The landscape rises northward from the forested southern plateau to the rugged Adamawa mountains. Due to its physical and cultural

diversity, Cameroon is considered as “Miniature Africa” because, most African ecosystems (92%) are represented in Cameroon (MINEPDED, 2012a).

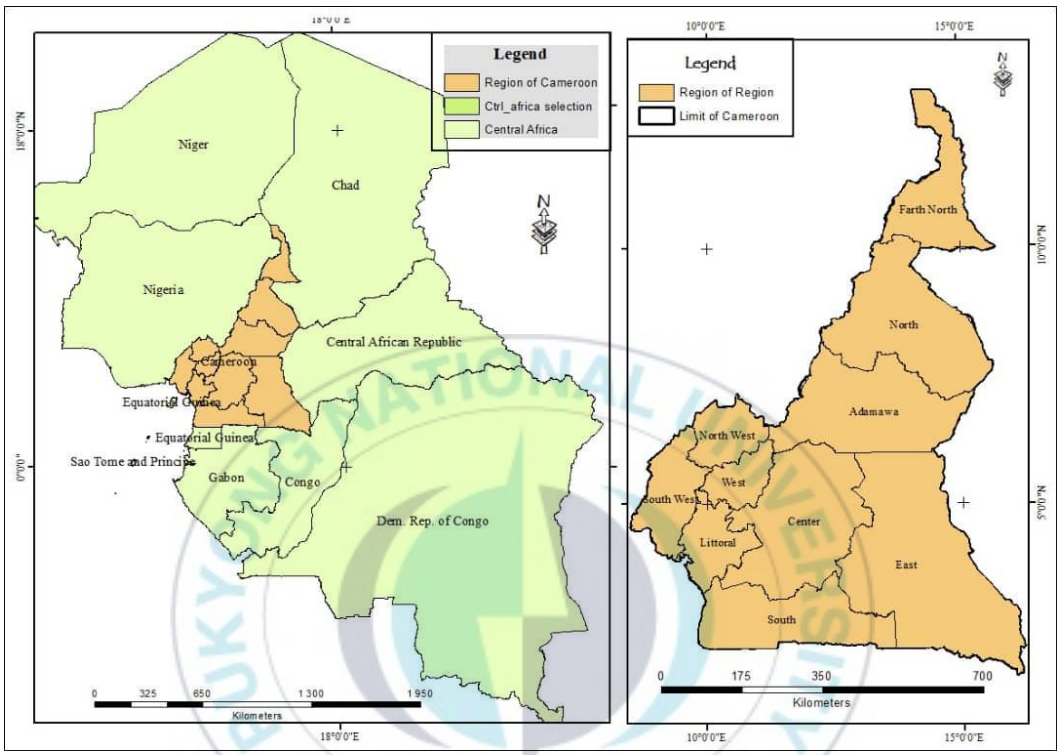

***Figure 1**:Map of Cameroon*

1.1.2. Economic Environment

After its independence in 1960, Cameroon's economy experienced years of prosperity controlled by the state and supported by five-year plans. The country recorded a growth rate of 22% in 1978, which was much higher than the sub-Saharan Africa region (-0.26%) (Figure 2), making Cameroon one of the wealthiest countries in Africa.

The economic crisis of the 1980s, caused by the fall in prices of the main export products (oil, cocoa, coffee, rubber) considerably degraded and modify the country's economic landscape with a drastic fall in the growth rate resulting into an irregular growth pattern of -1.96% in 1980, 7.5% in 1982, 8.06% in 1985 and dropping to -2.14 in 1987 and -6.1% in 1990 (World Bank 2020).

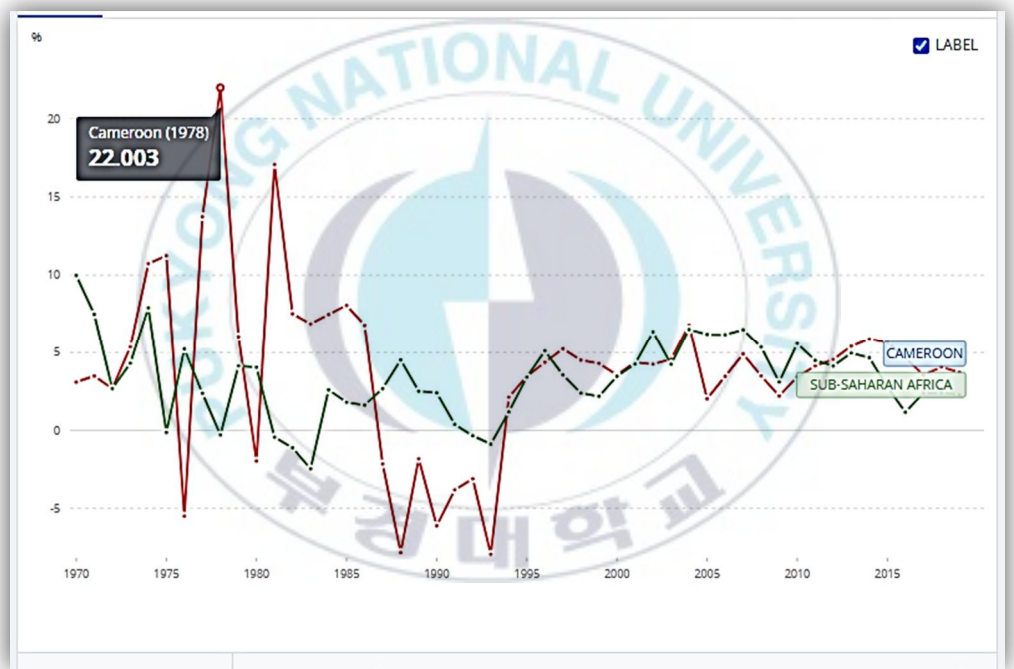

Figure 2: *Cameroon GDP trend from 1970 to 2019 (World Bank 2020)*

Consequently, under pressure from the Bretton Woods institutions (World Bank, IMF), Cameroon was forced to develop and implement a liberal economic policy

involving public disengagement from economic activity (the agricultural sector in particular will no longer benefit from subsidies)(Tong, 2016).

The resumption of economic growth (3.47% in 1995) and the stabilization of the growth rate at (3.72% in 2019) have not led to decline in poverty. Between 1996 and 2007, for example, the incidence of poverty more or less remained the same (40.2% (2001) and 37.5% (2014)) (World Bank 2020). This is accompanied by an increase in the inflation rate from 1.1% in 2018 to 2.4% in 2019 (BAD 2020). Growth is expected to remain around 4% in 2020 and to slow to 3.4% in 2021 (World Bank 2020). Cameroon plays a central role in CEMAC - controlling approximately 40% of the money supply. For example, from 2014-2017, total intra-community trade reached 24.7%, driven by the diversification of its economy, the ratification of the agreement on continental African free trade, the merger in 2020 of the two stock exchanges (Cameroon and Gabon) and the implementation of projects in the agro-sylvo-pastoral and fisheries sectors (BAD 2020).

Despite the security crisis (Boko Haram and the NOSO crisis), the Cameroonian economy recorded a growth rate estimated at 3.72% in 2019, due to the dynamism of the tertiary sector and the growth of consumption and investment.

To revive its economy, Cameroon has set up a recovery program supported by the DSCE (2007) with a development objective to improve the well-being of the population and rapidly achieve food self-sufficiency by 2035. Thus, the government plans to increase the national availability of fishery products in order

to achieve self-sufficiency in animal protein from fisheries by filling an estimated deficit of 230,000 tons (MINEPIA 2019).

1.1.3. Demographic and Socio-economic Indicators

The total population of Cameroon was estimated at 25.8 million people in 2019 with a density of 53.3 people per kilometer and a population growth rate of 2.6% (World Bank, 2020). Documented life expectancy at birth for Cameroon in 2018 was 64 years for women and 60 years for men (WHO 2020). The rural population represents 43% of the population with a growth rate of 1.2% in 2019. In 2019, the employment situation in Cameroon was characterized by a low unemployment rate 3.3% (ILO 2020). The primary sector of agriculture and livestock dominates the Cameroonian job market accounting for 56% whereas, the services and commercial sector accounts for 32% and the industry contributes 14%. The proportion of the population which have access to drinking water varies by region. For example, the North (56.5%), the Far North (63.7%), the South West (66.6%) and in the Eastern regions (67.9%). Additionally, only 24% of the inhabitants of rural areas have access to good sanitation (WASH, 2018). According to UNESCO (2018), the average adult literacy rate is 77.07% (disaggregated to 82.63% for men and 71.59% for women).

In 2018, the Cameroonian Demographic and Health Survey (CDHS or EDSC-V) recorded a total fertility rate of 4.8 per cent compared to 5.8 children per woman in 1991, an infant mortality rate of 48 deaths per 1,000 live births and most infant deaths occurring during the first month of life has been declining compared to 64 deaths in 1991 (CDHS, 2018). The doctor/patient ratio is estimated at 1 doctor per 1000 inhabitants in 2011, which is in line with World Health Organization (WHO) recommendations (1 doctor per 5,000 - 100,000 inhabitants) and 1.3 hospital beds per 1000 people in 2010 (World Bank, 2020a).

1.1.4. Poverty Situation

The most recent survey data on the Multidimensional Poverty Index (MPI) of Cameroon was done in 2014. A household is said to be poor if its annual consumption per adult is below the poverty line (World Bank). Given the international poverty line, which varies from $3.20 per day for lower-middle income countries, about 8.1 million Cameroonians live in poverty. In 2014, 37.5% of Cameroon's population live on or below the threshold of PPP $3.20, compared to 20% of the poor population living on less than $1.90 per day (World Bank, 2020a). The poor population increased by 12% between 2007 and 2014, due to the mismatch between population growth and poverty reduction. The northern regions of the country have the highest percentage with 56% of the poor population. The

Gini index varied from 42.1% in 2001 to 42.8% in 2007 and 46.6% in 2014, reflecting an increase in consumption inequalities within the Cameroonian population (World Bank 2020).

In order to consolidate the objectives of societal wellbeing and poverty reduction, emphasis is placed on the fishing sector, especially small-scale fishing. Fishing in Cameroon is an important source of income and employs about 200,000 people (1% of the active population) and 69% of those engaged (137,420) come from small-scale fishing (Tchoundi et al., n.d.). It is against this setting that the socio-economic stabilization of fishing communities including protection from vulnerabilities is crucial for poverty reduction

1.2. Research Goal and Objectives

1.2.1. Research Goal

The goal is to propose a pathway for achieving adaptive and resilient fishing communities in the face of the impacts of environmental changes such as lake shrinking, siltation and the concomitant effect on livelihoods along Lake Lagdo

1.2.2. Research Objectives

In pursing the stated goal, the following objectives will be the focus:

1. Analyze the cause and effects of the lake shrinking and siltation on fisheries production and productivity from the perspective of resources users;
2. Assess the impact of the lake shrinking and siltation on sustainable livelihoods of the fishing community;
3. Assess the available opportunities to cope with the vulnerabilities.

1.2.3. Research Questions

Following the abovementioned objectives will require answers to a number of questions including:

1.2.3.1. Principal Question

What are the causes of siltation and shrinking and what are the impacts on the livelihoods of the fishing community?

1.2.3.2. Sub-questions

1. What are the main causes of lake shrinking and siltation as perceived by resource users?
2. What is the impact of lake shrinking and siltation on the sustainable livelihoods of the fishing communities along Lake Lagdo?

3. What coping opportunities/strategies exist or are being develop to survive with the environmental changes?

1.3. Hypothesis

Our hypothesis provides that, it is a considered view of resources users that; Lake shrinking and siltation have no effect on the living conditions of fishing communities along Lake Lagdo.

1.4. Significance of the Study

Understanding the consequences of environmental changes on all aspects of human life, facilitates the development of coping strategies. As COFI recommended in March 1991, the development of new approaches to fisheries management which takes into account the imperatives of conservation and environmental protection is crucial for sustainable exploitation (FAO, 2015). This is so because, the characteristics and circumstances of a community or system that makes it susceptible to the effects of a hazard must be understood in order to mitigate against the effect of such hazard (UNISDR 2009). Cursory investigation suggests that progressively noticeable environmental changes such as; shrinking of Lake size and siltation may have adverse effect of livelihoods of Lake Lagdo community. Thus, the study set out to determine the impact of Lake siltation and shrinking on

the livelihoods of the fishing community especially from their own perspective and how they are coping or otherwise for policy consideration.

2. FISHERIES AND AQUACULTURE OF CAMEROON

2.1. Ecosystem Types and Distribution in Cameroon

Cameroon is located within the Equator and Sahelian regions and thus influenced by two major climates namely: tropical and equatorial climates - contributing to the acknowledged diversity of the Cameroonian ecosystem. This biodiversity can be categorized into six distinct ecosystems including mountain, forested savannah, dense tropical rainforest, coastal and marine as well as freshwater. However, the focus of the study is on the marine, coastal and fresh water ecosystem.

2.2. Marine and Coastal Ecosystems

These ecosystems represent about 3.78% of the total territory, spanning an approximate area of 18000 Km^2 along the continental shelf in the Gulf of Guinea including about 2494 Km^2 of Mangrove (Onana, 2018). This coastal area **(**Figure3**)** which is over 402 Km in length, interconnects the tip of the Atlantic Ocean and the edge of a Plateau located between 2°20'N South of Campo River estuary and 4°40’ N to the Nigerian border north of Akwayafe River. Furthermore, this área falls within several administrative units namely Fako, Meme,Ndian, Moungo, Wouri, Ocean and Sanaga Maritime Divisions; characterized by warm and humid climatic conditions with annual tempearture range of 24°C - 26.5° C. The average rainfall

is about 5,000 mm per year with the exception of one of the world's wettest places Debunscha with 11.000 mm per year (MINEPDED, 2012b).

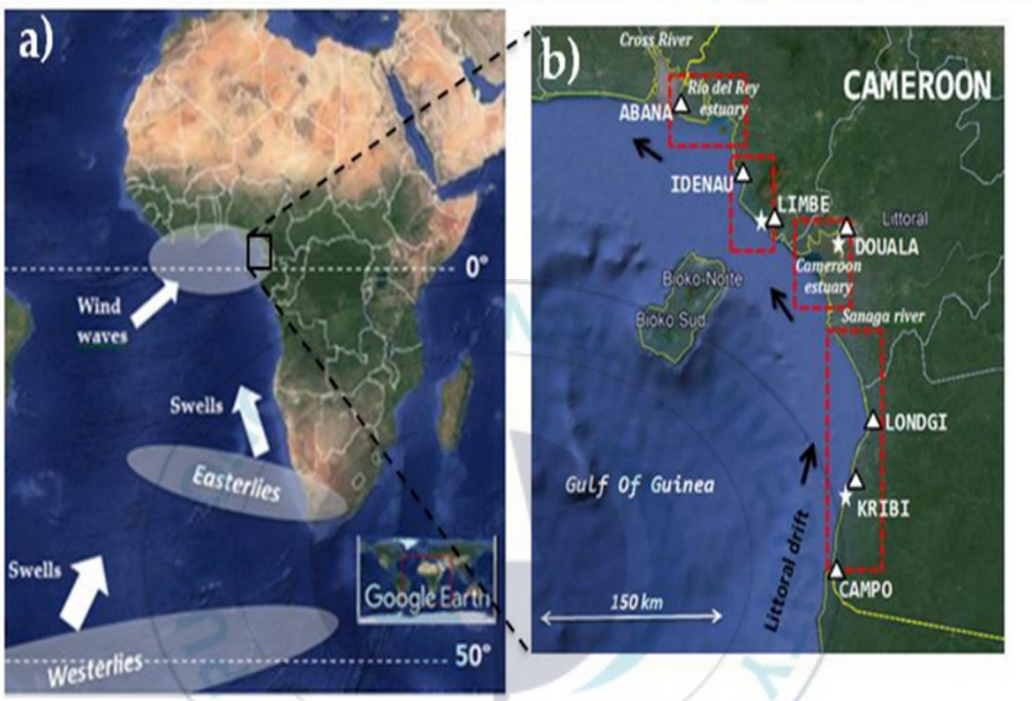

Figure 3: *(a) Costal Map Indicating Directions of Swells and Wind Waves). (b) Cameroon Coast (Source: Raphael Onguéné et al 2019)*

Several river outlets characterize the marine coastal zone as depicted in Table (1) below; amongst which are River Sanaga (the longest in Cameroon), Kienke, Nyong, Ntem and Lobe, as well as estuaries (e.g.,Wouri estuary, one of the largest) (Ondoa et al., 2018). According to Audrey (2019), Cameroon lays claim to an Exclusive

Economic Zones of an area of around 14,693 km2 together with about 13,000 to 14,000 km2 of continental shelf which is approximately 200 m deep.

Table 1: *Main Coastal Rivers and Volume of Water Discharged at Atlantic Ocean*

Regions	**Name**	**Length (km)**	**Drained Areas (m^3 S-1)**	**Flood (m^3 S-1)**	**Rate of Flow**	**The Volume of Freshwater Discharged at Sea**
Littoral	**Dibamba**	150	2400	480	480	
	Mungo	150	2420	236	27,5-236	**8**
	Wouri	250	82000	1425	49-1425	**16**
	Sanaga	890	135000	7570	500-5001	**65**
South	**Nyong**	800	14000	376	25,7-376	-
	Ntem	460	318000	764	50-765	-
West region	**Munya or Cross river**	160	500	7570	171-7570	-

Adapted from Tchoundi, (2019)

Ndjama et al. (2008) showed that Cameroon coast accommodates 70% of industries, thereby, being of great economic significance. Consequently, the coastal regions host about 25% of the Cameroonian total population (Ondoa et al., 2018).

2.3. Freshwater Ecosystems

Cameroon is endowed with freshwater resources; with the Adamawa Plateau as the vital source feeding a dense drainage network of rivers, streams and lakes. The Cameroon freshwater ecosystem composes of part of Lake Chad, Logone Valley, Rivers and Floodplains, Lakes, permanent or periodic Streams (Table 2). The

freshwater ecosystem constitutes 1.64% of the total area of the territory corresponding to approximately 7800 km2 (Onana, 2018).

Table 2: *The Main Fresh Water Body Ecosystems*

Type	**Area (ha)**	**% Total**
Floodplains	550 000	55
Lakes	300 000	30
Rivers	150 000	15

Source: Book for the Inland Fishery Resources of Africa Vol. 2

The dense hydrological network endorses a unique diversity of ecosystems in Cameroon. Indeed, fresh water in Cameroon is an important natural resource.

Table 3: *Main Fresh Water Bodies in Cameroon*

Water body	**Location**	**Surface & drainage area (km^2)**	**Discharges**	**Actual surface area (km^2)**	**Length (km)**	**Sources**
	River					
Benue	7°46' N 6°45' E	64 000	Niger River	-	920	(Bossche & Bernacsek, 1990)
Boumba	3°13'N 14°55E	40 400	Congo River	-	390	(Bossche & Bernacsek, 1990)(Energie & Eau, 2006)
Chari	5°47'N 15°13'E	65 000	Lake Chad	-	950	(Bossche & Bernacsek, 1990)(Kertemar et al., 2014)
Dja & Ngoko	2°48'N 13°2E	67 075	Sangha	-	700	(Bossche & Bernacsek, 1990) (Energie & Eau, 2006)
Lom &Djerem	6°20'N 12°49'E	20 200	Atlantic sea	-	935	(Bossche & Bernacsek, 1990) (Energie & Eau, 2006)
Logone	6° 54'N; 14° 15'E	73 700	Chari River	-	280	(Bossche & Bernacsek, 1990)
Mungo	4°34'N; 9°32'E	2 420	Atlantic sea	-	120	(Bossche & Bernacsek, 1990) (Energie & Eau, 2006)
Mbam	4°34'N; 11°22'E	42 300	Sanaga River	-	495	(Bossche & Bernacsek, 1990)(Lienou, 2007)
Ntem	2° 24'N 10°24'E	31 000	Atlantic sea	-	360	(Bossche & Bernacsek, 1990) (Energie & Eau, 2006)
Nyong	4°32 N ; 13°30 E	27 900	Atlantic sea	-	520	(Bossche & Bernacsek, 1990) (Energie & Eau, 2006)
Sanaga	3° 33' N ; 9° 39'E	140 000	Atlantic sea	-	920	(Bossche & Bernacsek, 1990) (Energie & Eau, 2006)
Wouri	4° 04' N ;9° 41' E	12.500	Atlantic sea	-	-	(Bossche & Bernacsek, 1990)(Lafond, 1965)
	Lake and reservoir					

Bamendjing	5° 50'N: 10° 35'E	250	Noun River	-	32	(Bossche & Bernacsek, 1990)
Mbakaou	6° 23'N; 12° 49'E	500	Djerem River	-	50	(Bossche & Bernacsek, 1990)
Maga	10°21'N; 15° 15'E	360	Logone	-	-	(Bossche & Bernacsek, 1990)
Lagdo	8° 54'N; 13° 54'E	700	Benue	586 km^2	-	(Bossche & Bernacsek, 1990)

2.4. Development of Fisheries and Aquaculture in Cameroon

The fisheries and aquaculture of Cameroon could be categorised into marine and inland fisheries and aquaculture of which 79% is artisanal marine fisheries (79%) (Figure 4.).

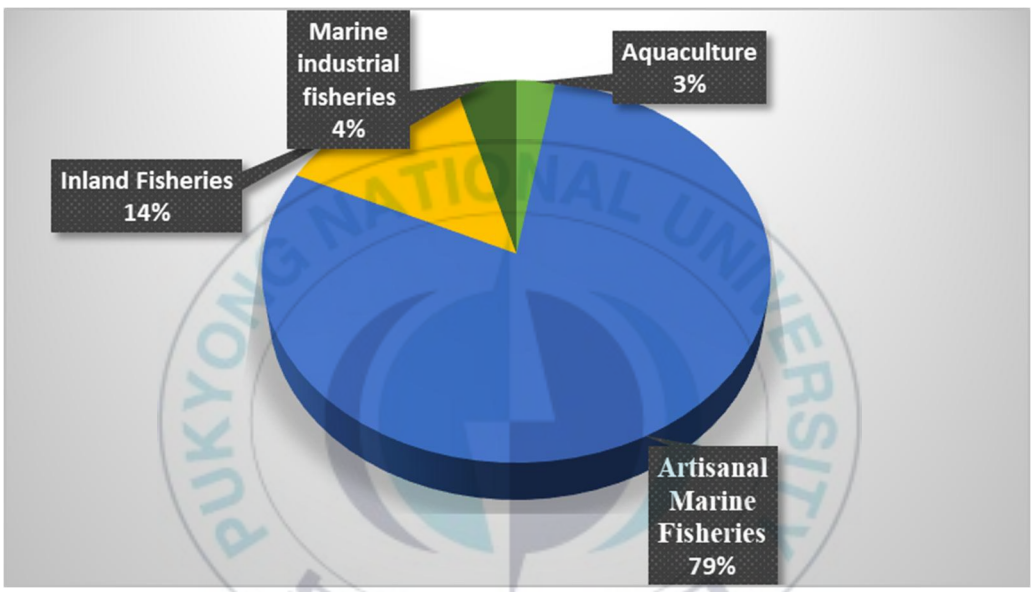

Figure 4: *Distribution of Fish Production System in 2019 (MINEPIA 2020)*

2.5. Marine Fisheries

The marine fisheries of Cameroon is divided into the artisanal and industrial fisheries. The fisheries sector is dominated by migrant fishermen (85%) mainly from Nigeria, Ghana, and Benin.

Artisanal fisheries activities takes place exclusively within the limits of 3 nautical miles and are more intensive north of Sanaga River, particularly in the coastal area

between Rio del Rey and the Cameroon River estuary. Artisanal marine fisheries has small and large Ghanaian type canoes called "Awasha" with or without monoxyle - made from tree trunk or plank. From 2015 to 2016, the production of marine artisanal fisheries increased, from 185,000 to 190,000 tonnes (INS 2017).

2.6. Industrial fisheries

Industrial fishing is carried out beyond 3 nautical miles, and the main areas are Ntem estuary, the coastline between Campo and Kribi, the Sanaga estuary, the Wouri estuary to Ambas bay Limbe and the Bakassi peninsula. According to the FAO (2007) Eight (08) industrial fishing companies provided most of the production from a total of 55 vessels (10 trawlers and 45 shrimp boats) with a power of between 50 and 250 GRT1and employs more than 700 peoples. With respect to production, FAO(2020) estimates that industrial production increased from 113000 tonnes in 2010 to 251 309 tonnes in 2018.

Table 4:*Commercially Exploited Species (2012-2016) (MINEPIA 2017)*

Scientific name	**2012**	**2013**	**2014**	**2015**	**2016**
	Tons				
Osteichthyes	5400	4700	4000	3400	2800
Cynoglossidae	350	350	350	350	-

[1] Gross Registered Tonnage

Pleuronectiformes	3100	3800	4500	5200	5975
Ariidae	4300	5100	5900	6600	7278
Lutjanus spp	400	400	350	350	-
Pomadasys jubelini	1460	1640	1820	2000	2176
Haemulidae	1650	1900	2150	2400	2665
Pseudotolithus senegalensis	755	700	645	590	543
Pseudotolithus elongatus	4800	6400	8000	9600	11265
Pseudotolithus spp	8500	11000	13500	16000	18788
Sparidae	980	1300	1620	1940	2280
Pseudupeneus prayensis	3000	3500	4000	4500	4851
Drepane africana	620	740	860	980	1110
Polydactylus quadrifilis	125	150	175	200	-
Galeoides decadactylus	224	228	232	235	238
Pentanemus quinquarius	890	1030	1180	1250	158
Polynemidae	4000	4500	4900	5400	7197
Trichiurus lepturus	3100	3550	4000	4450	4946
Sardinella spp	2400	2500	2600	2700	2808
Ethmalosa fimbriata	64500	69000	73500	78000	82313
Scombroidei	300	360	420	480	534
Carangidae	500	650	800	950	1092
Sphyraena spp	4700	5500	6300	7100	7913
Rajiformes	940	1200	1460	1720	1969
Elasmobranchii	575	450	325	200	62
Osteichthyes	7612	6116	4761	3537	4
Brachyura	4000	4800	5600	6400	7159
Panulirus spp	69	82	95	108	121
Penaeus spp	640	730	820	910	1000
Nematopalaemon hastatus	20400	22200	24000	25700	27487
Total	150290	164576	178863	193250	204732

2.7. Inland Fisheries

With a fisheries resource potential estimated at more than 80,000 tons per year (Nsangue et al., 2018), inland fisheries generally takes place mainly in flood plains, rivers and lakes, charaterised by small scale fisheries although very little is know about production levels. The target fish species include: *Tilapia sp. Lates niloticus, Clarias spp., Heterobranchus, Auchenoglanis spp, Labeo spp., Mormyrus spp., Hemichromis sp., Mormyrops spp., Alestes marolepidodus, Hydrocynus sp., Synodontis, Hemichromis fasciatus, Heterotis niloticus, Citharinus spp., Synodontis spp.* About 100000 fishermen using 9500 boats are involved in Inland Fisheries using gillnets, hooks and lines as well as other fixed and mobile nets (FAO, 2007). There are 7,335 canoes of which 4,930 are monoxyl canoes and 1,957 are made of plank (FAO 2007).

Table 5: *Types of Gear and Their Use in Inland Fisheries Sector*

Types	**Local name**	**Use**
Monofilament gillnet	Strong kanda	Catch bonga and Sardinella ;
Drift net	Waka-waka	Catch Bonga and Sardinella as target species ;
Artisanal purse seine	Watsha	Catch small pelagic and demersal
Cast net	Mbunja	Catch small pelagic
Small mesh-sized (shrimp)	Ngoto	Harvest shrimp
Multifilament gillnets	Musobo	Catch mainly Croakers, Threadfins, Soles, Catfish,
Hooks and line	-	Cath Tilapia, Carp, Captain…

Source: Mbotiji 2019

The framework survey carried out by the INS (2017) shows that inland fishery production fell drastically from 163,144.6 in 2012 to 19,337 in 2016 tonnes **(**Figure.5**).**

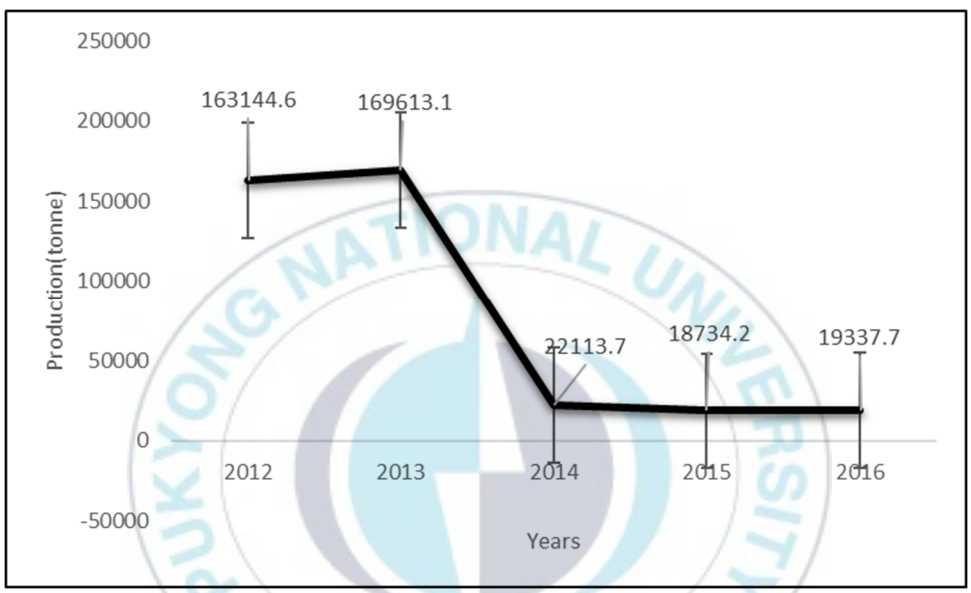

Figure 5: *Evolution (Tones) of Inland Production (2012 and 2016)*

Source: Cameroon Statistics Year Book (2017)

2.8. Aquaculture

Aquaculture is the fastest developing animal production system and the annual aquaculture potential is estimated at 20,000 tonnes per year (IBF 2011). Cameroon aquaculture is embryonic and mainly practised in ponds and freshwater, oriented towards the production of tilapia (*Oreochromis niloticus*), catfish (*Clarias*

gariepinus) and carp (*Cyprinus carpio*). Kenfack et al. (2019) indicated that aquaculture could cover the huge fish supply deficit considering suitable ecosystems such as floodplains and marshes, reservoir dams, natural lakes,rivers and streams. Despite its expansion and growth (Figure 6) of 546 tons in 2009 to 2340 tons in 2018 (FAO 2020), production remains low representing 3% of national supply.

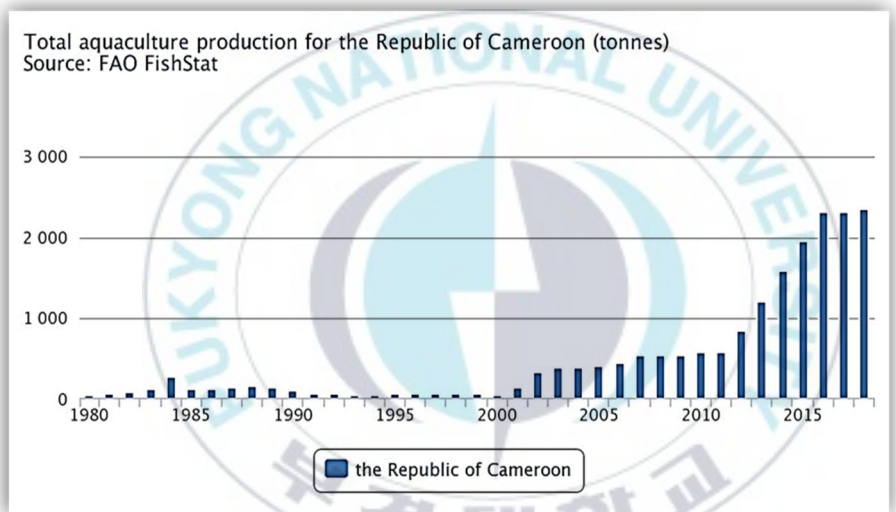

Figure 6: *Aquaculture Production 1980-2018 (FAO 2020)*

2.9. Fisheries Governance

2.9.1. Fisheries Governance Organigram

Cameroon implemented an operation model whereby the public administration is delegated to strategic management levels. This model can be likened to pyramidal

constituencies with a top central administration and descending decentralized-bodies, following various levels of administrative segmentation (Region, Departments, Districts). Each of these administrative units is headed by a mandated representative of the President of the Republic and Ministers alike, with the exception of the judiciary with a preserved independence (NOAH, 2010). Notwithstanding, several Ministries are involved in the fisheries sector in Cameroon amongst which are the Ministry of Livestock, Fisheries and Animal Industries (MINEPIA), the Ministry of Transport (MINTRANS), the Ministry of Scientific Research and Innovation (MINRESI) and the Ministry of the Environment and Nature Protection.

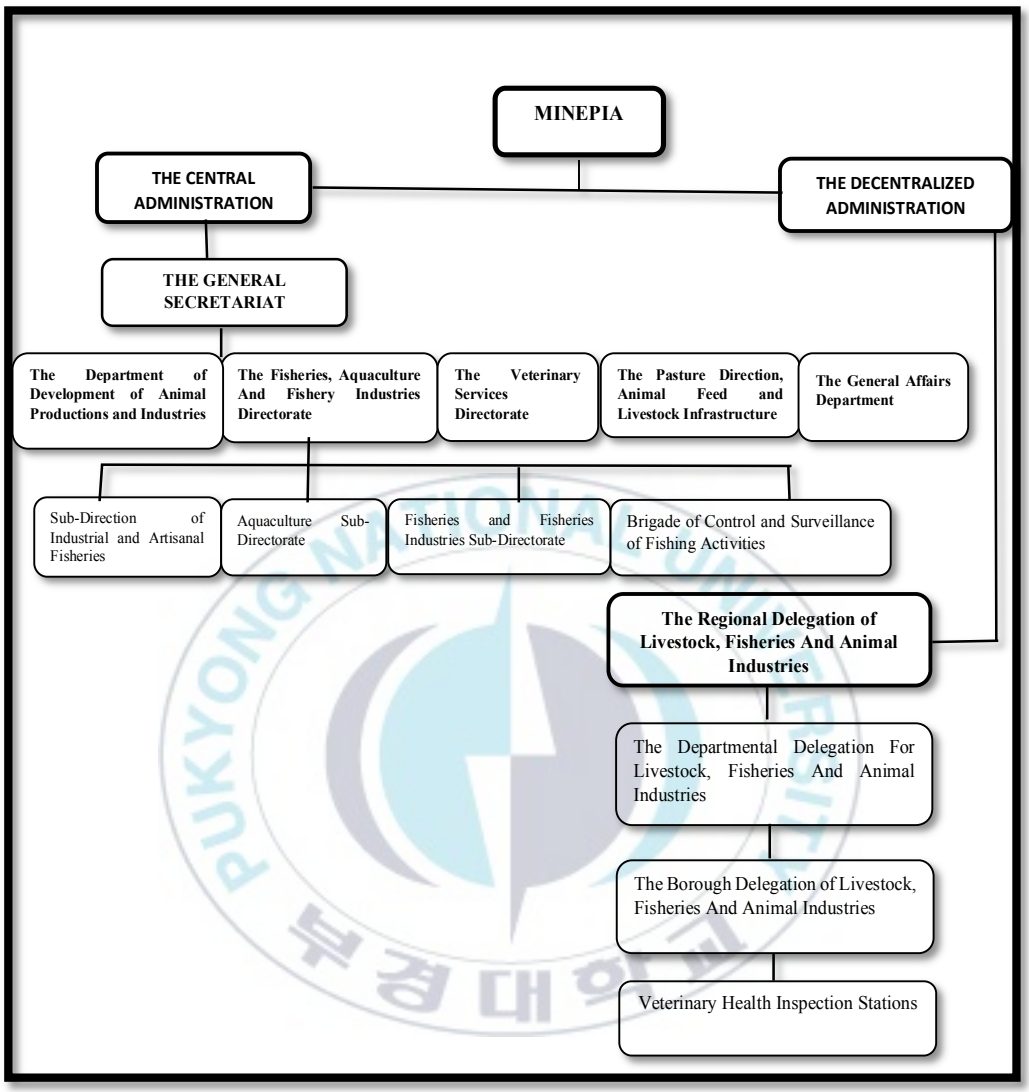

Figure 7:*Organizational Chart of the Ministry of Livestock, Fisheries and Animal Industries. (Presidential Decree N° 011/408 of 09 December 2011)*

2.9.2. Regulatory Framework

Cameroon Fisheries regulation is derive from the United Nations Convention on the Law of the Sea (UNCLOS) ratified on 19 November 1985 by Cameroon

(Tchoundi Audrey 2019). Thus, **Law n ° 94/01 of January 20, 1994** on the Regime of Forests, Wildlife and Fishing is the main national legislation for fisheries management in Cameroon. The following legislative provision are used in the stewardship of the fisheries and aquaculture of Cameroon.

- **Law n ° 74/012 of July 16, 1974**: Details the maritime fishery code, presents the exercise of fishing rights and determines the methods of production, handling, preservation, distribution of sea fishing products in Cameroon;
- **Decree n◦ 74/991 of the 16th of December 1974**: Created Maritime Fisheries Development Fund, to assists the ministry in the implementation of action programs related to the training of fishermen, the promotion of fishery research and improvement of fish distribution channels in small scale fisheries;
- **Order No. 017 / MINEPIA of September 29, 1987**, for the organizing and operationalization of fishery centers;
- The Fisheries Regulation **Law 94** deals with the reduction of by catch;
- Zone restriction defined by application **decree n ° 95/413 / PM of June 20, 1995**, defines five zones close to the coast and three nautical miles from the shore where trawlers are prohibited;

- **Order No. 0011 and No. 0012 / MINEPIA of April 24, 1998** specify conditions relating to establishments for processing fishery products for export and laying down the technical conditions applicable to fishing vessels;
- **Order No. 0002 / MINEPIA of August 1, 2001** fixing the terms of protection of fishery resources;
- **Order No. 2010/244**, establishing the procedures for exercising powers transferred by the State to the Council in the promotion of pastoral and fish production activities; management.

In fisheries, the fundamental objective is the sustainable management of fishery and fish farming resources. As a result, Cameroon has developed to date, several fisheries policies and strategies with various objectives and mechanisms. The most important and recent ones are:

- Master Plan for Fisheries Development 1992, promote domestic production in order to reduce imports
- Strategy for the Development of the Rural Sector, 2005;
- Strategic Framework for the Development of Aquaculture 2003.
- Aquaculture Development Strategy, 2009;
- Growth and Employment Strategy paper (DSCE) 2010.

2.10. Importance of Fisheries in the Economy

The fisheries and aquaculture of Cameroon contributes significantly to the social and economic welfare of the growing population. In 2019, the sector provided employment for about 200000 people and contributed approximately 3% of the Gross Domestic Product (US$205million) (MINFI, 2017). According to (FAO, 2007), the consumption of fishery products is about 11 kg / capita / year and represents about 40% of the animal protein intake and 9.5% of the total needs of the population. Self-consumption (sold, bartered or shared) of fish products represents about 25 to 35% of the volumes captured whilst; processing and trade is carried out by women. It is noteworthy that the rapid population growth in Cameroon has necessitated seafood importation in a quest to make up for the estimated deficit of 500000 tons. This has consistently registered a negative balance of trade regardless of the fisheries potential. It is therefore not surprising that 181,678 tons of frozen fish worth a sum of US$ 21million is imported (INS, 2017).

Table 6: *Evolution of Fish Imports (2012 -2016)*

Species	**2012**	**2013**	**2014**	**2015**	**2016**
	Tons				
Mackerel	86 146	53 251	91537,44	59449	75947
Sardinella	1 975	10 976	12351,9	8434	3 608
Tilapia	0	3 834	13563,8	5943	1872
Catfish	0	670	107,8	1461	301
Sea bream	6 627	11 876	15799,6	9155	5062
Tuna	0	7	0	0	0
Others	64 665	35 991	31217,1	43503	64161

Cane products	1 819	1 475	1911,41	2486	872,4
Total	161232	118080	166489.1	130431	151823.4

Source: MINEPIA/DEPCS

The Figure (6) illustrates the wide gap between imports and exports, indicating that fish export is almost diminished to nothing. According to (FAO, 2007) illegal exports are estimated at 50,000 tons/year and the main destination is Nigeria.

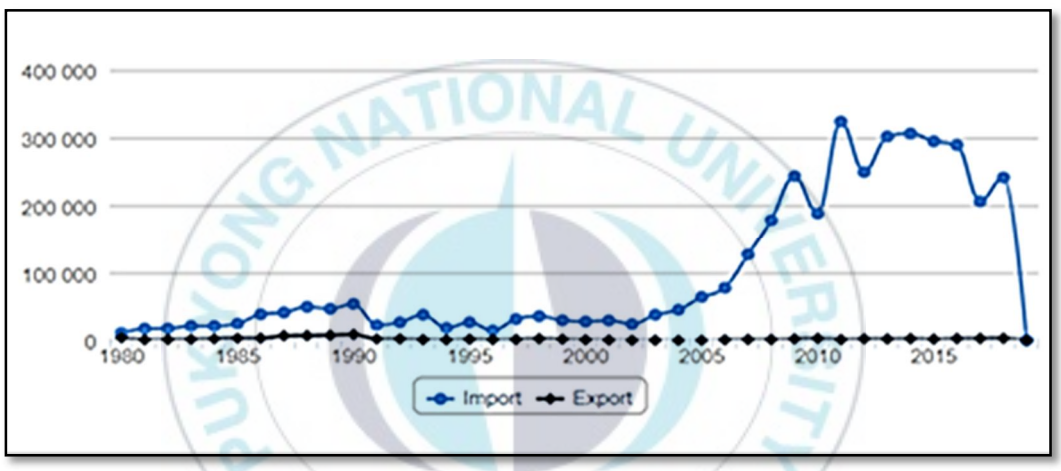

Figure 8:*Total Import and Export of Fish and Fishery Product 1980-2018 (FAO 2020)*

Consequently, Cameroon government in collaboration with the FAO has developed projects to remedy the deficiency in the domestic supply of seafood, by recommending and supporting the expansion of aquaculture. Some project that emanates from the will of the Government of Cameroon to actively increase fisheries sector include:

Project for the Development of Value Chains in Animal Husbandry and Fish Farming (ADB);

- Development of Fish Farming in a Cage in Cameroon (FAO);
- Fisheries and Aquaculture Research Strategy of the Cameroon;
- Livestock and Fisheries Development Project (LIFIDEP);
- The Aquaculture Entrepreneurship Promotion Project (IFAD);

These interventions have significantly reduced importations of seafoods between 2013 and 2017 (Table).

Table 7:*Evolution of Imports of Fish and Crustaceans 2013-2017*

Year	Quantity	Price US
2013	203 957	142 701
2014	205 656	145 078
2015	220 374	166 436
2016	237 152	166 835
2017	181 922	114 902

Source : http://www.statistics-cameroon.org

2.11. Situational Analysis of Study Area

In 1987, a dam was built on the Lake Lagdo which attracted migrants into the Lake side, thereby resulting into deforestation in the quest to construct houses. These anthropogenic activities altered the natural equilibrium for instance, by intensifying soil leaching, facilitating transportation of particles into the Lake resulting to siltation of about 815,960,695 m3 of deposits over 20 years (Abamet Kaigama, 2010 Pp7). This reduced the lake size bed from 700 Km2 to 500 Km2 (Op. Cit.) Consequently, this lake siltation and shrinking constrained production rate by

limiting the yearly capture from 20000 tons in 1990 to 3,000 tons in 2009 (INS 2017). It is against this setting that this Lake Lagdo case study assesses the vulnerability of fishing communities to environmental changes to determine the causes and impacts of siltation and shrinking on the livelihoods of the fishing community. Thus, the study hypothesis asserts that Lake shrinking and siltation have no effect on the living conditions of fishing communities along Lake Lagdo. This hypothesis is verified via observations, secondary data collection and a field survey based on questionnaires and interviews of the local population and the authorities. Results will inform strategies and policies on the adaptation and resilience of local populations in the face of environmental changes.

3. MATERIEL AND METHODS

3.1. Study Area

The study was conducted at Lake Lagdo in the Lagdo Council created by Presidential Decree N°93/321 of 25 November 1993. Located at 65 km from Garoua, Northern Region (09°03'440.4" North, and 13°39'335.5" East) (Fig.9), Lagdo Council has an area of 2,250 Km² with 167 villages (PCD 2015). The Council is bounded in the North, by the Communes of Ngong and Bibémi; in the South, by the Communes of Tcholliré and Poli; in the East, by the Communes of Rey Bouba and Bibémi, and in the West, by the Commune of Ngong. According to the Council Development Plan (2015), Lagdo's population is estimated at 269,420 inhabitants of which 53% are women and 47% men - with an average population density of 118 inhabitants/km².

The prevailing climate is a Sudano-tropical type characterized by two seasons, namely a short rainy season (mid-May-September) and a long dry season (October-mid-May). The average temperature is 31°C and reaches 42-45°C in April. The precipitation is between 600 and 1400 mm with average of 950 mm of water in 55 days (MEADEN 2020). The hydrographical network of Lagdo is influenced by Lake Lagdo (700km^2) and its hydroelectric dam built in 1984 supported by numerous rivers, such as the Benue, the Mayo-Bocki, the Mayo-sala, the Mayo-

Boulel and the Mayo-Alfom. This offers a great potential for fishing, pastoral, agricultural and tourist activities (ibid.).

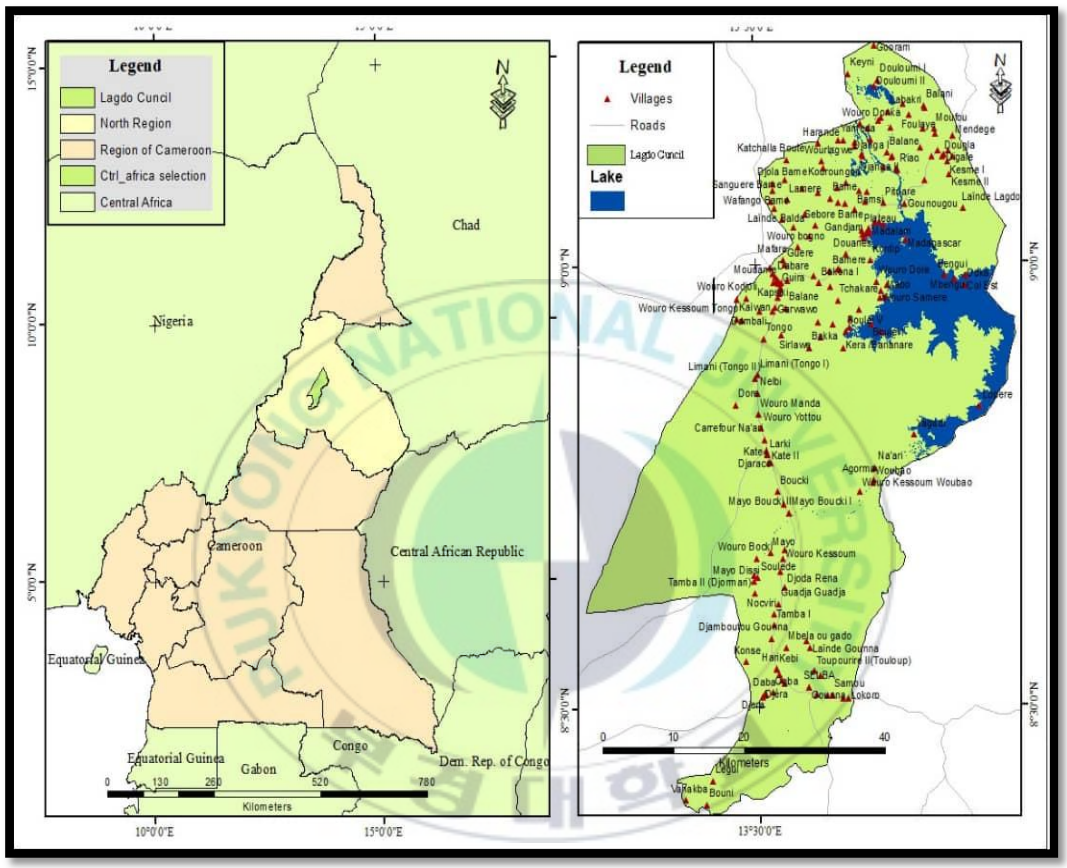

Figure 9: *Lagdo Municipality Map*

3.2. Data Collection and Analysis

3.2.1. Data Collection

Data was collected using semi-structured questionnaires and field observational

research. The snowball sampling was used to determine the population of fishermen with the help of local leaders who identified the gatekeepers in the fishing community and organized targeted discussions. The snowball sampling approach identifies a subject with the desired characteristics or traits; then, the subject in turn, gives names of suitable subjects to be contacted (e.g., Mash, 1982). As explained in Subsection 3.1.2. representative samples of 10% of the fishing population were randomly taken once the population was identified. The support of the local chiefs was very beneficial since the questionnaires were completed during the biological closed season established each year from July 1st to September 30th in Lagdo since 2013 (MINEPIA). During this closed season, migrant fishermen (Nigerians, Malians, Chadians) migrate to other fishing pools. Consequently, the study focused on indigenous Cameroonian fishermen who stay in situ. Secondary data were accessed from ministries, departments and agencies in addition to desk study and information from the internet.

3.2.2. Sampling

Fishing activities are primordial for certain families, while it represents a secondary activity for others, especially the Youths. The Lagdo Council has 1363 fishermen: 841 Cameroonians, 222 Nigerians, 292 Chadians and 8 Malians in 36 camps (MEADEN 2019). There are 08 (eight) major villages around the Lagdo Lake and every household in these villages have a potential fisherman (MINEPIA). Five (05)

of the 8 villages were targeted for the study. The choice of these 5 communities was influenced by accessibility factors. Some fishing villages like Madagascar I & II are islands, while others such as Madjalissa and Mayo Seini are inaccessible during the rainy season. The study focused on the 841 Cameroonian fishermen as our target population because foreign fishers migrated at the time of the study. Simple random sampling (Turner 2019) was employed to obtain the study sample. A representative sample of 10% of the population was randomly selected to form the sample. Accordingly, a total number of 84 fishers form the sample for the study from a total population of 841 fishers (Table 8).

Table 8: *Sampling Framework*

Study Area	**Survey Site**	**Estimated Fishing Population in Village**	**Numbers of Questionnaires Completed**
Lagdo	Gounougou	180	18
	Boulel I &II	80	08
	Ouro-Kessoum	170	17
	Yagagi	250	25
	Mbengui	90	09
Total		**841**	**84**

3.2.3. Data analysis

Data was subjected to basic descriptive statistics to determine, frequencies, cross tables and construct line diagrams, bar chart, pie charts and other graphs to illustrate results using Statistical Package for the Social Sciences (SPSS) 18.0 and Microsoft

Excel software. These analyses helped to assess the questionnaire data and illustrate the impact of environmental changes on livelihoods.

3.3. Study Approach

3.3.1. Conceptual Framework of Sustainable Livelihoods Approach

The sustainable livelihoods approach has been applied to understand the social and economic impacts from the vulnerability context characterized by the exposure of the fishing community to the siltation and shrinking of Lake Lagdo as well as their ability to cope with and recover from it. The conceptual framework of Sustainable Livelihoods Approaches (SLA) has become the primary method that places people at the center of all development activities (Figure10). Livelihood could be understood as activities to ensure basic needs (such as food, education, water, clothing, shelter and other necessities of life). Chambers and Conway (1991, 6) considers that “a livelihood comprises of the capabilities, assets and activities required for a means of living. A livelihood is sustainable when it can cope with and recover from stresses and shocks and maintain or enhance its capabilities and assets both now and in the future”.

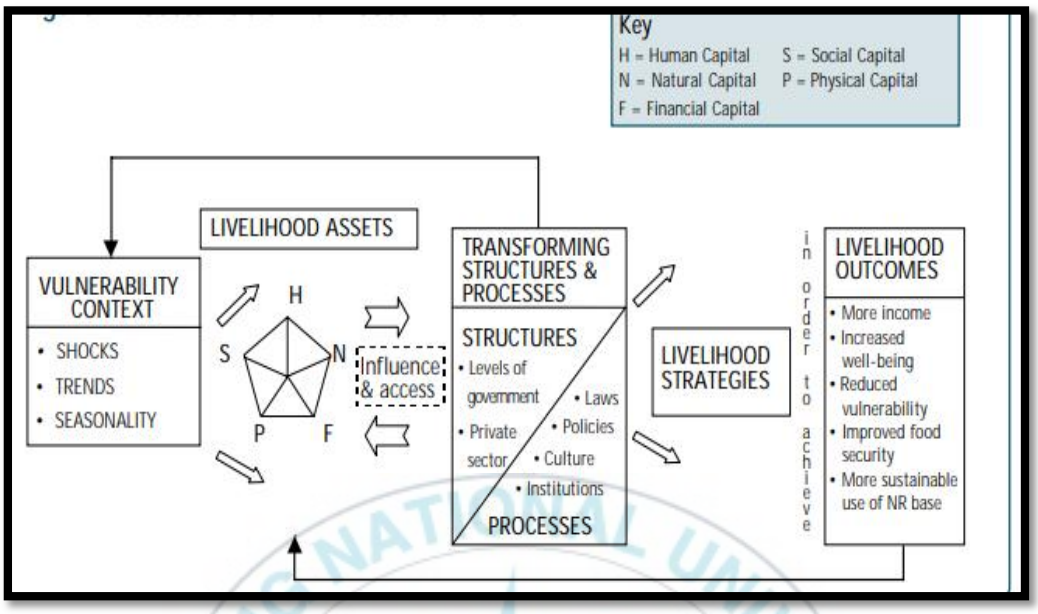

Figure 10: *Sustainable Livelihoods Framework (after DFID, 1999)*

Brocklesby and Fisher (2003), considers the Sustainable Livelihoods Framework as having four main components. First, the vulnerability context is the exposure of populations to risk through shocks, seasonal changes and trends over time. The Intergovernmental Panel on Climate Change (IPCC, 2007) defines "vulnerability" as "the degree to which a system is susceptible to and unable to cope with the adverse effects of climate change". Thus, vulnerability is a function of the character to which a system is exposed, its sensitivity, and its adaptive capacity (Figure11). Vulnerability impacts livelihoods through direct impacts on the state of the resources of the populations. Secondly, exposure refers to extrinsic stresses such as the magnitude and rate of change that a species or system is likely to experience. The third component refers to sensitivity which is related to innate characteristics

of a species or system and considers the degree to which the system is affected by exposure. Finally, adaptive capacity, refers to the ability of a species or system to accommodate or cope with climate change impacts (cf. Ellison, 2015).

In the context of vulnerability, the viability of livelihoods is affected by external shocks, trends and seasonality of activities. Thus, in response, fishing communities, based on their available assets, build a livelihood to reduce vulnerability and improve living conditions (Allison, n.d.).

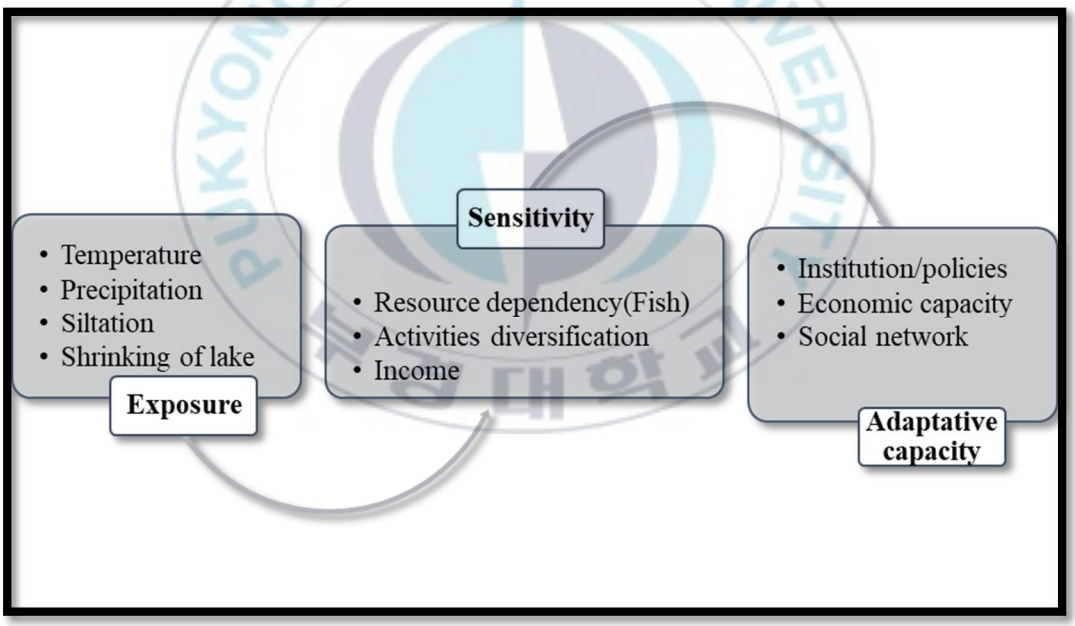

Figure 11: *Study Vulnerability Framework*

The availability of capital assets, such as; physical, financial, natural, human and social capital; the so-called capital asset pentagon is at the heart of livelihood analysis (Figure.12). These assets represent the livelihood assets in the evaluation

of the overall asset base of people. The purpose of a livelihood asset is to build assets that can bring positive changes to livelihoods and transform resources or build assets into positive outcomes and thereby improve people's living conditions (GLOPP, 2008).

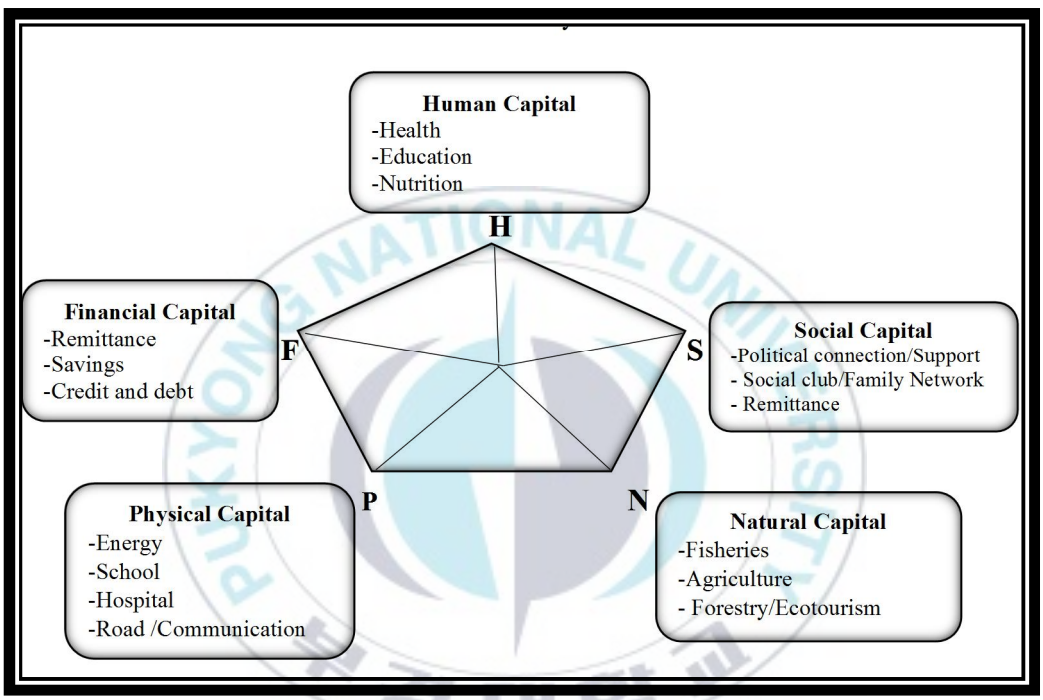

Figure 12: *Capital Asset Pentagon*

These assets influences the construction of livelihood strategies in order to generate coping activities. Livelihood strategies involve the dynamics of people combining activities to satisfy different needs in order to achieve livelihood goals (see Figure.10). Therefore, livelihood strategies are directly dependent on the state of assets and policies, institutions, and processes (GLOPP, 2008). Policies and institutions will shape strategies to ensure that people adapt or are resilient to this

vulnerable context. Thus, livelihood outcomes are the achievements of livelihood strategies. The conceptual framework of the sustainable livelihood approach aims not only to determine how people operate in a context of vulnerability determined by shocks, seasonality and trends, but also how they take advantage of this new condition to develop strategies and improve their well-being (UNDP, 2017).

3.3.2. Strength and Weakness of the Sustainable Livelihoods Approach

3.3.2.1. Strength

Sustainable livelihoods draw strength from three main principles; people-centered, holistic and dynamics (DFID, 1999). Firstly, the sustainable livelihoods framework puts people at the center of all planning processes, respecting their opinions (their strength, potential and goals). As Bene, (2004) argued, it begins with an analysis of people's livelihoods and involves them in the diagnosis of sustainable livelihoods, taking into account their opinions in order to help people achieve their livelihood goals. Another strength is its holistic nature, which is based on the idea that various factors can enhance or limit the ability to develop survival strategies. It therefore requires an understanding of the economic and social relationships that influence individuals and their survival strategies in order to provide a way of thinking about livelihoods that contributes to improved development effectiveness (ibid.). The third strength of the livelihoods approach is its dynamic nature. It

recognizes the effects of non-static external shocks on livelihoods, identifies the nature of cause-and-effect relationships, and demonstrates how individuals can or cannot influence the policy process (Neiland and Bene 2004; GLOPP 2008).

3.3.2.2. Weaknesses

However, sustainable livelihoods have certain acknowledged limitations. Firstly, the different indicators for each component, mainly livelihood assets, are not clearly defined and may change depending on each context or situation, such as remittances overlapping between financial and social capital; health status between physical and human capital - making it a complex task to understand. Secondly, the capital asset platform takes the vulnerability context as people living under insecure circumstances are targeted owing to a robust capital assest status thereby resulting into adverse outcomes (Baio,2009). Furthermore, increasing the sustainable livelihoods of one group may have a negative impact on the livelihoods of another (GLOPP, 2008).

3.4. Questionnaire Development

A semi-structured questionnaire (Appendix) was used to elicit fisher's viewpoint on the issue of siltation and shrinking of Lake Lagdo, its impact on their livelihoods and also to proffer way of reducing the impacts of the vulnerabilities (Siltation and

shrinking). Consequently, the questionnaire as aligned to the sustainable livelihood's framework is divided into 4 sections.

Section one (1) dwells on three main issues; the personal profile, the natural assets profile and the time series of fish production. The personal profile helps to identify demographic data such as gender, age, religion, and education level of respondents. Natural capital assets, refers to access to and state of natural resources around the lake. This segment aims to assess environmental change with a focus on biophysical factors such as changes in the size and depth of the lake that affect the sustainability of this ecosystem. Time series of fish production, looked at changes in fish production in order to assess the evolution of the catches and the sustainability of the resources.

Section two (2) evaluates the dependence on fishing through variables such as: time spent fishing, income from fishing, changed in income, percentage consumed and sold. This would indicate the degree of sensitivity to fishing and the role of fish in the diet and income derived therefrom. The aspect of livelihood diversification activities and income changes will show the impact of non-fishing income on livelihoods and wellbeing.

The third Section (3), deals with the immigration and emigration of fishers, bearing in mind that the reduction or abundance of fishing resources influences migration/emigration decisions. This Section will show the net movements of fishers currently and during the last ten years within the vulnerability contexts.

The Section four (4) of our questionnaire is designed to elicit the status of the five capital assets: natural, human, financial, physical and social. This will help to better understand how people build their livelihoods in order to improve the living conditions. Social capital platform of the community with respect to how the interactions between fishers and organizations, associations, projects/programs sustains fishermen's livelihoods was assessed.

RESULTS

4.1. Interviewee Profile

Our sample consisted of 84 elements, 91.7% of respondents were male while 8.3% were female. About 82.1% of the respondents mainly depend on fishing-based livelihoods and others fishermen are either unemployed/retired (6.6%), still in school (7.1%) or traders (4.8%). In terms of educational attainment, 46.7% of respondents had attended primary school, and 39.3% had attended secondary school; 8.3% had never been to school and 4.8% attended Koranic school. The age distribution of the sample was 36.9% were between 30-40 years; 20.2% between 40-50 years compared to 17.9% who were above 60 years old (Figure.13).

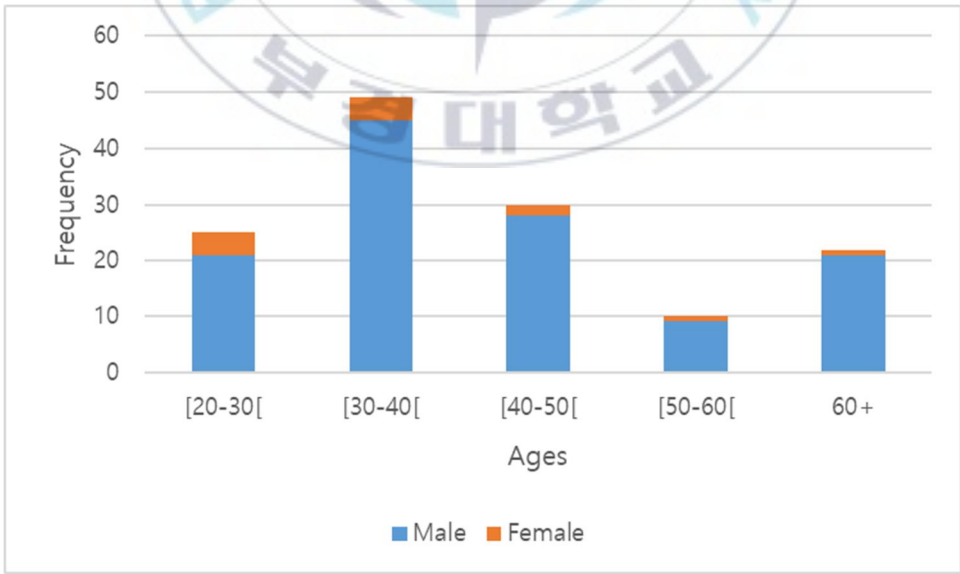

Figure 13: *Distribution by Age and Sex of the Respondents*

With respect to relegion, 59.5% of our sample is Muslim, 31.0% Christian and 9.5% Animist. Contrary to previous studies from the Lagdo area (**PCD 2015**), the relatively high percentage of Muslims could be attributed to the high migratory trends of the area, having seen the influx of the Muslims from the Far North and Ngaoundere regions.

Table 9: *Demographic and Socio-economic Characteristics of Respondents*

Attribute	**Frequency**	**Percent**	**Valid Percent**
Gender			
Male	77	91.7	91.7
Female	7	8.3	8.3
Age			
[20-30[	14	16.7	16.7
[30-40[	31	36.9	36.9
[40-50[	17	20.2	20.2
[50-60[	7	8.3	8.3
60+	15	17.9	17.9
Religion			
Islam	50	59.5	59.5
Christian	26	31.0	31.0
Animist	8.0	9.5	9.5
Level of Education			
Never been to school	7	8.3	8.3
Koranic school	4	4.8	4.8
Primary	40	47.6	47.6
Secondary	33	39.3	39.3
Main Economic Activity			
Fisheries	69	82.1	82.1
School	6	7.1	7.1
Unemployed/Retired	5	6.0	6.0
Trader	4	4.8	4.8

4.2. Vulnerability Context

4.2.1. Temperature

Temperatures are relatively high as compared with other areas of the country with an average of 32.2°C and an average maxima of 40°C in the month of April. However, we can observe significant variations between years and even between months. Humidity is relatively low (below 35%) for more than half of the year **(MEADEN 2020)**

Figure 14: *Temperature Trends (2008-2017)*

Source: *Field data collected from Agricultural Research Institute for Development.* ***(IRAD 2020)***

4.2.2. Precipitation

Precipitation for of the locality shows rainfall variabilities from 600 to 1400mm with the annual average rainfall of 950mm and about 55 days of rainfall per year **(DAADER-Lagdo Report, 2015).** The Sudano-tropical climate of Lagdo is characterized by two seasons namely a short rainy season (Mid May-September) and a long dry season (October-mid May).

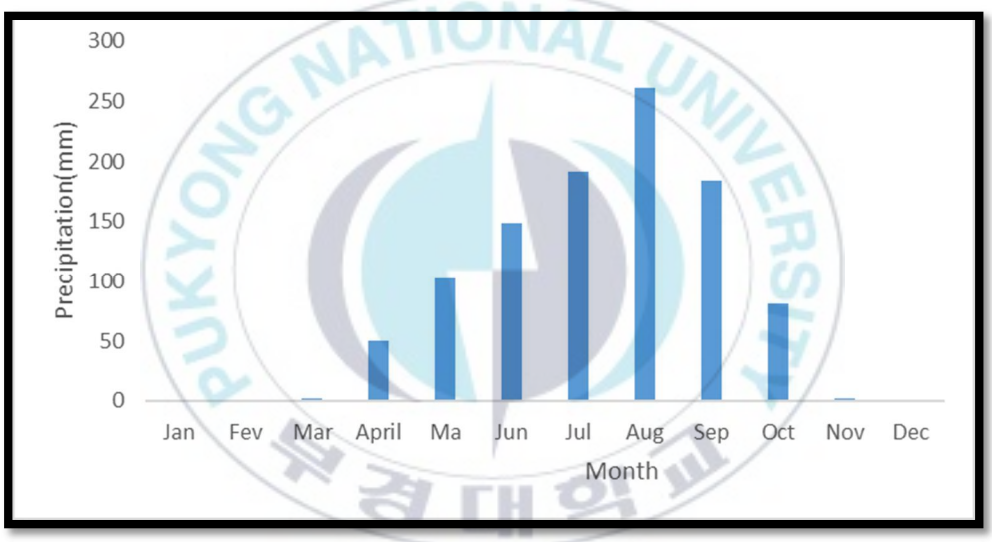

Figure 15: *Precipitation Trends (2008-2017)*

Source: *Field data collected from Agricultural Research Institute for Development* ***(IRAD 2020)***

The ombrothermic diagram below indicates that the locality has experienced abnormal drops in temperatures in 2012. Tesi et al. (2016) argued that it is due to

the extreme floods of September and October 2012 from intense rainfall causing the release of excessive water from the dam.

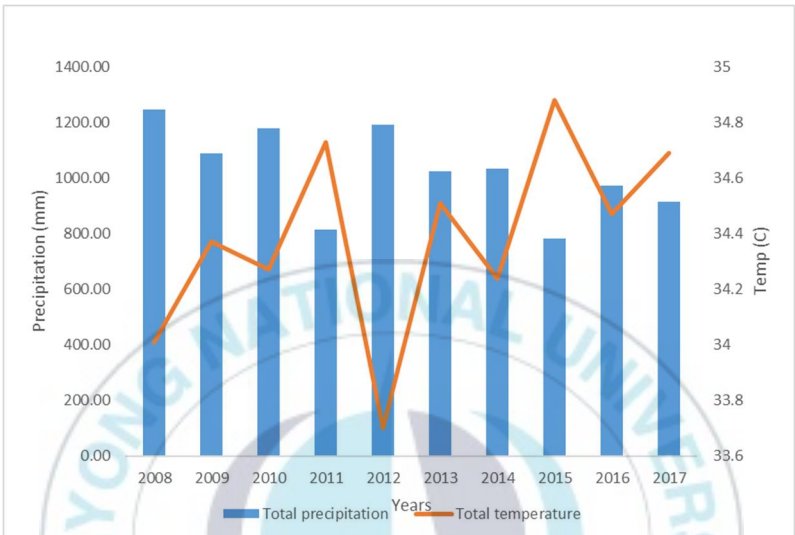

Figure 16: *Ombrothermic Diagram (2008-2017)*

Source: *Field data collected from Agricultural Research Institute for Development* ***(IRAD 2020)***

4.2.3. Siltation and Shrinking of Lake Lagdo

The study of the siltation of the Lagdo reservoir enabled the assessment of the amount of sediment accumulation in the reservoir. This sedimentation is considered as an indicator of the degradation of the Lake. Ngondjeb and Ayuk (2021), suggests that the average annual sedimentation is about 40 800 000 m3, which has diminished the reservoir volume by 0.9%. The Mission for the Planning and

Development of the Northern Region (MEADEN) indicate that in 20 years, 815, 960, 695 m3 of deposits, mainly made up of coarse sands, were deposited in the dam. Located in the Sudano-tropical zone, Lake Lagdo which provides a livelihood through its freshwater resources is threatened with droughts that affects livelihoods due to environmental changes and population pressure over the past decades. The calculated % change shows that the size of the Lake has reduced by 19.45 %, from 700 km2 in 1983 to less than 586 km2 currently. Several reasons (Figure 17) have been given to explain these environmental changes.

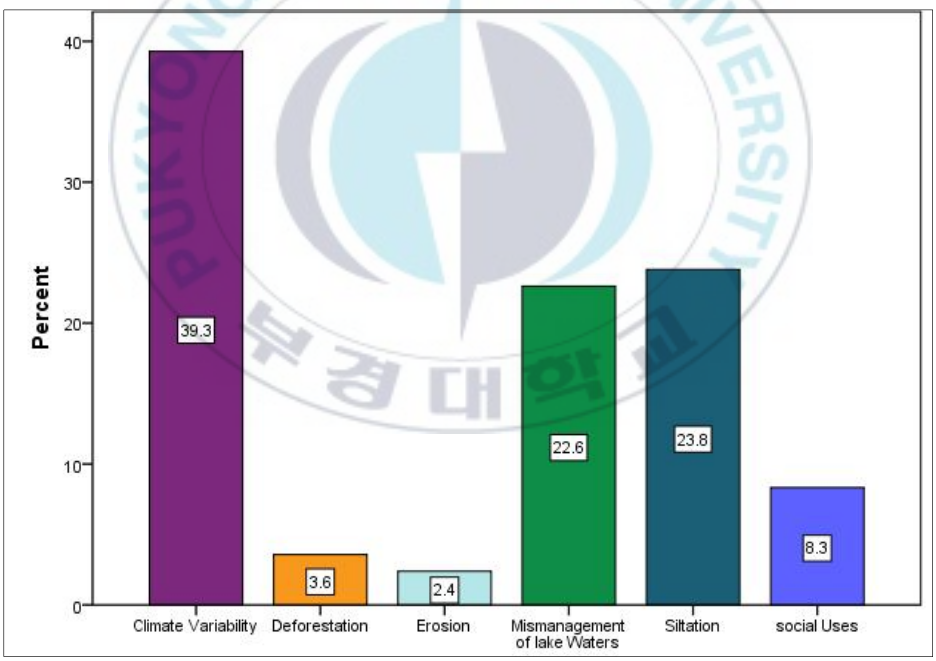

Figure 17: *Reasons of Changes*

4.2.4. Fish Production at Lake Lagdo

Considered as an 'Inland Sea' fishery is important in the Lake Lagdo community. The development of fishing in Lagdo evolved from the creation of the Lagdo reservoir in 1984. This induced migration and settlement of many indigenous people with a devotion to fishing and other fishing related activities (Figure 18).

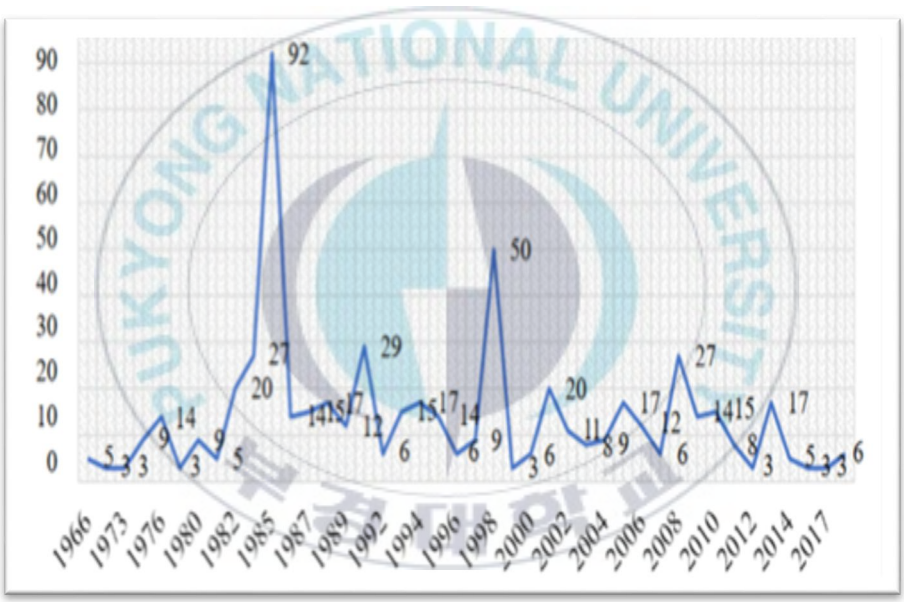

Figure 18: *Migrations Trends (1966 to 2017)*

Source: MEADEN 2019

Total catches of 2500 tons was recorded in Lagdo in 1983 when the dam was impounded, exploding in to 20,000tonnes in 1990. In 2009, production dropped drastically to 3,000 tones before slowly increasing to 9620 tons in 2019.

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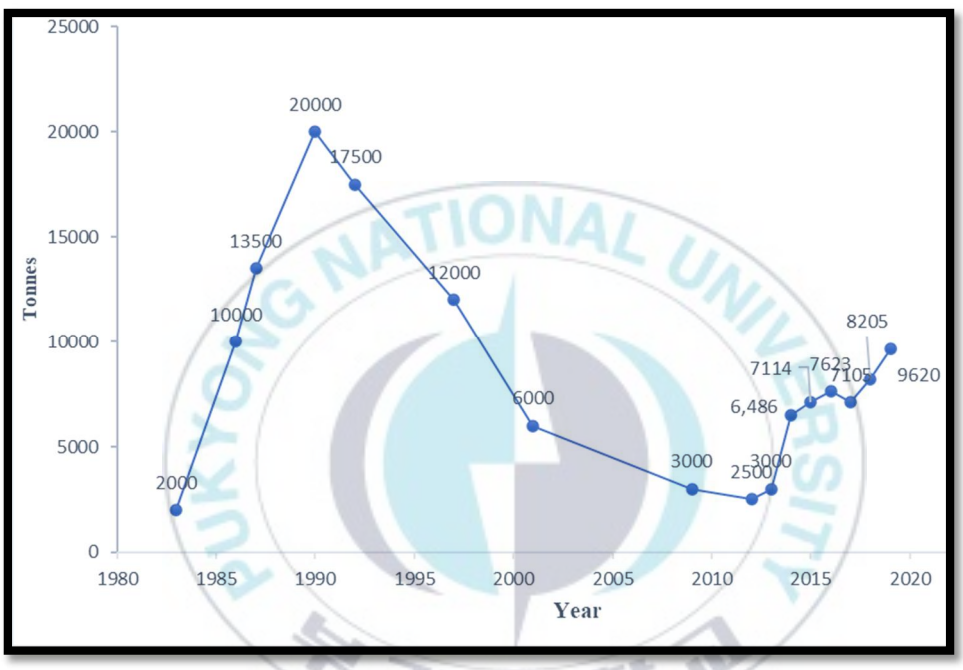

Figure 19: *Time Series of Fish Catches (1983 to 2019)*

4.2.5. Type of Nets and Vessels

The fishing gears are varied and essentially made up of dugout canoes and nets. According to INS (2015), there are 1452 paddle canoes, 94 plank canoes, 20 motorized canoes and 676 nets. Regarding the type of nets, the following can be identified; The Cast Net (26,58%), locally called 'Birgui', the Malian nets or

Gillnet locally called ‘Goura’ (36,71%), the Beach Seine or ‘Taro’ and mosquito Net (17,72%).

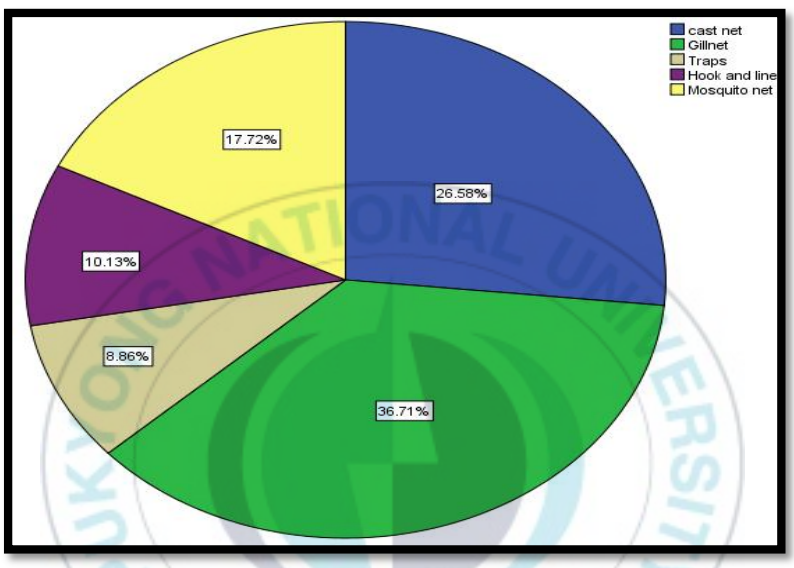

Figure 20: *Types of Nets*

4.2.6. Female Participation in Fish Capture

Fish production was once considered a ‘Man’s activity’. Women are now also engaged in financing activities across the value chain; receiving fish, processing and marketing of fish and aquaculture products. From field observation, women in Lagdo area do not engage in the capture of fish as it remains largely male dominated wherein, 91.2% of actors are men and 8.8% are women. A number of

reasons have been put forward to explain the limited participation of women in other segments of the value chain apart from the post-harvest node. These include; social restriction (51.2%) and the lack of interest (28.6%). Only one of the many ethnic groups have a culture of allowing the women to fish. It is mostly the Mousgoum, originating form around Yagoua and Maga who have a culture were women are allowed to fish.

Table 10: *Female Participation in Fish Capture*

Variable	Frequency	Percent	Cumulative Percent
Social restriction	43	51.2	51.2
Lack of interest	24	28.6	79.8
Participants	17	20.2	100.0
Total	**84**	**100.0**	

4.2.7. Dependence on Fishing

Fishing is an important economic activity in Lagdo as evidenced by the dependence on this activity. The analysis of this dependence (Figure 21) during two periods (current times and 10 years ago) shows that fishermen spent an average of 80% of their time fishing a decade ago, compared to 47% today. In 1990, quantities caught were larger (Figure 19). Today, the quantities caught have drastically reduced to more than 70% with increasing number of fishermen causing unhealthy competition. In order to keep family livelihoods at an acceptable level, most

fishermen have turned to engaging in multiple activities to diversify sources of family income. In terms of the utilization of the fish, the result reveal that the majority of the products are sold. However, the quantity sold has diminished currently compared to 10 years ago. This is due to declining catches and increasing family size compared to a decade ago. Currently smaller quantities are harvest (Figure 19) whilst family sizes have increased thereby reducing the quantity fishing families can sell as catcg is increasingly used for family food and nutrition security.

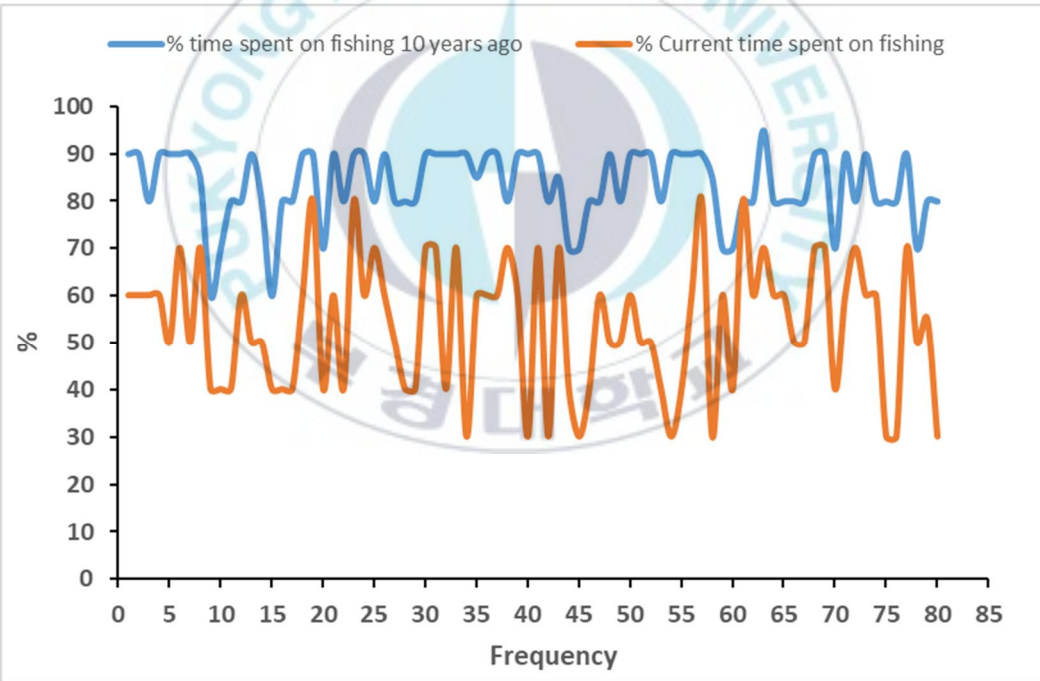

Figure 21: *Dependence on Fishing*

The change of time spent on fishing from a decade ago to the status quo is attributed to fish scarcity 39.3%, development of other activity 31%; reduction in income 21%

and biological rest season 8.3%. Most of the fish produced is sold so the quantities consumed by the producers remain low. Fishermen sell an average of 97.76% of their fish 10 years ago, compared to 85.65% today. The graph below shows that fishermen's households currently consume an average of 14.34% as against 2.24% 10 years ago due to increase in family size.

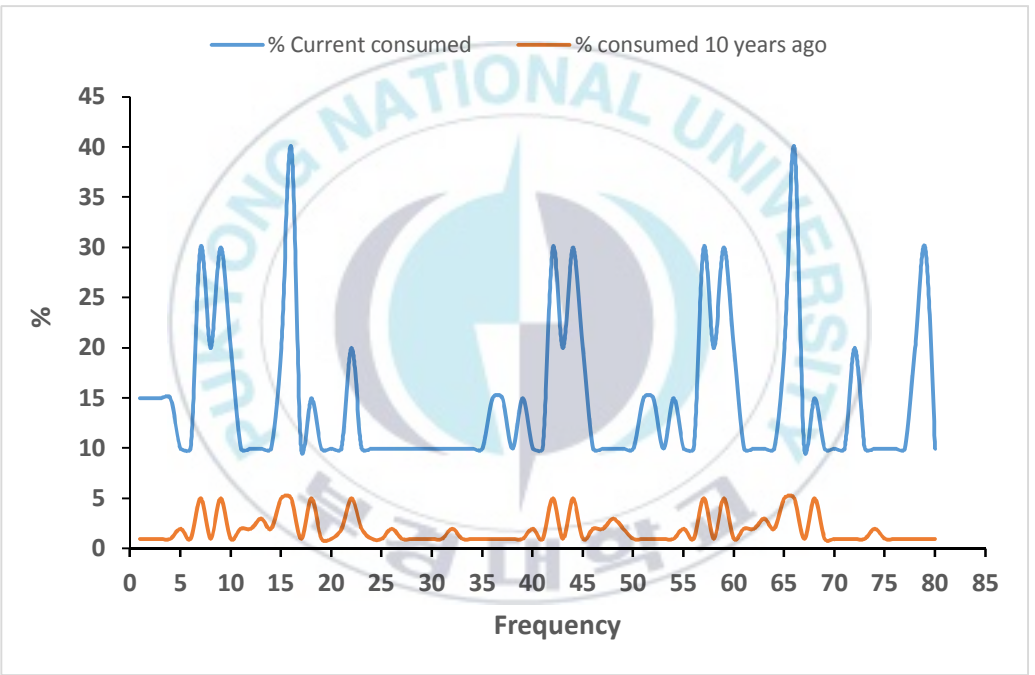

Figure 22: *Dependence on Fishing*

4.2.8. Change in Income

In the municipality of Lagdo, the sale of fish products provides households with a significant portion of their annual income. The lack of precise statistics on fishing

income limits this analysis to an estimation of the average income made by the fishermen (the fishermen do not record their catch nor income from their activities). Nevertheless, income from the fish trade is an important source of revenue because it allows fishermen to overcome poverty, resolve problems and satisfy the needs of their households. The calculations of the % change in income from 10 years ago to current period non-group data of each fishermen gave a reduction of 69.67% in fisheries income over the period.

Table 11: *Grouped % Change in Income (10 Years ago to Current Status)*

Valid	**Frequency**	**Percent**
Current Income		
[10000-50000[	26	31.0
[50000-100000[	30	35.7
[100000-150000[	10	11.9
[150000-200000[	8	9.5
[200000-250000[	6	7.1
[250000-300000[	2	2.4
350000+	2	2.4
Total	**84**	**100**
Income 10 Years Ago		
[100000-200000[	12	14.3
[200000-300000[	20.2	20.2
[300000-400000[	26	31.0
[400000-500000[	7	8.3
[500000-600000[	7	8.3
[600000-700000[	6	7.1
800000+	9	10.7
Total	**84**	**100**

There are several reasons for this change in income, but the most significant factor is reduced catches or drop in fishing output (44%).

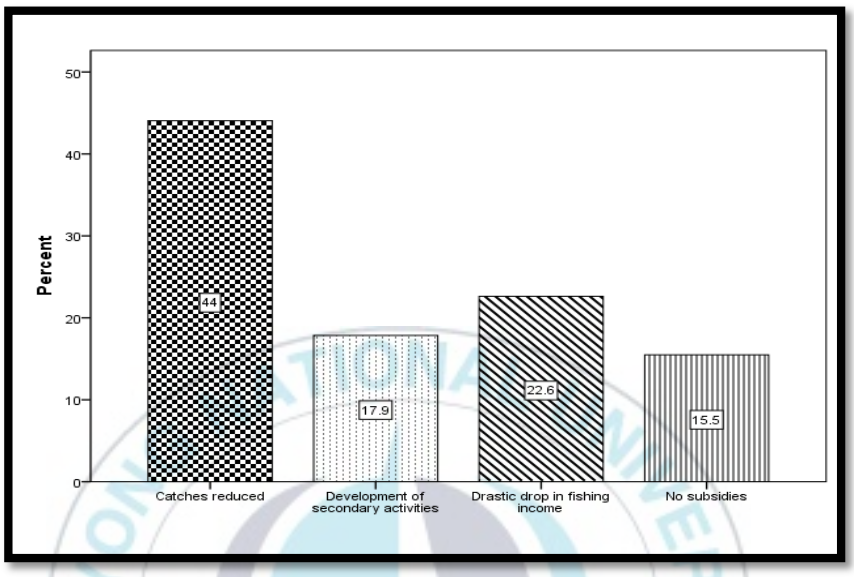

Figure 23: *Reasons for change in income*

4.3. Capital Assets Assessment

4.3.1. Physical Capital

4.3.1.1. School

General data on education in Lagdo at the primary and secondary levels reveals that Lagdo district counts 80 primary schools according to Municipal Development Plan (PCD 2015) and a total of 10 secondary schools (4 colleges and 6 high

schools). These institutions could be further categorised into 9 general education institutions and 1 technical school (http://www.schoolmapcm.org/).

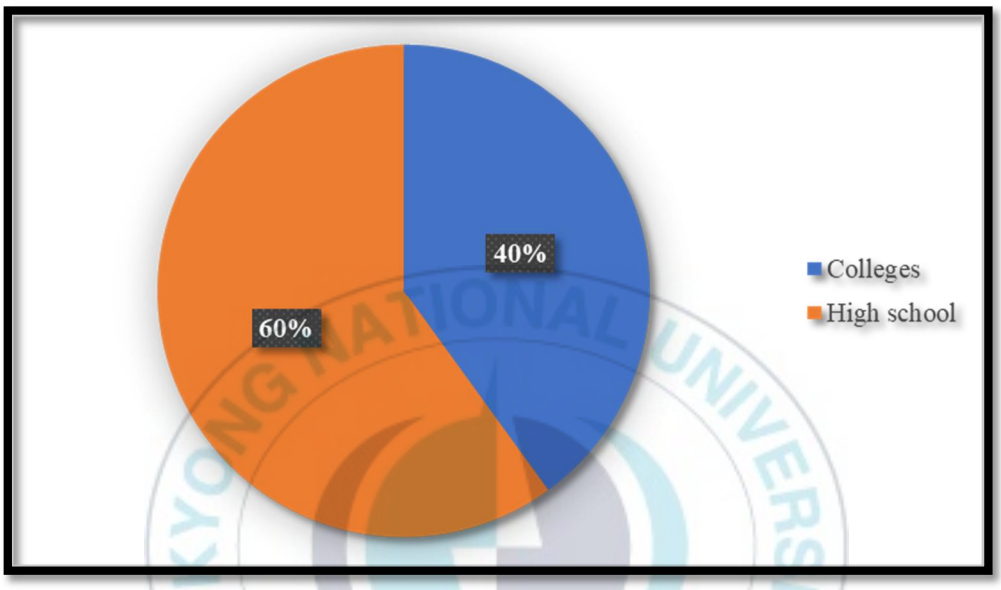

Figure 24: *Distribution Educational Institutions*

4.3.1.2. Hospital

Order No. 95/040 of 7 March 1995 reorganizing the hospital system in Cameroon into three levels: central, intermediate and peripheral. At the peripheral level is the health district, which has two levels of health care facilities: the district hospital, and health centers called "integrated health centers" (CSI). In the Lagdo district, according to the PCD (2015), the health sector has a hospital (Lagdo) and 17 health structures called "integrated health centers" (CSI), located in the localities of

Djanga, Djippordé, Doulol Bocki, Gouna, Gounougou, Laindé Lagdo, Ouro Kessoum, Mayo Bocki, Tongo, Rabingha, Badankali, Badjaoulé, Bakona I, Boumédjé, Na'ari, Dingalé. In addition to these public health structures, there is a private health facility in Djippordé.

4.3.1.3. Hydroelectric Dam

The hydraulic system of Lagdo is influenced by the hydroelectric dam built in 1984 on the Benue River. This dam is 308m in length and 4 m in height covering an area of 586 km2 mainly built for the purpose of producing energy. The Lagdo dam has landing stages for boats with motors coming from Nigeria.

4.3.2. Financial Capital

The analysis of the financial interactions of our sample reveals that 53.6% of fishermen are involved in rotating credit/savings, which is an informal financial sector that combines savings and credit. This traditional financial system is made up of a group of people who have connections (family, friends, profession, etc.) and pool their savings for the profit of all wherein members have access to a relatively significant amount of money in a rotating manner. In addition, 26.2 % of the population uses mobile money, which refers to financial transactions using a mobile device such as a phone. Conventional financial institutions are limited

(microfinance 17.9%, bank 2.4%). Concerning access to financial and credit institutions, there are two microfinance institutions operating in the study area: Express Union and Sahel Credit.

Table 12: *Financial Assets in Lagdo Community*

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	**Bank**	2	2.4	2.4	2.4
	Microfinance	15	17.9	17.9	20.2
	Rotating Credit/Saving	45	53.6	53.6	73.8
	Mobile money	22	26.2	26.2	100.0
	Total	84	100.0	100.0	

4.3.3. Human Capital

Fishing communities' adaptive ability can be improved through education and good health. Education and wellbeing have a major impact on environmental change mitigation. The following cross-tabulation between age and education level shows us that fishermen between]30-40[years of age, with an average age of 35 years, and]20-30[represent 53.6% of the active population. Of these, 1.19% are illiterate and 15.48% completed primary school 19.05% (Figure. 25).

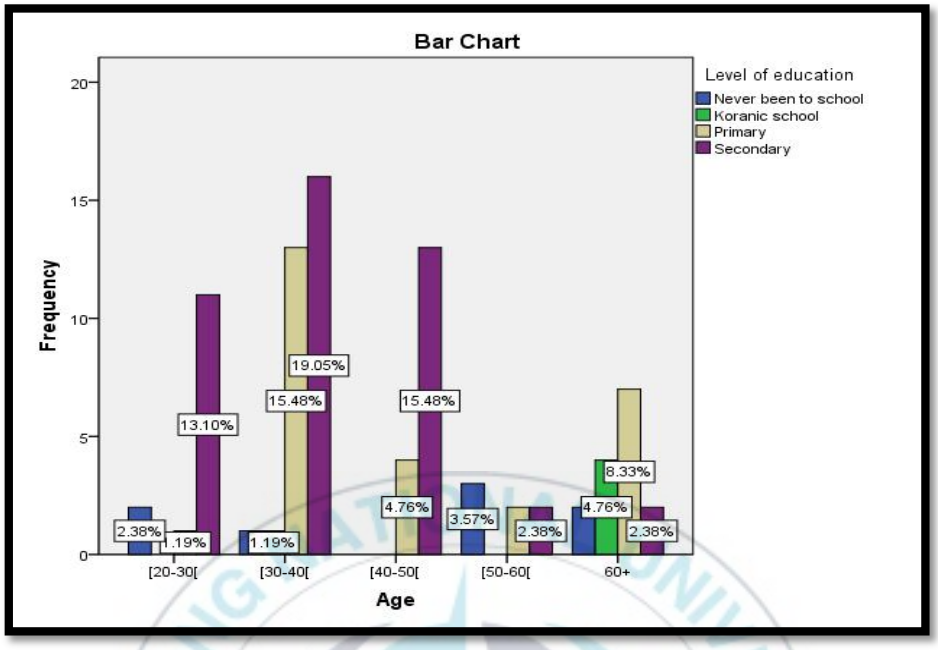

Figure 25: *Crosstabs between Age and Level of Education*

The health map of Lagdo shows that 03 of the fishing villages (Gounougou, Ouro-Kessoum, Djiporte Kabawa) have a health facility called "Integrated Health Centers". These centers generally have 1 to 2 buildings containing all services and managed by nurses.

Table 13: *Distribution of Staff by Health Facility in Lagdo (Lagdo District Health Office – 2018)*

Community	Doctor	Pharmacist	Nurse	Technical Health Officer	Nurse Assistant	Mid-Wife	Laboratory Assistant	Total
Djippordé	0	0	1	1	2	0	0	04
Gounougou	0	0	1	1	1	0	0	3
OuroKessoum	0	0	1	0	1	0	0	2
Bame	0	0	1	0	1	0	0	2

Lagdo Urbain	0	0	2	1	0	0	0	3
Djanga	0	0	1	0	1	0	0	2
Hospital of district	4	1	5	2	7	1	1	21
Dingale	0	0	0	0	1	0	0	1
Total	**04**	**1**	**12**	**07**	**14**	**1**	**1**	**38**

4.3.4. Naturel

4.3.4.1. Fisheries

The Lagdo reservoir, due to its high fishing productivity, typifies the fisheries sector of the Benue Department by providing up to 88% of the catches (INS 2016) and constitutes one of the natural assets of the Northern Cameroon Region. A total of 121 fishing camps are dotted along the Lagdo River, accessible by canoe or by road. Small scale fishing is mostly practice with theaquatic fauna comprising of 90% of fish including; *Chrysichthys* (Loro, Cat fish), *Citharinus* (Falia, Moon fish), *Heterotis* (Kanga, Laréou, Boney Tongue), *Hydrocynus* (Binga, Gniéou, Tiger fish, Sagaie), Lates (Capitaine, Nil perch) and Tilapia (Mango fish) (MEADEN 2019; PCD 2015). After having reached a peak of 20,000 tons in 2000, catches have significantly decreased in 2019 to 9,620 tons. The resource is exploited by canoe, both motorized and non-motorized. The gear used are traditional, such as purse seines (120), cast nets (135), Malian traps (2,800), Nigerian traps and nets (2,000), longlines (3,100), standing gillnets (900) and conservation traps (120) (PCD 2015; MEANDEN 2019). Lagdo has an ice-making and two fishing sheds in Boulel I.

Fresh fish, smoked fish and dried fish are sold on the market. These fish products are also sold in the North and Far North regions including neighboring countries such as Nigeria, Chad.

4.3.4.2. Agriculture

Agriculture is in many cases the main source of income and the driving force of the economy. Lagdo has natural resources (lowlands, valleys, flood plains.) that are suitable to the development of agriculture. Semi-intensive agriculture is practiced using ox ploughs and manual labor. Lagdo's climate supports two types of cultivation; rainfed and irrigated farming. Agriculture policy is oriented towards irrigated agriculture, promoted by the establishment of the Lagdo dam, which provides 400 million m3 of water per year for irrigation (Meanden report). The main agricultural products of the Lagdo district are rice, cotton, peanuts, onions, sugar cane, corn and millet. Besides, other secondary crops such as; potato, cassava, sesame and cowpea, tomato, lettuce and other vegetable are cultivated (MEADEN 2020). The government has provided a number of structures to boost the agricultural sector in Lagdo, namely; Agricultural borough office, seven (07) agricultural posts; Education and Animation Center (CEAC); Family Farming Exploitation (EFA); Agricultural Value Chains Development Program (PADFA); and a technical agricultural high school (Communal Development Plan 2015),.

4.3.4.3. Livestock

The livestock reared in Lagdo District include cattle, sheep, goats, pigs and poultry. Cattle raising is common and is practiced in two forms: semi-intensive and extensive (practiced by the Fulani Mbororo). The Lagdo area counts 30,000 cattle, 11,000 goats, 9,000 sheep, and 27,000 poultry spread over an area of 300 ha covered by five (5) tracks and two (2) national and international corridors of transhumance that cross Lagdo on their way to Nigeria, Chad, and the Central African Republic (PCD 2015; Meanden 2019). Regarding animal husbandry infrastructure, Lagdo has three slaughter areas, a slaughterhouse, a watering point for animals and a holding pen. In terms of facilities or support services, the Livestock Development Project (PRODEL), the DAEPIA and the Zootechnical and Control Centers are operational

4.3.4.4. Forestry and Ecotourism

Forests are important in maintaining functions such as water quality and quantity because they promote the filtration of water. There are gallery forests and forest massifs (Ouro Doukoudjé and Gouna). The Ouro Doukoudjé forest is the most important; has been owned by the state since 1991 and has been converted into a communal forest in 2019 with approximately 8000 ha and located between the

villages Ouro Doukoudjé, Laïndé Lagdo and Bengui (Meaden 2019). The tourist potential of the region is characterized by the rich and diversified fauna and the presence of three (03) ZIC (area of hunting). The terrestrial fauna is made up of cob, elephants, antelopes, lions, jackals, hyenas, warthogs and hypotenuses. The relief of contiguous landscapes with a vast alluvial basin is surrounded by mountains (PCD 2015).

4.3.5. Social Capital

The fisheries sector of Lagdo is structured as a GIC and association. In total, 14 fishermen's organizations exist in Lagdo. These associations include fishermen (09), Sellers (04), women's associations (01).

Table 14: *Distribution of Fishermen's Organizations (MEADEN 2019)*

N	**Name**	**Designation**	**Location**
1	AVENIR	Ice factory	Carrière
2	AMOU	Fishermen	Ouro-Kessoum
3	FARTERE	Fish product sellers	Bobbi-Lagdo
4	SAGAIE	Fish product sellers	Chantier
5	NARRAL NGAOBE	Fishermen	Boulel I
6	AZOUGON TILAPIA	Fishermen	Djippordé
7	ASGON	Fishermen	Djippordé
8	OUMA TADA	Seller	Djippordé
9	WITCHO SAHIRE	Fishermen	Gounougou
10	KAFI	Fishermen	Carrière
11	GUIWA CAPITAINE	Fishermen	Djippordé
12	AGRO-HALIEUTIQUE	Assistance fishermen	-
13	RAFLAG DOCKA	-	Chantier

14	UNIONS DES GIC	women's organizations	Djippordé

Regarding the social networks of our sample, the survey revealed that the social capital of fishermen in Lagdo is mainly based on family relationship s (57.1%), community or social clubs (22.6%) and remittances (16.6%).

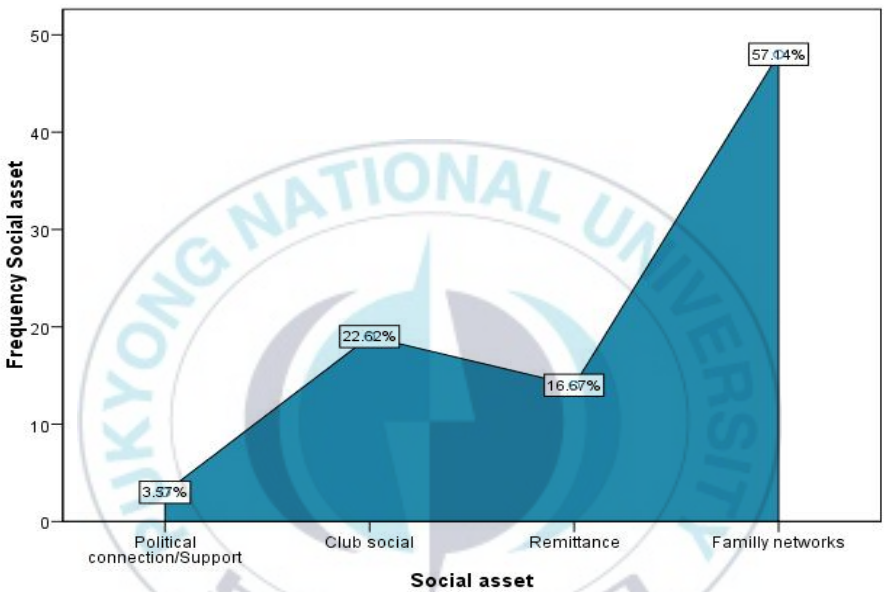

Figure 26: *Social Network in Lake Lagdo*

4.4. Policies, Institutions and Processes (PIP).

Policies, institutions and processes (PIPs) in livelihoods frameworks are seen as the foundation for overcoming vulnerability since their contribution allows assets to be modified or transformed into a sustainable livelihood strategy. Processes, structures and institutions essentially determine the extent to which a community

is able to access assets (Njagi 2005). According to (Ostrom 1990), institution is a rule used by individuals to determine who and what is included in the decision, situation, how information is structured and what action can be taken. In other words, institutions consist of cognitive, normative and regulatory structure and activities (Scott 1995). Similarly, processes implemented by structures include policies, laws, legislation, and international and national agreements (DFID, 1999). The regulation of fishing in Cameroon is derived from the United Nations Convention on the Law of the Sea ratified on November 19, 1985 (Tchoundi Audrey 2019). Law No. 94/01 of January 20, 1994, establishing the regime of forestry, wildlife and fishing through decrees, decisions and notes, is the principal legal instrument governing the fisheries sector in Cameroon, which is placed under the administrative supervision of the Ministry of Livestock, Fisheries and Animal Industries (MINEPIA). The governance model includes a central administration and decentralized units (Region, Departments, Districts). The deconcentrated units are the operational structures that participate in the implementation of the governance of fisheries management policies. As far as structures are concerned, MINEPIA, through the Directorate of Fisheries and Aquaculture (DIRPEC) carries out activities through deconcentrated structures through which the government recognizes the administrative autonomy of the so-called territorial communities in the management of local affairs at three levels, namely the Region, the Department and the District. The DIRPEC is accompanied by the Maritime Fishing

Development Fund (CDPM), in charge of improving the working and living conditions of fishermen, the Artisanal Maritime Fishing Development Mission (MIDEPECAM), in charge of the training and supervision of artisanal fishermen, the National Veterinary Laboratory for the control of fishery products, the National Center for Zootechnical and Veterinary Training (CNFZV) and the Limbe Halieutic and Oceanographic Research Center (CRHOL). Further, in Lagdo, at the district level, there is a Fish Breeding and Control Unit in charge of the elaboration, implementation, monitoring of government policy in the field of fisheries and aquaculture. In addition, several other sectors such as the environment, trade, transport, the municipality, and the army through the navy are involved. In addition to the public sector, the private sector is present through the farmers' associations (see social capital).

4.5. Livelihood Strategies

4.5.1. Diversity of Economic Activities

Currently, environmental changes and population growth have caused a decline in fish production and income, leading to diversification of activities to strengthen livelihoods. According to the results, 66.67% of the respondents practice agriculture as an alternative to the decline in catches, 11.90% trade and 14.67% Cattle rearing.

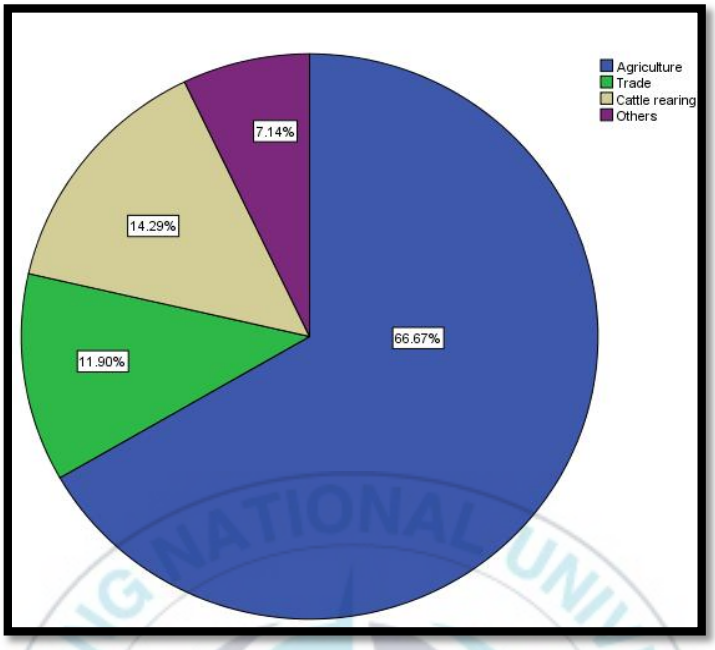

Figure 27: *Livelihoods Diversity*

It should be noted that 10 years ago, fishermen's activities were not as diversified as 81% of the interviewees were engaged only in fishing.

Table 15: *Economic Activities 10 years ago*

	Frequency	**Percent**	**Valid Percent**	**Cumulative Percent**
Fisheries	68	81.0	81.0	81.0
Agriculture	8	9.5	9.5	90.5
Cattle rearing	6	7.1	7.1	97.6
Others	2	2.4	2.4	100.0
Total	84	100.0	100.0	

4.5.2. Immigration and Emigration

In Lagdo, there are 2 main migration resulting from the implementation of the North East Benue Project (NEB) and the construction of the hydroelectric dam (PCD 2015). Migration is an important strategy by which fishermen adapt to environmental change. Assessment of the movement of people within this vulnerability context involved an analysis of current and migration patterns from 10 years ago.

4.5.2.1. Immigration

Field study indicate that the current rate of immigrations is 5% of the population as against 30% 10 years ago. Several reasons (Table 12) have been put forward for the situation. The factors that influenced immigration 10 years ago, include fishing potential (44%); profitability of fishing (31%). Factors that influenced emigration include; search for new fishing areas (28.6%); reduction of fish resources (52.4%), available land for agriculture (10.7%) and population growth (8.3%). Therefore, a net reduction of 0.74.3% was observed.

Table 16: *The % Change in Income (10 Years ago to Current Status)*

	Frequency	**Percent**
Current		
Immigration		
Search for new fishing areas	24	28.6
Reduction of fish resources	44	52.4
Available land for agriculture	9	10.7
Population growth	7	8.3
Total	84	100
10 years Ago		
Emigration		
Fishing potential	37	44
Fishing / Agricultural potential	21	25
Profitability of fishing	26	31
Total	84	100

4.5.2.2. Emigration

Emigration is movement away from a locality. A % change in population from 10 years ago to current status depicts an increase in population by 3.94%.

Table above gives change in population over the period. The most important factor influencing emigration is searching for new fishing areas (59.5%) such as Lom Pangar, Maga, Mape.

Table 17: *The Reasons for Emigration*

	Frequency	Percent	Valid Percent	Cumulative Percent
To exploit new fishing areas	50	59.5	59.5	59.5
Catches decreased	21	25.0	25.0	84.5
Biological rest period	11	13.1	13.1	97.6
Social visits	2	2.4	2.4	100.0
Total	84	100.0	100.0	

5. DISCUSSION, CONCLUSION AND RECOMMENDATIONS

5.1. Discussion

5.1.1. Vulnerability Context

The shrinking and siltation of Lagdo is the vulnerability of the study. The IPCC (2014) provides that the impact of climate change increases the risk of high temperatures, rainfall, drought and tropical depressions. As Tchawa (2017), had submitted, the Northern Region, which includes Lagdo, is classified as having a medium level of water scarcity. The author further maintained that the Northern Region climate's trend over the past decade indicates a general increase in temperature, frequent droughts and decreased precipitation (ibid.). The combined action of decreased rainfall and increased evaporation from the Benue River which sustains the Lagdo reservoir; – is a factor which has been suggested to be responsible for an increase in average temperature ranging from 32.2 to 42°C since 2008, thereby affecting river flows (Tchawa 2017). Therefore, environmental changes in Lagdo are significantly related to low rainfall and increased temperature. While the physical factors seem to be the main drivers of climate change, anthropogenic factors such as erosion caused by runoff water induced by deforestation, also play a significant role. For example, soil erosion accelerated by anthropogenic factors also reduced the depth of Lake Baringo to 3metres from an average depth of 8 metres in Kenya (Lwenya et al. 2010). These positions are

consistent with the finding of recent studies (Meaden 2020), which insisted that the siltation process in Lagdo involves both anthropogenic and natural factors. The natural factor being rainfall interacting with deforested soil rich in the sand – a good condition for land erosion. The anthropogenic factors include, extensive cultivated areas, deforestation, and agricultural techniques facilitative of runoff. Consequently, addressing the environmental factors directly related to siltation borders on anthropogenic activities such as pollution, land use pressures, irrigation and dam construction.

The effects of temperature and precipitation variabilities on the availability of water, resources, and the livelihoods of the people who depend on it is real. Fisheries represent a significant livelihood activity in Lagdo, as evidenced by the extent of dependence on this economic activity. Currently fishing communities are vulnerable to the 70% reduction in catch which affects their income. Thus, it is not surprising that reduction in catch by such a magnitude is accompanied by a 69.67% reduction in fishing income over a decade. Thus, the average income of fishermen is currently between [50,000-100,000] as opposed to [300,000-400,000] a few years ago.

5.1.2. Livelihood Assets

The capital assets (physical, human, social, financial, and natural) are the key

resources needed to achieve sustainable livelihood outcomes in order to reduce vulnerability, enhance food security, and increase income. Education is a crucial and essential instrument for poverty reduction and enhancement of sustainable livelihoods. Accordingly, Denga's (2005) assertion, education is a process through which people build physical, intellectual and social capacities is plausible. A minimum level of education is often an essential prerequisite to access information, technology and technical training programs and extensions. About 47.6% of producers attended primary school whereas; 39.3% proceeded to the secondary level to give a relatively low level of education in the Lagdo community. However, it is worth mentioning that elementary school attendance is mandatory despite the poor state of infrastructures.

In terms of health, despite the presence of 22 health facilities in Lagdo, they are poorly equipped and unevenly distributed. The WHO recommends one doctor to 10,000 people, but as Meaden (2020) found out, Lagdo can barely afford one doctor to 5,2438 people. The road network at the level of the municipality of Lagdo is almost impassable which makes transport and communication difficult. However, mobile telephones accompanied by several network distribution services have facilitated their access to information.

The hydroelectric dam represents the major physical asset of the Lagdo area. Although this hydroelectric power station supplies a large part of northern Cameroon (Garoua, Maroua, Kousseri and Ngaoundéré) the rate of connection to

the electricity network remains very low in the Lagdo district (Meaden 2020, PCD 2015). Thus, proximity to hydropower has not translated into accessibility. This underscores Sen's (1981, 1) conclusions that "scarcity is the characteristic of people not having enough....it is not the characteristic of there not being enough". Social Capital in Lagdo comprises of largely family relations (57.1%) which is the basis of mutually beneficial cooperation facilitating the creation of community or social clubs (22.6%) and rotating credit associations (16.6%). The local fishermen's associations, beyond collective community actions, exchange of information and mutual support, are also part of rotating credit and savings operations that contribute to improving fishermen's income. However, social capital is undermined by fragile social cohesion due to loss of trust, conflicts, religious or inter-ethnic differences, and misplaced policies. As Kebe (2009) submitted on a "Livelihoods Analysis of Coastal Fisheries Communities in Liberia", the major problem of fishermen is the lack of organization due to the distrust among fishermen, the loss of interest and common purpose as well as indifference about community support. This observation may underscore the fact that only 22.6% of our sample joined social or community clubs.

The financial capital asset status of Lagdo is characterised by rotating credit/savings (53.6%). The monthly income of the fishing community is quite low and does not empower fishermen to improve their standard of living from their income due to the inability to fully cover their expenses. The absence of

conventional institutions and the inaccessibility of the credit system considerably handicap the financial capital of fishermen and undermines savings culture. In general, their daily income is instantly redirected to food expenses, equipment and other family emergencies at the expense of savings which remains very low. Rotating savings and credits associations remain the viable means of savings in the region (cf. Ben-Yami 2001).

As far as natural assets are concerned, Lagdo is endowed with natural resources such as: fisheries, agriculture, livestock and forests. Fishing resources constitute the main natural capital of the fishing communities of Lagdo, however, access to the fishing resource, although open to all fishermen, is not accessible all year round. The biological rest period (July 1 to September 30) instituted by the Lagdo authorities since 2013 suspends all fishing activity for 3 months, when the areas around the dam are closed to fishing. Agriculture, is considered as the most important natural resource of the commune with a potential of 17,000 hectares of irrigable land (Meaden 2020). The persistent land conflicts have implications for access to land resources, as 2/3 of the commune is occupied by areas of hunting interest, the dam and industrial plantations such as SODECOTON (Meaden 2019). Also, the pressure exerted by the populations on the shrinking land areas causes recurrent conflicts. Although the council has an undeniable tourist potential, the absence of tourist services/facilities undermines the development of tourism potentials in Lagdo (PCD 2015).

5.1.3. Principles, Institutions and Processes (PIP)

The institutions and processes operate at both the centralized and decentralized level. Decentralized units represent operational structures involved in the governance and management of fisheries. The decentralization process, although not effective, encourages the inclusion of fishing communities in fisheries development. The resource governance framework has a significant impact on access to resources. There are three levels of PIPs in Lagdo: The District Delegation, the Council and the Fisheries Control Centre, which decide on livelihood strategies and determine when, where and how fishing should take place. These institutions at the local level carry out policies as well as create strategies and processes to help fishers capitalize on their potentials and institutional strengths, thus promoting an environment where fishing can develop. The organization of the fishing sector into associations and cooperatives that unify all stakeholders (fishers, fish sellers, fish product sellers, etc.), facilitates participation in the resource management process. Fishing communities on Lagdo are aware of the institutional, national, local policy framework and fishing regulations (such as inappropriate and illegal fishing gear, biological rest period, taxes, etc.). Thence, the inclusion of the fishing community through cooperatives and associations should promote the flow of information, transparency in management to ensure efficient management of fishery resources

and to improve the livelihoods of fishermen.

5.1.4. Livelihoods Strategies

Nowadays, Fishermen explore alternative sources of income as their conventional source is affected by environmental changes, population growth as well as pressure on resources resulting in limited catch. The study of the livelihood strategies of the fishing community in Lagdo highlights the vulnerability of fishermen to environmental changes. To cope with the effects of environmental change, fishermen have developed some strategies and practices. The diversification of economic activities by fishermen in response to various vulnerabilities involves breaking-out of the dependence on fishing cycle by engaging in alternative livelihoods ventures. Thus, the profile of livelihood diversification in Lagdo includes; agriculture (66.67%), trade (11.90%) and cattle breeding (14.67%). Yuerlita (2013) revealed similar livelihoods profile Lake Chad fishing communities depending on agriculture, livestock, wage labor and migration.

Migration is an important adaptive strategy for the fishing community of Lagdo. According to Westlund, et al. (2008) migration contributes to poverty alleviation by providing better livelihood opportunities for fishermen. The comparative study between the migration trend of fishermen over the last 10 years shows that migration flows have increased by 44% due to a reduction of fish resources

Fishermen also adopted practices such as the utilization of illegal nets like mosquito nets (17.72%), which allow the capture of small fish. This practice affects recruitment and minimizes the renewal of fish stocks due to recruitment and growth overfishing with a negative impact on productivity. Similar situation was also observed on Lake Tanganyika in Burundi and Lake Toho in Benin where fishermen use small mesh size nets boost their catches (e.g., Cirhuza, 2015; Codjo, 2018).

5.2. Conclusion and Recommendation

The study aimed to determine the impact of Lake siltation and shrinking on the livelihoods of the fishing community. The Lagdo area in Benue is subject to erosion, flooding, decreasing rainfall (average of 55 days/year), increasing temperatures (average highs of 40°C), windstorms, intense human activities among others. The effects as perceived by the fishermen have resulted in a significant reduction of catches. triggered temporary and permanent migration of fishermen, decreased fishing income, undermined food insecurity and generated conflicts (between fishermen and breeders). In addition to the impacts of environmental changes, the communities on Lake Lagdo also face challenges such as ineffective governance, attacks by hippopotamus, destructive fishing practices, overfishing and lack of management supervision. Access to the different types of capital (natural, physical, human, social and financial) available in the region remains inadequate thereby

providing a weak asset platform incapable of buttressing the adaptive capacity of the fishing community which remains low due to pervasive poverty in rural areas of Cameroon, especially in the Far North and Northern regions (Lagdo). Siltation and shrinkage in Lagdo have been shown to have a negative impact on fishermen's livelihoods requiring immediate attention. As a result, we reject the hypothesis that the lake's shrinking and siltation have no effect on the livelihoods of the fishing communities along Lagdo Lake. However, the availability of significant capital assets (which ones)? as well as structures, public policies, and legislative mechanisms that can assist fishermen in reacting to environmental change are opportunities that should be seized upon. The study objectives to analyze the causes and effects of lake shrinkage and siltation on fisheries production and productivity from the perspective of resource users; to assess the impact of lake shrinkage and siltation on the sustainable livelihoods of the fishing community; and to assess the opportunities available to address the vulnerabilities have been adequately addressed.

In order to mitigate the impact of environmental changes on fisheries, the following actions should be taken:

- Develop fisheries management mechanisms through specific fisheries regulations related to freshwater ecosystems (Lake), to ensure the sustainability of fisheries in Lagdo. Such policies would provide vital support to enhance the livelihoods of fishing communities;

- Strengthen reforestation of the lake banks to reduce the risks of erosion that constitute the main cause of the siltation of the lake;
- Conduct a detailed Environmental Social and Health Impact Assessment (ESHIA) of Lake Lagdo before implementing a stock restoration programme including restocking;
- Improve adaptive capacity through the design of appropriate programs and access to viable alternative livelihoods that could empower fishermen such as promoting fish farming through capacity building, the rehabilitation and redistribution of abandoned ponds;
- Conduct a dredging operation on the lake to restore carrying capacity and re-use the sediments extracted to improve on physical assets of the communities.
- Consider restocking the Lake to enhance biodiverty mindful of invasive species.
- The lake ecosystem should be considered an asset that deserves adequate and specific management measures to ensure sustainability, mitigate current and future vulnerability to climate change, and optimize fisheries productivity.

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Reference

Adeoti, É.O.B., I. Yabi, A. M. Akpo, M. Amontcha, and E. Ogouwale. 2018. Socioeconomic effects of inland fishing in the in doublet Adjohoun-Dangbo, Benin. *Africa Development* 43, no. 2: 173-189. Accessed January 20, 2021.

Allison, E.H., 2005. Potential applications of a sustainable livelihoods approach to management and policy development for European inshore fisheries, school of development studies, University of East Anglia, Norwich. *Who owns the sea*, pp.25-43.

Baio, A. C. M. 2009. Governance of the Marine Capture Artisanal Fisheries of Post-War Sierra Leone. PhD. Thesis, Centre for the Economics and Management of Aquatic Resources (CEMARE), Department of Economics, Portsmouth Business School, University of Portsmouth, United Kingdom.

Barange, M., T. Bahri, MC. Beveridge, K. L. Cochrane, S. Funge-Smith, F. Poulain. 2018. *Impacts of climate change on fisheries and aquaculture: synthesis of current knowledge, adaptation and mitigation options*. FAO. Retrieved from http://www.fao.org/3/i9705en/i9705en.pdf on August 1, 2020. FAO 2018.

Calvo, C., and S. Dercon.2007. Vulnerability to poverty. 2007. Retrieved from https://econpapers.repec.org/paper/csawpaper/2007-03.htm on August 3, 2020.

Ellison, J. C., 2015. Vulnerability assessment of mangroves to climate change and sea-level rise impacts. *Wetlands Ecology and Management*, *23*(2), 115-137 https://doi.org/10.1007/s11273-014-9397-8

DFID.1999. Sustainable livelihoods guidance sheets. *The Department for International Development*, 150. GLOPP (2008) DFID's Sustainable Livelihoods Approach and its Framework

FAO. 2007. Fishery profile by country: Republic of Cameroon.

FAO 1995. Code of Conduct for Responsible Fisheries (CCRF) Rome

FAO 2012. Voluntary Guidelines on the Responsible Governance of Tenure of Land, Fisheries and Forests in the Context of National Food Security (VGGT). FAO, Rome.

FAO 2015. Voluntary Guidelines for Securing Sustainable Small-Scale Fisheries in the Context of Food Security and Poverty Eradication (VGSSF), FAO, Rome

ILO. 2020. Cameroon statistics. Retrieved from hpp//www.ilo.org

INS. 2016. Cameroon Statistical Yearbook. Yaoundé, Cameroon. Retrieved from http://www.statistics-cameroon.org on January 2021

INS. 2017. North Region Statistical Yearbook. Yaoundé, Cameroon.

INS. 2020. Benoue a crossroads of people and economies. Yaoundé, Cameroon.

GLOPP. 2008. *DFID's Sustainable Livelihoods Approach and its Framework*. 1.5.

Kertemar, D., T. Mesmin, & M. Bedjaoué 2014. Évolution du lit majeur du fl euve Chari à N'Djamena de l'Holocène à nos jours. *Geo-Eco-Trop*, *38*(1), 75 –83.

MEADEN 2020. Realization of the Environmental and Social Impact Assessment (ESIA) of the Lagdo, Right Bank-Rehabilitation (1000 ha), Right Bank-Extension (5000 ha) and Left Bank-Extension (5000 ha) perimeters.
Retrieved from http://www.documents.worldbank.org on August 1, 2020.

Neiland, A. E., and C Béné, 2013. eds. *Poverty and small-scale fisheries in West Africa*. Springer Science & Business Media, University of Portsmouth, Portsmouth, United Kingdom.

MINEPDED. 2009. Fourth National Report of the Convention on Biological Diversity Cameroon. Retrieved from https://www.cbd.int/doc/world/cm/cm-nr-04-en.pdf on July 29, 2020.

MINEPDED. 2012a. National Biodiversity Strategy and Action Plan Version II (NBSAP II). Yaoundé, Cameroon.

MINEPDED. 2012b. National Biodiversity Strategy and Action Plan Version II (NBSAP II). Yaoundé, Cameroon.

MINEPIA. 1994. Republic of Cameroon Law No. 94/01 of 20 January 1994: To lay down forestry Wildlife and fisheries regulations. Retrieved from https://sherloc.unodc.org/res/cld/document/ on August 2, 2020.

MINFI. (2017). Report on the nation's economic, social and financial situation and prospects. In *Report* (Issue November 2016) Yaoundé Cameroon.

Ngatcha, B., R. Njitchoua, and E. Naah, 2002. The Lagdo dam (North Cameroon) Impact on the Benoue flood plains, far North Camerron. *Integrated management of natural resources in tropical flood zones,* 455.

Ngoran, S. D., Z. X. Xiong, and A.B. Ndah, 2016. Exploring the Challenges of Implementing Integrated Coastal Management and Achieving Sustainability within the Cameroon Coastline. *Journal of Integrated Coastal Zone Management,* 16(1), 45-56.

Nsangue, N., B. Thierry, R. Kindong, & L. Xu. 2018. Reconstruction of Historical Fisheries Profile of Cameroon, Shanghai Oceans University, China *International Journal Fisheries Science Research*.

Njock, J.C. 1990. Cameroon's coastal demersal resources: biology and exploitation of the main species. PhD Thesis, University of Aix-Marseille II. Faculty of Sciences, France.

Njock, J. C., and O. Njifonjou. 2001. Cameroon. National report on reducing the impact of tropical shrimp trawling fisheries on living marine resources through the adoption of environmentally friendly techniques and practices in Cameroon. *FAO Fish. Circ. 974*. Retrieved from http://www.fao.org/3/y2859e/y2859e06.htm on July 7, 2020.

Njifonjou, O., F. Laloe, C. Chaboud, & M. Simier, 1999. Marine fisheries management in Cameroon: overview and perspectives for improvement of the survey system and data collection, Institute for agricultural research for development, Limbe, Cameroon. *ICES Journal of Manne Science*.

Noah, A. M. N. 2010. Législation et réglementation de l'inspection des produits de la peche au Cameroun: étude et propositions d'amélioration. Universite cheikh anta diop, Dakar, Senegal.

Lienou, G., 2007. Impacts de la Variabilité Climatique sur les Ressources en Eau et les Transports de Matières en Suspension de quelques Bassins Versants Représentatifs au Cameroun. *These de doctorat PhD, université de Yaoundé I* (2007) Cameroun.

Lewins, R., C. Béné, M. Baba, O. Belal, E. Donda, S. Lamine, A. Raji. 2014. African inland fisheries: Experiences with co-management and policies of decentralization. *Society & Natural Resources*, 27(4), 405-420.

Onana, J. M. 2018. Cartographie des écosystèmes du Cameroun. *International Journal of Biological and Chemical Sciences*, *12*(2), 940. https://doi.org/10.4314/ijbcs.v12i2.25

Onguéné, R., G. Abessolo, M. Eyango, T. Duhaut, G. Mama, D. Angnuureng, and R. Almar, 2018. Assessment of the Evolution of Cameroon Coastline: An Overview from 1986 to 2015. *Journal of Coastal Research,* 81,122–129

Oyedele. E., et al. 2018. Socioeconomic effects of inland fishing in the Adjohoun-Dango doublet in Benin. *Africa and Development,* Vol. XLIII, N ° 2

Osman-Elasha, B. 2019. Climate change impacts, adaptation and links to sustainable development in Africa. Retrieved from http://www.fao.org/3/i0670e03.htm on August 4, 2020.

PNDP. 2015. Lagdo Development Plan

Republic of Cameroon. 2003. Poverty Reduction Strategy Paper. Yaoundé

Sen, A. 1981. *Poverty and Famine: an essay on entitlement and deprivation*. Oxford, England: *Clarendon Press*.

Tchoundi K. A, 2019. Policy formulation and implementation of fisheries

governance for aquatic resource management in Cameroon. Master Thesis World Fisheries Graduate School, Pukyong National University, South Korea.

Tchoundi K.G.A., D. Wembe, P.-R. Tchouagou, L.-E. Yaka, M.W. Nono, 2020. *Unlocking legal and policy frameworks for small-scale fisheries in Cameroon*. Eds V., Kerezi, J. Nakamura, M. El Halimi, and R. Chuenpagdee *Global Illustrations. TBTI Global Publication Series*, St. John's, NL, Canada

Tesi, Godswill O., et al. 2016. Lagdo dam flood disaster of 2012: An assessment of the concentrations, sources, and risks of PAHs in floodplain soils of the lower reaches of River Niger, Delta state university, Nigeria. *Journal of environmental quality*.

Tong, C. M. N. 2016. The Operationalization of the Pro-Poor Growth Strategy in Cameroon. *Interventions Économiques*, *56*, 0–25. https://doi.org/10.4000/interventionseconomiques.

UN. 2015. Sustainable Development Goals (SDGs). Retrieved from https://www.un.org/sustainabledevelopment/sustainable-development-goals/ January 2020.

UNISDR. 2009. Terminology on Disaster Risk Reduction. Retrieved from: http://www.unisdr.org/we/inform/terminology. January 2021

Vanden, J.P., and C.M. Bernacsek, 1990. Source book for the inland fishery resources of Africa. Vol. 1. *CIFA Technical Paper.* No. 18.1. Rome, FAO. 240 p.

World Bank. 2020a. Report on Development Indicators. Retrieved from https://databank.worldbank.org/home.aspx January 2021

Appendix. Questionnaire

2020 GRADUATE SCHOOL OF FAO WFU PILOT PROGRAMME

FAO/World Fisheries University (WFU) Graduate School, Pukyong National University,

Hanmir Building, 365, Sinseon-ro, Nam-gu, Busan, 48547,

Republic of Korea

TOPIC: VULNERABILITY OF FISHING COMMUNITIES TO ENVIRONMENTAL CHANGES ON LAKE LAGDO, CAMEROON

This household questionnaire collects information on the vulnerability of fishing communities to environmental changes and their impact on household incomes in Lagdo. With your consent, this interview will last approximately 10 to 15 minutes. The information you provide will be used confidentially for research purposes only. You will not be identifiable in any dataset or publication.

Date (DD/MM/YY)	
Name Interviewer	
Full name Respondent	
Respondent Code	

Country	
Region/ Province	
Division/Sector	
Ward/Cell	
Village	
if possible: GPS latitude, longitude and altitude	
How many years have you been in this residence?	

Use always codes 00 or 000 for:	**code**
Don't know/ no answer	00
Not applicable	000

FORM A

A-1 Personal Profile

N°	**Name (in full)**	**Resident** **1.Resident** **2. Usually absent**	**Gender** **1. Male** **2. Female**	**Age**	**Religion**	**Specify location (district and village)**	**Previous place of residence (before current one**	**Highest level of education completed**	**Main activity** 1. Fisheries 2. school 3.Unemployed 4. Retired 5. Subsistence production 6. Other (specify)

A-2-Natural assets

Environmental Changes	
Do you observe any Change in Lake size over the past 10 years? 1-Yes 2-No	
If yes Explain how the size of lake has changed (+ve or –ve) compared to 10 years ago 1. 25% 2. 50% 3. 75% 4. 100% 5. Others	
Specify why	
Do you any change in extension of siltation of the Lake 1-Yes 2-No	
If yes Explain how siltation has changed (increased or decreased) compared to 10 years ago 1. 25% 2. 50% 3. 75% 4. 100% 5. Others	
Specify why	

A-3-Time Series of Fish Production

Species Name or different types of Fish (list 5 main species)	Time Series of Fish Production		Different type of Nets	Different type of Vessels	% of female
	Year	Production (Tons			

FORM B

B-1 Dependence on fishing

	% Time Spent on fishing	% Income from fishing	Change in price	Change in income	Change in family Size	% Consumed	% Sold
Current							
10 years ago							

Why have your time spent on fishing changed	

B-2- Livelihood Diversity Activities

Current		
Other Economic Activities (Rank)	**% Time Spent**	**% Income Derived**
a		
b		
c		
d		
e		
f		
g		

After 10 Years		
Other Economic Activities	**% Time Spent**	**% Income Derived**
a		
b		
c		
d		
e		
f		
g		

B-3- Changes in Income

Current Income	Income 10 Year Ago	% Change	Remarks

FORM C:
C-1- Immigration/emigration

A) Fishermen

	Immigration	Emigration
Current		
Explain Why		
10 years ago		
Explain Why		
What is the % net- movement of people over the past 10 years?		

B) Community

	Immigration	Emigration
Current		
Explain Why		
10 years ago,		
Explain Why		
What is the % net- movement of people over the past 10 years?		

FORM C:

C-1 Capital Assets assessment

Physical	**Financial**	**Natural**	**Human**	**Social**
1-Hydroelectric dam 2-School 3-Hospital 4-Road condition 5-Communication (radio, phone) 6- Other(specify)	1-Bank 2-microfinance 3- Other(specify)	1-Fisheries 2-Forestery 3-Ecotourisme 4- Agriculture 5- Other(specify)	1-level of education 2-state of health 3- Other(specify)	1-Political connection/support 2-Club social 3-Remittance 4-Family networks 5-Other(specify)

Form D: Societal Cohesion

Do you have a communal management system; such as organizations/associations, state institutions, local fisheries project/program? 1. Yes 2. no	**If yes, (How Many) - List** a b c d **What are their impact on fishing community?** 1. Adverse 2. Neutral 3. Favourable	**What is their importance in improving your livelihood?** 1. very important 2. Important 3. not important 4. Insignificant 5. other
What are the major difficulties you encounter in Fisheries? (Rank – 1-5)		
a		

b	
c	
d	
What measures do you propose to solve these problems? (Rank 1-5)	
a	
b	
c	
d	
e	

Would you be willing to receive us again for a follow-up interview?	**Yes**	**No**
Length of interview		

THANK YOU FOR YOUR PARTICIPATION