ASSESSMENT OF POST-HARVEST FISH LOSSES AMONG SMALL-SCALE FISHERMEN IN ONDO STATE, NIGERIA

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DOCTOR OF PHILOSOPHY
UNIVERSITI UTARA MALAYSIA
October 2018

ASSESSMENT OF POST-HARVEST FISH LOSSES AMONG SMALL-SCALE FISHERMEN IN ONDO STATE, NIGERIA

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Thesis Submitted to
School of Economics, Finance and Banking,
Universiti Utara Malaysia,
In Fulfilment of the Requirement for the Degree of Doctor of Philosophy

Kolej Perniagaan
(College of Business)
Universiti Utara Malaysia

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(Title of the Thesis / Dissertation) : **Assessment of Post-Harvest Fish Losses among Small-Scale Fishermen in Ondo State, Nigeria**

Program Pengajian
(Programme of Study) : **Doctor of Philosophy (Economics)**

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ABSTRACT

Post-harvest losses need to be addressed in order to ensure balance of food demand and supply. Small-scale fisheries has been identified as one of the sectors with high post-harvest losses among food production sub-sectors. In Nigeria, small-scale fisheries sub-sector has been neglected despite its significant contribution to local fish production. Hence, this study aims to estimate the magnitude of post-harvest losses, their handling practices, possession of storage facilities and analyse the factors that influence post-harvest fish losses among small-scale fishermen in Nigeria particularly in Ondo State. A survey was conducted on 400 small-scale fishermen from 20 fishermen communities along the coastal area of Ondo State. The data were analysed using descriptive statistics like frequency, percentage and standard deviation; fish loss model for three dominant marine fish species {croaker (*Pseudotolithus spp.*), catfish (*Arius spp.*) and shrimp (*Nematopalaemon spp.*)}; and multiple regression model. The findings show that small-scale fishermen lack access to ice, suitable covering materials and storage facilities in the process of transporting fish from the fishing ground to the landing site. The fishermen incur average post-harvest fish losses of 8.15 percent for croaker, 7.76 percent for catfish and 7.57 percent for shrimp. Regression model indicates that variables such as age, educational level, fishing experience, credit facilities, fish training, duration of fishing cycle, storage facilities and transportation facilities are statistically significant in determining post-harvest fish losses in the study area. Consequently, the government should provide suitable infrastructural facilities such as ice blocks, covering materials and storage facilities to small-scale fisheries to reduce post-harvest losses. The government should formulate suitable policies to develop the small-scale fisheries sub-sector, and fishermen should be trained on the appropriate post-harvest handling techniques to enhance the livelihood of small-scale fishermen.

Keywords: small-scale fisheries, food security, post-harvest losses, fish species, fish loss model

ABSTRAK

Kerugian pascatangkapan perlu ditangani untuk memastikan keseimbangan permintaan dan bekalan makanan. Perikanan berskala kecil telah dikenal pasti sebagai salah satu sektor yang mengalami kerugian pascatangkapan yang tinggi antara sub-sektor pengeluaran makanan. Di Nigeria, sub-sektor perikanan berskala kecil telah dipinggirkan walaupun ia memberi sumbangan yang penting kepada pengeluaran ikan tempatan. Oleh yang demikian, kajian ini bertujuan menganggar magnitud kerugian pascatangkapan, amalan pengendalian, pemilikan kemudahan penyimpanan dan menganalisis faktor-faktor yang mempengaruhi kerugian pascatangkapan di kalangan nelayan berskala kecil di Negeria terutamanya di Negeri Ondo. Soal selidik telah dijalankan terhadap 400 orang nelayan berskala kecil daripada 20 komuniti nelayan sepanjang kawasan perairan Negeri Ondo. Data telah dianalisis menggunakan statistik diskriptif seperti kekerapan, peratusan dan sisihan piawai; model *fish loss* untuk tiga spesis ikan laut dominan {ikan *croaker* (*Pseudotolithus spp.*), ikan duri (*Arius spp.*) dan udang (*Nematopalaemon spp.*)}; dan model regresi berganda. Hasil kajian menunjukkan nelayan berskala kecil mengalami kesukaran mendapatkan ais, kemudahan penutup dan simpanan yang sesuai semasa proses mengangkut ikan daripada kawasan tangkapan ikan ke tapak pendaratan. Nelayan menanggung kerugian pascatangkapan sebanyak 8.15 peratus bagi ikan *croaker*, 7.76 peratus bagi ikan duri dan 7.57 peratus bagi udang. Model regresi menunjukkan pemboleh ubah seperti umur, tahap pendidikan, pengalaman menangkap ikan, kemudahan pinjaman, latihan menangkap ikan, tempoh kitaran tangkapan ikan, kemudahan simpanan dan kemudahan pengangkutan adalah signifikan secara statistik dalam menentukan kerugian pascatangkapan ikan dalam kajian ini. Oleh yang demikian, kerajaan perlu menyediakan kemudahan infrastruktur yang sesuai seperti blok ais, kemudahan penutup dan simpanan untuk perikanan berskala kecil bagi mengurangkan kerugian pascatangkapan. Kerajaan juga perlu menggubal dasar-dasar yang sesuai bagi membangunkan sub-sektor perikanan berskala kecil, dan nelayan pula perlu diberi latihan tentang teknik-teknik pengendalian pascatangkapan yang sesuai bagi meningkatkan taraf hidup nelayan berskala kecil.

Kata kunci: perikanan berskala kecil, jaminan makanan, kerugian pascatangkapan, spesis ikan, model fish loss

ACKNOWLEDGEMENT

All glory and adoration to Almighty God, the giver of understanding and knowledge for the successful completion of this study. Without Him nothing can be achieved.

My special thanks goes to my supervisors; Dr. Roslina binti Kamaruddin and Dr. Lee Wen Chiat for their kindness, motivation and constructive guidance rendered to me throughout the course of my programme. Thank you for your priceless ideas that have helped me to attain this feat.

My sincere gratitude is extended to Assoc. Prof. Dr. Shaufique Sidique, Prof. Dr. Kuperan Viswanathan, Prof. Dr. Ali Jamal, Prof. Datuk Dr. Amir Hussin Baharuddin and Assoc. Prof. Dr. Bakti Hassan Basri for their comments and suggestions during my Viva and Proposal Defence session. My appreciation goes to UUM faculty members and students for their support throughout my stay in UUM.

The efforts and cooperation of small-scale fishermen and fisheries officials in Ondo State, Nigeria during my field survey are also commendable. Without their support this study would not have been a success. Thank you.

Finally, my appreciation goes to my husband, Dr. Ashley-Dejo, Samuel for his love, support and effort in managing the home front during my absence. To my wonderful parents, Mr. and Mrs. A. T. Adelaja, siblings; Mr. Adetayo Adelaja, Mrs. Deniran, Mr. Abidoun Adelaja, Miss Deola and my niece Oluwatosin; to my in-laws, Chief and Mrs. Ashley-Dejo, Mr. and Barrister (Mrs.) Aregbesola, Mr. and Mrs. Ashley-Dejo, Mr. Deniran and Mrs. Adelaja for your financial support and prayers during my programme. Thank you all.

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BLP	Better Life Programme
CBN	Central Bank of Nigeria
DfID	Department for International Development
DOI	Diffusion of Innovation Theory
DBR	Drum-Buffer Rope
EC	Evaporating Cloud
EEZ	Exclusive Economic Zone
FAO	Food and Agricultural Organization
FDF	Federal Department of Fisheries
FGD	Focus Group Discussion
FRT	Future Reality Tree
GDP	Gross Domestic Product
GRP	Green Revolution Programme
HLPE	High Level Panel of Experts
ICLARM	International Centre for Living Aquatic Resources Management
IFLAM	Informal Fish Loss Assessment Method
IFR	International Fisheries Research
IFPT	Indigenous Fish Preservation Techniques
IFPP	Indigenous Fish Processing Practices
IISD	International Institute for Sustainable Development
IRD	International Rural Development
LT	Load Tracking
MDGs	Millennium Development Goals

NBS	National Bureau Statistics
NPC	National Population Commission
NAPEP	National Poverty Eradication Programme
NPAFS	National Programme on Agriculture and Food Security
NRI	Natural Research Institute
NTWG	National Technical Working Group
₦	Nigerian Naira (currency)
NGO	Non-Governmental Organization
NGO	Non-Governmental Organization
OECD	Organization for Economic Cooperation and Development
OPT	Optimized Production Timetables
PPMC	Pearson Product Moment Correlation
QIM	Quality Index Method
QLAM	Questionnaire loss assessment method
SSF	Small Scale Fisheries
SLA	Sustainable Livelihood Approach
SOFIA	State of World Fisheries and Aquaculture
SIFR	Strategy for International Fisheries Research
TOC	Theory of Constraints
UDE	Undesirable Effects
UNDP	United Nations Development Program
UNEP	United Nation Environment Programme
WDR	World Development Report

CHAPTER ONE

INTRODUCTION

1.1 Background of the Study

Nigeria is a maritime nation with boundless population of more than 190 million people with yearly percentage change of 2.64 percent and multi-ethnic (World Population Prospects, 2017). Nigeria has 36 states which 9 has boundaries with the Atlantic Ocean; estimate indicates that one-quarter (25 percent) of the country's population lives across the coastal zone comprising of 9 states which include Akwa-Ibom, Bayelsa, Cross-Rivers, Delta, Edo, Lagos, Ogun, Ondo and Rivers states (Omole & Isiorho, 2011). Coastal areas of Nigeria are confronted with series of problem such as environmental effluence due to activities of oil, civil conflict and this has publicized the areas (United Nation Environment Programme (UNEP), 2007; Omole & Isiorho, 2011).

Nigeria is bounded by Republic of Niger and Chad to the North, Benin Republic towards West, Republic of Cameroon towards East and South by Atlantic Ocean (Ibe & Nymphas, 2010; Mohammed, Gajere, Eguaroje, Shaba, Ogbole, Mangut, Onyeuwaoma and Kolawole, 2013). Nigeria consists of about 900 kilometres coastline with 42,000 km^2 total flat area of rock (Osagie, 2012). Nigeria consists of about 14 million hectares of inland water bodies that is fished by small-scale/artisanal fishermen (Omorinkoba, Ogunfowora, Ago & Mshelia, 2011). The full extent of water resources cannot be precisely specified due to seasonal variation from year to year depending on rainfall (Ita, 1984; Oladimeji, 1999 & Food and Agricultural Organization (FAO), 2013).

1.2 Fisheries Sector in context of Food Security

Fisheries sector is one of the significant sub-sectors under agriculture, which has the tendency of poverty reduction, food security and sustainable growth of the economy. Food security is of great concern in feeding over 190 million Nigerians who are required to have sufficient calories and stable nutrients (Nigerian Fishery Statistics, 2016). According to Adeniyi, Omitoyin and Ojo, (2012), indicated that Nigeria is a food-deficit nation with average protein intake to be 50.8g per day, which is inadequate when compared with the global protein requirement of 70.0g per caput per day. Poor level of fish nutrition have led to serious ailment such as kwashiorkor among Nigerian people most especially young children and nursing mothers due to severe deficiency of protein in their diets (Ahmed, 2015).

Fish provides source of protein and source of livelihood through harvesting, handling, processing and marketing to lots of people aside from provision of foreign exchange earnings to many countries. Fish is a perishable food, which requires proper handling to ensure good quality (Eyo, 1997; Kumolu-Johnson & Ndimele, 2011, Odongkara and Kwangwa, 2007; Mungai, 2014). Global fish demand has increased over the years with increase in fish consumption per capita due to increased population.

Consequently, fish protein demand has been projected to grow by additional 700,000 metric tonnes over the period (Federal Department of Fisheries (FDF), 2007). According to figures from Food and Agricultural Organization (FAO), (2016), 7.6 kilogrammes are current fish consumption per person in low-income food-deficient countries (LIFDCs) compared to 18.8 kilogrammes of global fish consumption per person annually. This implies that there is a large deficit of 11.2 kilogrammes per person in the current consumption. In order to reduce the shortage existing between fish demand and supply, Nigeria imports over 700,000 tonnes of frozen fish valued at over $US 500 million yearly which have an impact on the trade profit of the national economy and this makes Nigeria to be categorized as the top importer of seafood in Africa (Atanda, 2012; FAO, 2013).

According to National Bureau Statistics (2016), Nigeria household expenditure contain more of seafood (fish and fish products) compared to meats (mutton, pork, beat and goat) especially in the rural areas. Furthermore, over 96 percent households consume mostly vegetables along with flours, grains, followed by 87.9 percent of households consume oil and fat products and 84.2 percent of households consume animal products, fish and meat respectively. Globally, fish is a vital diet due to high nutritious quality in improving human health and contributes to people's dietary protein intake (Amao, Oluwatayo & Osuntope, 2006). Fish is also an important source of protein for many poor fishing communities along the coastal areas of the country while fish and meat serves as an essential protein food in the diet of people in Nigeria. The contribution of each of these protein sources vary based on household income level and their availability. In Nigeria, fish plays a significant role in people's diet and provides over 50% source of animal protein intake (Gomna & Rana, 2007; Olusegun & Matthew, 2016).

Furthermore, people spend more on fish than other sources of animal protein such as beef, chicken etc. due to affordability in terms of price and most preferred (Ogundari & Akinbogun, 2010; FAO, 2016). Fish has soft tissue, easy digestibility, has low cholesterol compared with red meat and greatly recommended for both young and old people. Fish is quite cheap compared with beef, mutton, poultry, pork, bush meat, offal's and meat and also contain high biological value of protein which makes it more preferred than other animal protein (Adeniyi et al., 2012; Alhaji, Jim-Saiki, Giwa, Adedeji, & Obasi, 2015; Sivagnanam, 2016).

Fish is a vital element in food diets especially for infants, pregnant women and young children. It provides wide variety of micronutrients such as iodine, calcium, iron, vitamins A and B and protein that is easily absorbable. Consumption of fish reduces the risk of having heart attack due to fish oil containing omega-3-fatty acids, which reduce clotting of blood (Béné, Arthur, Norbury, Allison, Beveridge, Bush & Thilsted, 2016; FAO, 2016). Fish protein comprises up to 22 essential amino acids in a well stable portion. Among the low income households, believe is that fish consumption is meant for the adult/old members of the family and this has led to nutritional problems among the younger ones Fish is a food that is low in acid and highly vulnerable to pathogenic and enzymatic decomposition (Adeniyi et al., 2012).

Data provided by FAO (2016) indicated that fisheries sector provides source of livelihood for 660 to 820 millions of people involving in various jobs such as fishing gear making, processing, packaging, construction of boat and maintenance, marketing and production of ice. Due to poor enforcement of management guideline, it has led to severe overfishing of the fisheries stocks and sustainability becomes paramount. According to United Nations High Level Panel of Experts on Food Security and Nutrition (HLPE), (2014), indicated that fish is essential to any deliberation and action to lessen poverty and increase food security and nutrition (Mehta, Cordeiro-Netto, Oweis, Ringler, Schreiner & Varhghese, 2014). Bene et al., (2016) opine that fish is a significant source of direct food security for households along the coastal areas, source of income generation derived from trade of fish, which serves as indirect contribution towards food security.

1.3 Fisheries Sector in Nigeria

According to National Bureau Statistics (NBS), (2018), agriculture contributes 26.18% to the Gross Domestic Product (GDP) as at 2017 to the growth of Nigerian economy even though the sector has been neglected since 1970s due to oil discovery while services and industries sectors contributes 53.45% and 20.38% respectively to the Nigerian economy. Fisheries contributes 5% to the GDP as at 2017 while aside its contribution to GDP, it also provides job opportunity for about 60 to 70 percent of the country's population (Olomola, 2013; PRESHSTORE, 2013; Tiamiyu, Olaoye, Ashimolowo, Fakoya & Ojebiyi, 2015; Nigeria Fishery Statistics, 2016). Fishery is an integral part of agricultural sector which contributes significantly (4%) to Gross Domestic Product (GDP) (National Technical Working Group, NTWG, 2009). Previous literatures have reported that fisheries sector noted a growth level of 4.5 percent in the year 2004 compared with growth level of 4.1 percent in the year 2003 and contributed 6 percent to the GDP in the year 2006; as well as 4.0 percent in the year 2007 (CBN, 2004; Areola, 2007). It sustains a stable contribution of 3.5 to 5% to total GDP in 2008 to 2013 (FAO, 2013; Oladimeji et al., 2013). Total value of fishery sector to African economies in 2011 was estimated at more than US$24 billion, which was only about 1.26% of Africa total GDP (de Graaf and Gerabaldi, 2014).

Faturoti (2010) reported that in Nigeria, the aggregate contribution of fisheries to the economy is at Nigerian Naira ₦126,417 billion ($351,159 million). The author explained that artisanal fisheries contribute over 82 percent of fish supply in the whole household. This is very noteworthy when seen from the point of income generation (to improve the standard of living of the people), tourism, supply of dietary protein and micronutrients for general wellbeing of the general population, creation of employment, rural development and foreign exchange earnings potentials (Béné & Neiland, 2003; Dada, 2003; Adepegba, 2007). According to Adekoya and Miller (2004), contribution of fish and its products account above 60 percent of protein level intake of adults in the rural areas.

Nigeria is the biggest buyer of fish in Africa due to high utilization of fish (FDF, 2005; 2008; Tiamiyu et al., 2015); its local yield of 0.62 million metric tonnes still misses demand of 2.66 million metric tonnes (FDF, 2008; CBN, 2012). A shortage in the supply requires 2.04 million metric tonnes to meet continually expanding fish demand in Nigeria. In addition, report from United Nations indicated that the population of Nigeria, which is over 190 million people currently, might surpass 210 million in the year 2020. According to FDF (2007) and CBN (2012) to bridge the deficit gap between fish demand and supply, over $850 million is spent yearly to import fish of about 700,000 tonnes such as mackerel, herring, horse mackerel, croaker and blue whiting (sourced via capture fisheries) from Europe, Latin America and Asian countries in order to meet up with the market gap. Studies have shown that importation of fish can be substituted in Nigeria with local production to provide job opportunities and poverty reduction among rural dwellers where over 70 percent populace live (Areola, 2007; FDF, 2005; Olaoye, 2010).

Similarly, Adewumi et al. (2012) stated that about 1.5 million tonnes of fish is needed yearly in Nigeria to meet its day-to-day protein requirement. Additionally, Nigeria Fishery Statistics (NFS, 2016) reported that based on population estimate of the country as at 2014 to be 180 million, the total fish demand is 3.32 million metric tonnes while local production realised from small-scale/artisanal, aquaculture and industrial fisheries is 1.123 million metric tonnes.

Nigeria fisheries sector comprises of aquaculture and capture fisheries. Capture fisheries is sub-divided into small-scale/artisanal and industrial which flourish well within and around the country's coastline to open deep waters of 200 nautical miles Exclusive Economic Zone (EEZ) across the nine (9) coastal states (Ipinmoroti, 2012, Oladimeji, Abdulsalam & Damisa, 2013; Okeowo, Bolarinwa & Ibrahim, 2015). The Nigeria fish supply by fisheries sector from 2010 to 2015 include small-scale/artisanal (616,981 – 694,867 tonnes), industrial (31,510 – 15,464 tonnes) and aquaculture (200,535 – 316,727 tonnes) sub-segments in Table 1.1. From the three (3) sub-sectors, small-scale fisheries has the highest contribution to fisheries production (National Bureau Statistics (NBS), 2017).

Table 1.1
Nigeria Fish Supply by Sectors (2010 - 2015) tonnes

SECTORS/YEAR	2010	2011	2012	2013	2014	2015
ARTISANAL-: SUB-TOTAL	616,981	638,486	668,754	759,828	759,828	694,867
Coastal & Brackish Water	328,332	346,381	370918	435,384	435,384	382,964
Inland: Rivers & Lakes	288,649	292,105	297836	324,444	324,444	311,903
AQUACULTURE (Fish Farm)	200,535	221,128	253,898	278,706	313,231	316,727
INDUSTRIAL (Commercial Trawlers)	31,510	33,485	45,631	58,871	49,952	15,464
Fish (Inshore)	19,261	19,736	27,977	37,652	29,237	10,727
Shrimp (inshore)	12,249	13,749	17,654	22,219	20,715	4,737
EEZ	-	-	-	-	-	-
GRAND-TOTAL	849,026	893,099	968,283	1,083,507	1,123,011	1,027,058

Source: National Bureau Statistics (NBS), 2017

1.4 Nigeria Small-scale/Artisanal Fisheries Sector in the context of Value Chain

Nigeria small-scale fisheries sector operate with the use of traditional fishing gear such as small boat, drift net, set gill nets, traps, hooks and lines and involves low cost of operation, low capital expenses and low application of invention (Adeokun, Adereti & Opele, 2006; Ogunniyi, Ajao & Sanusi, 2012; Oladimeji et al., 2013). According to Jamiu (2014), operations of marine small scale (small-scale/artisanal) are classified into two main subdivisions; (a) Brackish water fishing carried out within the estuaries and creeks where river (fresh water) mixes with ocean (salt water) moving up with great tide; (b) Coastal artisanal fisheries is an area where fishermen operate at less than 18 metres depth within the near shore waters and less than 40 km distance from the coast. They operate with the use of either passive or active nets and traps thrown from wooden canoes with or without outboard engines ranging between capacities of 15 and 40 horsepower (Bangura, 2012). Active gears involved the use of boat by pulling the net before fish could be captured such as trawl net while passive gears are known as stationary gears such as traps, hooks and lines, gill net, drift net which does not involve dragging nor pulling before capturing fish because it is based on fish species movement. Small-scale/artisanal fishers are observed as the poorest of the poor and their poverty is attributed to lack of infrastructural facilities for their fish catch (Béné & Friend, 2011).

In Nigeria, major fishing activities takes place in the fishing settlements situated in the Atlantic Ocean area of the southern part. Inherited vocation of riverine and coastal communities is majorly fishing which they rely on for their source of revenue. About 12,904km^2 is occupied by species that is highly rich in the brackish water existing in the estuaries, creeks, mangrove wetlands and lagoons (Akintola & Fakoya, 2017). The role of women fishers is significant in the fisheries sector. Marine fishing is controlled by the canoe fisheries and coastal mechanized operating within less than 20m depth or

5 nautical miles of the seashore which is a zone for non-trawling and 853km country's coastline and 39,644 km^2 continental shelf area.

Fisheries resources are exploited from 120 nautical miles (nm) by the fishers migrating from neighbouring countries of West Africa within the Exclusive Economic Zone (EEZ) 216,325 km^2 of the country in the Gulf of Guinea (Akintola & Fakoya, 2017; Us, 2006). The fishing gears used in small-scale fisheries (SSF) depends on the fishery operation. Gears used for targeting different species of fish include traps, set gill nets, purse seine, cast nets, long lines, basket and traps, bag nets and trawl nets. The craft used majorly is between 3 to 13 metres long which ranges from small-sized planked or dugout canoes, paddled, half dug-out or half plank motorized canoes with outboard engines ranging in size from 15 to 45 horse power as shown in Appendix II (Akintola & Fakoya, 2017).

According to Fish for All Summit (2005), the main source of livelihood for the small-scale/artisanal, coastal and inland dwellers is fishing. Akinbote (2016) stated that the main occupation of inhabitants of the coastal regions of Nigeria is fishing. Small-scale/artisanal fisheries contributes over 70 to 80 percent of the country's local fish supply annually and provides source of livelihood for roughly 6.4 million fishers (Akintola & Fakoya, 2017). Similarly, Adewumi, Ayinde, Adenuga and Zacchaeus (2012), Nigerian fishery sector does not only provide job opportunities for people along the coastal areas but also offers above 40 percent of animal protein consumed by Nigerian. It also generates high foreign exchange annually of around 20 million dollars because of shrimps exporting. Based on Central Bank of Nigeria (CBN), (2004) estimates nearly 10 million people mainly youth are involved in small-scale/artisanal fishing in Nigeria and many people along the coastal areas rely on marine resources harvested for direct consumption and sale.

Species diversity is the major benefit of the coastal communities. Fish (finfish and shellfish) are often cheaper and relatively better source of dietary animal protein to the ever-increasing Nigerian population (Amire, 2003; Akinbote, 2016). Finfish target species include catfishes (*Clarias, Heterobranchus* and *Synodontis spp.*); Nile perch (*Lates niloticus*); tilapias (*Oreochromis* and *Hemichromis spp.*); trunk fish (*Gymanrchus spp*) and tongue fish (*Heterotis spp*). The small pelagics of Clupeidae inhabits the estuaries, coastal and creeks waters while coastal pelagic fisheries are dominated by Bonga (*Ethmalosa fimbriata*) while Croakers (*Pseudolithus spp*.) are the major demersal commercial stock in brackish and coastal fisheries. Sardines (*Sardinella spp*.) and Shad *(Illisha Africana*) are also found in small quantities while shell fish target species are mostly cray fish and estuarine white shrimp (*Nematopalaemon hastatus*) which is found less than five (5) kilometres from the shoreline in the inshore waters (Tobor, 1993; Akinbote, 2016; Akintola & Fakoya, 2017). The marine waters of Nigeria composed of demersal and pelagic fishes, which show distinct ecological fish communities. The dominant fish species in the community include *Pseudotoliths spp., Ilisha spp., Arius spp., Ethmalosa fimbriata,* soles, shrimps etc.

Several studies (Abdullahi, Abolude & Ega, 2001; Adeparusi, Ajibefun & Akeremale, 2003) stated that roughly 200 million Africans depend on fish because of its rich source of essential nutrients required to supplement both infant and adult human diets. Ten million houses straightforwardly get income from fish production through either fish processed or fisheries trade. Yet the tremendous possibility of fisheries to help feed and enhance the nutritional status of the quickly expanding populace of Africa is greatly under-realized and degradation of precious aquatic resources. Similarly, Williams (2006) and Okeowo et al. (2015) stated that artisanal fisheries in Africa offers job opportunities for over 10 million individuals and provision of food for more than 20 million folks worldwide. In 2011, employment of full time people of around 12.3 million as full-time fishers or full-time and part-time processors take place in the fisheries sector which take into account the employment of 2.1 percent of Africa's population of 15-64 years' old (Ogunniyi et al., 2012; de Graaf & Gerabaldi, 2014). Likewise, Delgado, Wada, Rosegrant, Meijer and Ahmed, (2003) and Chuenpagdee, (2011) specified that around the world especially in developing countries, small-scale fisheries support millions of fishers and play significant part in eradication of poverty, food security and conservation of biodiversity in coastal communities.

Despite the importance of small-scale fisheries sub-sector, it is faced with post-harvest losses, which amount to 30 – 50 percent weight of captured fish landed (Bolorunduro et al., 2005; Emere & Dibal, 2013; Olusegun & Matthew, 2016). Post-harvest loss is a serious issue in Nigerian fisheries sector particularly at the artisanal fisheries sector. These losses are major problem that occurs in fish distribution chains from capture to point of marketing (Diei-Ouadi & Mgawe, 2011; Kumolu-Johnson & Ndimele, 2011; Olusegun & Matthew, 2016). It is so unfortunate that even though small-scale fisheries (SSF) is the main source of local fish production in Nigeria and fisheries worldwide, insufficient attention for the importance within the perspective of food and nutritional security is received (Guyader, Berthou, Koutsikopoulos, Alban, Demaneche, Gaspar & Curtil, 2013). Moreover, research works have paid little or no attention to the challenges faced by small-scale fisheries within the framework of food security, which has led to huge deficit between demand and supply (Akintola & Fakoya, 2017).

Fish demand deficit can be solved if post-harvest fish losses can be reduced in the small-scale fisheries, which will improve fish quality, increase fishers income and improved livelihood. In the whole food production system, small-scale fisheries are among the highest commodities faced by post-harvest losses ((Bene et al., 2016; Olusegun & Matthew, 2016). According to FAO (2010), losses of fish because of spoilage are estimated at 10 to 12 million tonnes annually in the whole world. In Africa, post-harvest fish losses are estimated at 30 to 50 percent which implies that level of fisheries production can be significantly increased by improving management strategies on post-harvest (Bolorunduro, Adesehinwa & Ayanda, 2011; Olusegun & Matthew, 2016). This can be achieved by understanding the amount of post-harvest fish losses at fish distribution chain.

According to Thilsted, Thorne-Lyman, Webb, Bogard, Subasinghe, Phillips and Allison, (2016) stated that low-income countries have high post-harvest fish loss as a result of poor/lack of storage facilities, poor infrastructures and lack of processing equipments while rich countries suffers huge waste at retail and consumer stages. The small-scale fisheries keeps suffering due to lack of appropriate data and this makes it difficult for policy making to enhance the development of the sector.

Similarly, Mgawe & Diei-Ouadi (2011) argued that the key problem facing small-scale fisheries is post-harvest fish losses. Factors such as poor fishing methods, poor handling and processing techniques as well as unproductive means of fish preservation and marketing cause enormous losses in terms of quality, physical and market losses.

It is necessary to have improved understanding of where losses occur, extent of losses, causes, how it can be handle to increase income level and how to improve the fish quality supplied to consumers. The chain of post-harvest fish losses commence from losses from the fishing ground to the landing site, losses at the point of sales of fresh fish if ice facilities is deficient, losses during fish transportation, losses during storage/packaging and losses during marketing (Mgawe & Diei-Ouadi, 2011).

In Bangladesh, severe post-harvest losses pose threat to the fisheries sector yearly because of lack of awareness and carelessness during fish handling and processing at various phases along the distribution chain from point of harvest until it gets to final consumer. Similarly, quality of fish products is affected by unsuitable handling and processing which leads to food insecurity i.e. it leads to less fish available for the consumer. To ensure food security and good public health, fish that is low in quality becomes a major apprehension. Fish traders and processors suffer mostly from low fish quality because it causes economic loss (Nowsad, 2010; Mgawe & Diei-Ouadi, 2011; Kumolu-Johnson & Ndimele, 2011).

According to Nowsad, (2010), important source of protein in the diet is fish, which provides source of living for huge number of people through provision of income and source of revenue to countries. In adults, total protein intake is over 60% which fish is the major contributing factor supplying balanced vitamins, protein and minerals particularly in the rural parts (Widjaja, Abdulamir, Saari, Abu Bakar & Ishak, 2009; FAO, 2012; Gbolagunte, Salvador & Enoghase, 2012). Fish becomes the readily accessible source of animal protein but unfortunately, it has resulted in huge losses due to poor post-harvest techniques in African countries (Kumolu-Johnson & Ndimele, 2011). It is exceptionally perishable food, which requires proper handling, processing and supply in order to generate good income. If fish is not consumed within one day of capture, then it needs to be subjected to form of processing to extend its shelf life to become fit for consumption (Agbolagba & Nuntah, 2011). Likewise, Jeeva, Srinath, Unnithan, Murthy and Rao (2007) stated that losses which occur at the fisheries sector is as a result of improper handling practices after catch, insufficient or lack of icing and ineffective containers used for fish transportation making fish unfit for human consumption.

Demand of fish is increasing as a result of high population and lessening of losses from post-harvest will create a great influence to meet up the demand by enhancing fish quality and quantity for end users which leads to increase in income for fishers (Ahmed, 2008; Nowsad, 2010; Béné, Arthur, Norbury, Allison, Beveridge, Bush & Thilsted, 2016). Data that focuses on issues regarding reduction of post-harvest losses are not available due to inaccessibility of the rural fishing communities. In order to improve food security, analysing the magnitude of loss and ways of reducing it has become paramount (Ahmed, 2008; Sime, 2015; Getu, Misganaw & Bazezew, 2015).

Reduction of post-harvest losses started after the mid-1970s food crisis and ever since then the problem persists. This issue led the United Nations in 1975 to notify the attention of worldwide towards post-harvest losses reduction in developing countries that needs immediate intervention. Studies have shown in underdeveloped and developed countries that losses both quantity and quality occurs at all stages in the production chain, from point of harvest, storage, processing, packaging, transportation, marketing until the final consumers (FAO, 1992; Ibengwe & Kristofersson, 2010; Olusegun & Matthew, 2016).

The development of small-scale/artisanal fisheries sector can be enhanced by provision of adequate technology to reduce the high post-harvest losses in the sector. World Development Report (2008) stated that increase in productivity of fisheries sector could be achieved by proper technology that will reduce poverty and improve food security. It has been discovered from previous studies that infrastructures for processing, storage and transportation facilities are inadequate in many rural fishing communities (FAO, 2010; Lokuruka, Singh, Gupta, Mishra, Kanaujia, Paul, & Islam, 2015).

According to Mgawe and Mondoka (2008) to reduce post-harvest losses, processing techniques like brining, salted- dried, drying racks on fish should be used. Similarly, Masette (2007) and Emere and Dibal (2013) suggested that the procedures for processing should consist of low-cost processing technologies such as washing, salting, smoking and drying. Provision of developed processing technologies will help to process fresh fish as required not resulting to quality loss. Livelihood of the fisher folks especially those whose revenue solely comes from post-harvest activities are adversely affected due to high losses in the fishing communities. Similarly, socioeconomic status (SES) of the communities is affected and availability of protein source to large section of the populace is reduced due to harmful losses. World Bank (2000) reported that Nigeria is one of the countries in Africa with high severity level of socioeconomic status deterioration. More than half of the populace's standard of living is underneath the line of poverty. Development in the economy cannot be achieved if poverty level is not reduced. Intervention programmes on alleviation of poverty and Millennium Development Goals (MDGs) have been carried out but it was not successful due to lack of continual check.

However, there is lack of quantitative data evidence in Nigeria regarding causes of post-harvest fish losses, effective loss assessment method and precise extent of post-harvest losses in small-scale/artisanal fisheries sector (Etim, Ukoha & Akpan, 2009; Omotesho, Adewumi & Fadimula, 2010; Nandi, Gunn, Adegboye & Barnabas, 2014; Olusegun & Matthew, 2016). There is need for adequate information to be able to plan for suitable strategies to alleviate post-harvest fish losses (Davies & Davies, 2009; George, Ogbolu, Olaoye, Obasa, Idowu & Odulate, 2014). Government has not given adequate attention to significant part of post-harvest fish losses when proposal of fishery management strategies are done. Quantifying of losses would help to identify the stages of serious post-harvest losses and full consideration to the lessening of losses at these stages (Eyo & Mdaihli, 2001).

In addition, assessing the post-harvest losses in small-scale/artisanal fisheries could serve as a reference medium for improving the livelihood of the people at large as well as encouraging more farmers into the fishing industry (Nandi et al., 2014). Livelihood comprises of five capitals (natural, physical, human, financial and social capital), the actions, and access intervened by institutions and social relations which is determined by individual or household living gained. It can also be measured through livelihood outcomes (income, food security and well-being) (Siyanbola & Adebayo, 2012; Adeleke & Fagbenro, 2013). Therefore, enhancing food security requires improving utilization of fish by lessening post-harvest losses. This increases the utilization rate of fish consumed directly by human and ensures availability of product at the right place, price and time for the purpose of consumers' satisfaction (Beierlein & Woolverton, 1991; Getu et al., 2015).

In a nutshell, studies on post-harvest fish losses are scanty and the amount of losses is yet to be ascertained. Also, small-scale fisheries have received less effort on research, which led to deficient quantitative data on amount of post-harvest losses and causes. This study is motivated to assess the magnitude, handling practices, storage facilities, factors influencing post-harvest fish losses and measures to reduce the issue of post-harvest losses resulting to improved livelihood of the fisher folks. This will also increase the level of fish production towards ensuring food security and reduce the amount spent yearly on importation of fish by the government.

1.5 Problem Statement

Due to increase in population, food security has become a vital issue that requires urgent attention in Nigeria and globally. In order to move the country's economy activities forward and cater for the ever-increasing population through provision of adequate protein, Nigeria wants to diversify into agriculture sector. The basis of food security is to ensure that food is available and affordable by everybody at all times. Food insecurity occurs as a result of loss of food throughout the supply chain from production to the marketing stage (Bene et al., 2016). Global report on loss of food worldwide and food waste indicates that almost 1.3 billion tons annually is lost which is approximately one-third of production of food for human consumption. This results to shortages of food and nutritional deficiency due to food insecurity in the developing countries (Gustavsson, Cederberg, Sonesson, Van Otterdijk & Meybeck, 2011).

Small-scale/artisanal fisheries sector (SSF) is a significant sub-sector in agriculture and provides source of livelihood for majority of residents along the coastal areas but this sector has faced a lot of challenges such as post-harvest losses, lack of infrastructures for preservation/processing and lack of good transportation system due to inaccessibility of the rural communities (Olusegun & Matthew, 2016; Tefay & Teferi, 2017). This has been confirmed to be true in countries such as Bangladesh, Indian, Sri-Lanka and other countries throughout the world. Small-scale fisheries globally have been neglected in the area of development and few researches have been carried out in the sector (Nowsad, 2010; Mungai, 2014). High level of post-harvest fish losses occur within the small-scale fisheries sector due to lack of technological limitations impeding the growth of the sector (Akintola & Fakoya, 2017).

Fish wastage in Nigeria is estimated to be 30 to 50 percent of the total fish catch while about 10 – 12 million tonnes of fish are wasted annually after capture due to spoilage. This is a serious issue that needs urgent intervention in the small-scale/artisanal fisheries sector in order to reduce fish wastage (FAO, 2010; Olusegun & Matthew, 2016). Problem faced by small-scale/artisanal fishers that contribute to fish wastage include handling, lack of infrastructural facilities such as electricity, good road network and storage facilities at processing sites. Fish needs suitable handling practices and preservation for a long shelf life and good nutritional value due to high perishable food (Jeeva et al., 2007).

Post-harvest fish losses does not only affect the livelihood of fishing communities in terms of income generation but also reduce the amount of animal protein obtainable to large part of the people (Adeyeye, & Oyewole, 2016). Presently, there is a deficit of 11.2 kilogrammes of fish consumption per person in Nigeria. Local fish production from the 3 fisheries sub-sectors (small-scale, industrial and aquaculture fisheries) is 1.123m metric tonnes in 2014 while fish demand is 3.32m metric tonnes based on estimate of 180 million population in 2014 which shows that a large gap of 2.197m metric tonnes exist (Nigeria Fishery Statistics (NFS), 2016). To meet up with the demand, government spend over $850 million on importation of fish yearly.

Government has not been able to provide suitable programmes on post-harvest losses in the small-scale fisheries due to lack of quantitative data but intervention programmes such as Green Revolution Programme (GRP), Better Life Programme (BLP), Millennium Development Goals (MDGs) and National Poverty Eradication Programme (NAPEP) on poverty reduction among rural areas have been carried out but the programmes failed due to lack of continual check, lack of human capacity and implementation, corruption, lack of finance, lack of transparency and accountability and inadequate data system (Ajiye, 2014; Taiwo & Agwu, 2016). Early this year, the House of Representatives passed a bill to ban fish importation in order to boost the local fish production, create more employment opportunities in the sector, reduce poverty through community development and improve livelihood of the people (www.premiumtimesng.com; dailypost.ng).

Ibengwe and Kristofersson (2010) opine that due to lack of data and tangible information regarding type, causes and revealing quantitative loss levels it has made it difficult to get the particular bearing of post-harvest fish losses. Availability of data and precise information will give a better understanding of the magnitude of losses and appropriate measures to be taken. Collection of information and data regarding post-harvest fish losses have been seen as a difficult task; this is due to inaccessibility of fishing communities and lack of cost-effective fish loss assessment procedures. Timely study to evaluate the handling practices on the extent of post-harvest fish loss and to recognise the serious point for development of suitable interventions to alleviate the problem is needed.

In order to address the problem of losses in small-scale/artisanal fisheries sector to ensure food security, wider perspective is vital to assess post-harvest fish losses. Olusegun and Matthew (2016) discovered that suitable attention has not been given to post-harvest development when fisheries management strategies are proposed. As a result of this, quantitative fish loss data is deficient and the available studies on the assessment of post-harvest fish losses does not provide clear cut results about the major causes of post-harvest fish losses and magnitude. Availability of quantitative data has been difficult for policy implementations due to inaccessible road to rural fishing communities and different fish species. This condition simply shows that further research on post-harvest losses in small-scale fisheries in Nigeria where studies are scanty on the issue is essential. Based on this assertion, the study assess post-harvest losses among small-scale fishermen at the landing site in order to calculate the magnitude of post-harvest losses, identify the handling practices used, storage facilities, transportation system, causes and suggestions on policy implication on how to reduce post-harvest fish losses in the study area.

1.6 Research Questions

This study therefore set to answer the following relevant research questions.

i. What is the magnitude of post-harvest fish losses at the landing site?

ii. What are the handling practices, storage facilities and transportation system used at the landing site?

iii. What are the effect of handling practices, storage facilities and transportation system on post-harvest fish losses at the landing site?

1.7 Research Objectives

The main objective of this study is to assess post-harvest fish losses among small-scale/artisanal fishermen. The specific objectives are to:

i. Calculate the magnitude of post-harvest losses at the landing site.

ii. Examine the handling practices, storage facilities and transportation system used at the landing site.

iii. Analyse the effect of handling practices, storage facilities and transportation system on post-harvest fish losses at the landing site.

1.8 Significance of the Study

The role of small-scale/artisanal fisheries to the national economy in terms of food security, employment opportunities and sustainability of livelihoods cannot be underestimated. Due to the challenges faced by this sector, transformation programme for rural fishing will help to improve the dwindling internal generation of the third tier of government and also enhance the socioeconomic status of fisher folks in the fishing communities of the study area. Also, substantial amount of foreign exchange spent on importation of fish yearly will be reduced.

However, very few studies such as Mungai (2014); Olusegun and Matthew, (2016); Tesfay & Teferi (2017) have concentrated on post-harvest fish losses among fishermen in the rural fishing communities due to difficulties involved in data collection as a result of inaccessible fishing communities (poor road network), cost involved due to distance and different fish species. This study fills this knowledge gap by estimating magnitude of losses, identifying causes of high post-harvest losses, handling practices and storage facilities used in order to suggest strategy for reduction to ensure optimum productivity and quality fresh fish.

This study will be beneficial to the Fisheries Department and the Government by providing fish loss database to develop improved loss assessment method as it was done in Tanzania. It will also help the department of fisheries to develop model from the loss data provided and management strategies aiming at loss reduction.

The findings of this study provide information that will guide policy makers in formulating policies and also enhance the growth and development of the small-scale/artisanal fisheries sector in Nigeria. This study provides data on post-harvest fish losses and demographic information of small-scale fishermen in the study area that is of interest to the policy makers. The policy makers will be able to identify where significant losses occur, factors causing it and attention will be focused on areas where little research has occurred. It will also help small-scale fisheries to be included in the National and Regional development policies and decisions favourable to the fisheries sector will be put in place.

In addition, this study provides idea for technology and infrastructure transformation to improve standards of living among the fishermen with increase in fish supply to satisfy national goals and objectives and bridge the supply-demand gap. This study is useful for policy makers, NGO's, academicians and rural researchers because it influences and fine-tunes their policies holistically in solving problems in whole groups instead of individual groups. Also, academicians will use it has a guide to identify future areas of research through the available information provided by this study while non-governmental organizations will know which aspect they can render help to the small-scale fisheries sector.

1.9 Scope of the Study

Fisheries sector have attracted the attention of the scholars in the past due to job opportunities, animal protein and source of revenue. However, little have been said or done on the post-harvest fish losses affecting the growth of the small-scale fisheries despite its level of contribution to production of fish locally. It is of vital significance to focus on the small-scale fishers because larger percentage of them live in the rural areas. The small-scale fishers need capital and good fishing equipments to produce sufficient income for their households. More priorities need to be given to rural development by the government with provision of basic amenities such as health, education and good infrastructural facilities mainly to the small fishing communities (Kay, 2006).

Nigeria has nine (9) coastal states out of which six (6) are oil-producing States (Figure 1.2). Oil producing traditional member States includes Akwa-Ibom, Bayelsa, Cross-Rivers, Delta, Edo and Rivers States. Other coastal but are non-oil producing states which are not prone to petrochemical wastes from petroleum exploration are Lagos, Ogun and Ondo States (Omole & Isiorho, 2011). Out of these nine (9) coastal States, Ondo State has the longest coastline of about 180km and high level of fishing activities (Akinbote, 2016). The choice of this study area is based on high level of fishing activities and easy access of fishermen for effective data collection. The research is carried out in Ondo State and the target group were small-scale fishermen from different fishing communities along the coastal areas of Ondo State, Nigeria. The survey was carried out from March to June, 2017 with the support of enumerators that were trained before the exercise. The questions in the questionnaire were limited to the demographic, economic and social factors of the respondents. These are anticipated to disclose the essential data for the assessment of post-harvest fish losses in the study area.

Figure 1.1 *Map of Nigeria showing Coastal States*
Source: https://en.wikipedia.org/wiki/Nigeria

1.10 Organization of the Thesis

The thesis is organized in six chapters. Chapter one presents the general introduction of small-scale fisheries in Nigeria and post-harvest fish losses in Nigeria and review of previous literatures are discussed in chapter two. Chapter three provides the research methodology, measurement of variables, data collection strategies and survey instrument of the study. Data analysis and results are presented in chapter four and five while chapter six gives the summary of the findings of the study and recommendations.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

The aim of this chapter is to highlight on post-harvest losses in the small-scale/artisanal fisheries sector in terms of definition, types and causes in the sector. This chapter starts with the definition of post-harvest losses in small-scale/artisanal fisheries, types and causes. It further explains post-harvest fish losses in different part of the country and in Nigeria. Definition of small-scale/artisanal fisher folks and their socio-economic status are discussed. Theories to this research are highlighted one after the other. Different forms of processing involved in the fishing communities are emphasized accordingly. Empirical studies on post-harvest fish losses are discussed as well. All chapters are summarised in section 2.10.

2.2 Post-harvest Losses in Small-Scale/Artisanal Fisheries

Post-harvest simply means removal of fish from the medium of production for the purpose of consumption. Post-harvest process begins when edible fish products are separated from the source by human act with the purpose of ensuring it gets to the consumer (Ward & Jeffries, 2000; Diei-Ouadi & Mgawe, 2011; Mungai, 2014; Sebeko, 2015). Post-harvest losses occur along the fish production channel from point of harvesting until it gets to the consumers (or other end uses) (Ames, Clucas & Paul, 1991; Aulakh, Regmi, Fulton & Alexander, 2013; Getu et al., 2015). According to Mungai (2014), post-harvest losses simply mean changes that occur in the fish in terms of quality, edibility and wholesomeness by preventing it from consumption by the end users.

Studies on post-harvest losses define losses as means of discarding fish or selling of fish at a lower price due to deterioration of quality or changes in market system. It can also be viewed from the perspective of fish waste, which is due to accidental losses along the different stages (Grolleaud, 2004; Diei-Ouadi & Mgawe, 2011; Bene et al., 2016). According to Aulakh et al. (2013) opine that post-harvest losses can arise due to wastage of fish or unintentional fish losses along the chain. Fish waste is defined as the loss of fish fit for consumption due to human act such as throwing away fish due to spoilage or fish products that are wilted while fish loss is the accidental loss in quantity because of lack of infrastructure (Ibengwe & Kristofersson, 2010; Pessu, Agoda, Isong & Ikotun 2011).

Post-harvest losses can be measured through qualitative and quantitative of fish losses along the chain from the point of harvest until it gets to the consumers (Eyo, 1997; Hodges, Buzby & Bennett, 2011; Getu et al., 2015). Quantitative fish loss is decrease in weight due to factors such as spoilage, pest consumption, temperature changes, moisture changes and chemical changes while qualitative fish loss is as a result of nutrient composition, acceptability of the products by human and edibility of the product (Abbas, Saleh, Mohamed & Lasekan, 2009; Buzby & Hyman, 2012; Aulakh et al., 2013).

As a result of lack of data and adequate information on post-harvest fish losses, Ward and Jeffries (2000) developed a manual with the help of Food and Agricultural Organization (FAO) and Natural Research Institute (NRI) of the University of Greenwich United Kingdom which explains three methods of fish loss assessment. The methods include; the Informal Fish Loss Assessment Method (IFLAM), Load Tracking (LT) and Questionnaire Loss Assessment Method (QLAM). The purpose of this manual is to give researcher better understanding on quantitative and qualitative post-harvest fish losses, which is essential for planning towards reduction of loss measures.

Ward and Jeffries (2000) states that IFLAM is used to explore when the researcher is not aware of the problem facing the fishers or possible solution. It is also use to develop the general understanding in the key areas of losses. LT is used to measure and identify losses. It is a biometric support that provides data on weight and selling prices of good and low quality fish. It is a descriptive assessment used when the problem is already known. QLAM is used to validate assessment of data on causes and effects of losses when problem is identified.

2.2.1 Types of Post-harvest Losses

a) Physical losses

Eyo (2001) stated that physical losses occur to fish that are not utilized after catch or landing. They are either cast-off accidentally or deliberately. According Akande and Diei-Ouadi, (2011) and Hall, Hilborn, Andrew and Allison, (2013) opine that physical loss can be as a result of robbery, fish eaten by insects or by winged creature or creature predation. For instance, delay of fish in the fishing gear submerged in the water will ruin the fish and at the end of the day it does not attract a good price. Fishing for high-esteem species, for example, shrimp is frequently connected with large amounts of by catch. Most by catch is disposed of adrift as it comprises of low-esteem and will not command good price (Eyo, 1997; Kader 2004; Kumolu-Johnson & Ndimele, 2011).

b) Economic/Quality losses

This occurs when fish are sold at a reduced price by the fishermen or processor due to physical damage or spoilage. It is caused as a result of poor handling, poor packaging and lack of suitable storage facilities (Ames et al., 1991; Eyo, 2001). Fish that has been dried and slightly consumed by insects or animals will not be attractive and consumers will prefer fish that has not been damaged and can afford to pay any amount for it without bargaining (Kader, 2004; Ghaly, Dave, Budge, & Brooks, 2010; Nguvava, 2013; Getu et al., 2015). The damaged fish leads to quality and financial losses because the worth of the fish has dropped. Equally, Sivagnanam (2016) stated that when fish is not iced, deterioration sets in which definitely lead to drop in fish price and financial losses for the fishers.

c) Nutritional losses

According to Kader (2004), nutritional losses happen in fresh fish and processed fish. Processing of fish result in nutritional deterioration of fish protein. Mgawe (2008) opine that quality of fish reduced as the microbes bringing about the deterioration corrupt the protein which is proposed for human utilization. Notwithstanding, bacterial activity produces nitrogenous mixes with poisonous smells and the influenced fish will turn out to be exceedingly ugly in light of the fact that there is an excessive amount of nutritious harm (Torres, Serment-Moreno, Escobedo-Avellaneda, Velazquez & Welti-Chanes, 2016). Fish of that caliber are sold at a reduced price compared with fish of good quality which attract higher price.

Table 2.1
Stages of Distribution and Reasons for Losses Adverse

Stages of distribution	**Reasons for losses**
Fishing	• During shipping, fish falls back into the water from the net. • Fish bruises due to poor handling. • Exposure of fish on board to high temperature with lack of ice cubes in the boat for a longer period.
Landing	• Lack of ice leads to high spoilage of fish being neglected on beach. • Dropping of fish as a result of offloading/unloading from the container for transportation to the shore.
Processing	• Lack of large processing facilities to cater for the fish landed. • Weather condition which is hostile gives difficulty in drying. • Infestation of insect
Transport	• Fish damage mechanically • Interruptions/delays during transportation
Storage	• Fish spoilage due to lack of storage facilities • Infestation by insects
Marketing	• Demand and supply • Infestation by insects • Price changes

Source: Diei-Ouadi and Mgawe (2011)

2.2.2 Causes of Post-harvest Fish Losses

The main causes of post-harvest losses include intrinsic and extrinsic factors such as microbial and chemical reactions, handling technique during fish catch, spoilage due to high temperature, delay in time from fishing ground to the landing site, pests and disease infestations, lack of storage facilities and poor transportation system (Diei-Ouadi & Mgawe, 2011; Mungai, 2014).

From the literatures reviewed, fresh fish is one of the perishable food. Fish spoils quick due to the intrinsic factors (inside) and extrinsic factors (outside) (Chen, Xu, Deng &

Huang, 2016; Job, Agina & Dapiya, 2016). The inside element is as a consequence of the earth from which the sustenance was gotten and microbiological nature of the nourishment in its crude or natural state while outside components is because of the handling process, preparing, stockpiling condition and viability of bundling in limiting microbial development (Abowei & Tawari, 2011; Udo & Okoko, 2014; Chen et al., 2016).

According to Amos, Einarsson and Eythorsdottir (2007) and Ghaly et al. (2010) define spoilage as fish or fish products change that reduces the acceptability level or becomes dangerous for consumption by human. Signs of fish spoilage include formation of slime, texture changes, foul smell, discolouration and production of fume. These signs are due to bacteriological, enzymes formation and chemical combination. Microbial factor is as a result of microbes such as bacteria, fungi and yeast consuming and causing damage to the fish (Bourne, 2004; Mungai, 2014). The microbes feed on a small amount of the fish, which eventually cause damage to the whole fish and makes it unacceptable for consumption. Mycotoxins are toxic substance that makes fish unfit for consumption. This toxin is produced by mold called *Aspergillus flavus* (Bourne, 2004, Ghaly et al., 2010).

Studies from Abass et al. (2009) revealed that immediately after capture, chemical and biological changes occur in dead fish, which may lead to rejection due to spoilage and becomes unsuitable for consumers. Findings indicated that high temperature leads to spoilage of fish while in the boat, at the landing site, during processing, transportation to market especially in the tropical countries. It increases the activities of microorganisms, proteins and fat oxidation in the body of the fish (Ababouch, 2005; Mungai, 2014). Equally, Diei-Ouadi and Mgawe (2011) shared the same view that temperatures as high as 20^0C give opportunity for spoilage of fish while temperatures as low as 5^0C slows down activity of bacteria and spoilage rate. Ahmed (2008) opines that estimates of losses caused as a result of spoilage are about 10 and 12 million tonnes yearly. Furthermore, Boziaris (2015) revealed that specific spoilage organisms (SSOs) are the causes of spoilage producing metabolites responsible for off-odours and off-flavours leading to rejection of fish while Diei-Ouadi and Mgawe (2011) reported that time between death and final consumption are an important factor of spoilage.

According to Amos et al. (2007), delay in time taken for the fish to arrive at the landing sites is also responsible for the rejection of fish due to bacterial growth. When fish are landed and not iced immediately before selling to the middlemen, the spoilage rate is aggravated in the fish. Equally, Diei-Ouadi and Mgawe (2011) and Sivagnanam (2016) opine that rate of spoilage in fresh fish is influenced by time and hours spent in the fishing nets. This is due to physical damage such as bruises on the fish body, loss of scales during capture, which will give room for microbial attacks. Findings of Ghaly et al. (2010) indicated that over 30 percent of fish landed at the site are lost as a result of bacterial activity due to lack of storage facilities. Fish flesh begins to soften or becomes watery or tough and dry once bacterial spoilage set in. The fish becomes putrid and inedible for human consumption.

According to Huss (1994), chemical reaction that occurs in the lipid section of the fish is another cause of losses. This reaction takes place with oxygen and unsaturated lipid, which results in hydro, peroxides formation causing brown and yellow discolouration of flesh of fish. Studies of Ghaly et al. (2010) and Pessu et al. (2011) were of the opinion that colour discolouration, off-flavour, texture, nutritional value were as a result of chemical elements reaction in the fish.

Moreover, another causes of post-harvest losses identified by Idah, Ajisegiri and Yisa, (2007) include inappropriate handling, infestation of pests and diseases, absence of storage and processing facilities, deficiency of packaging materials, poor transportation system and lack of dissemination of information can lead to losses in the aspects of marketing system. In 2010, Expert Consultation shared the same view with Idah et al. (2007) that losses arise due to poor post-harvest management and lack of suitable processing and marketing facilities. As a result of this loss, farmer's income, product quality and consumer prices are affected. Likewise, Pessu *et al.* (2011) stated that losses could be due to biological causes. This is as a result of fish infestation by rodents, birds and other large animals during sun drying and this becomes unfit for human consumption.

2.3 Post-harvest Fish Loss situation all over the World

Post-harvest fish loss is a serious issue facing the small-scale/artisanal fisheries sector. Despite several studies carried out on this aspect, the problem persists and on the high side. According to Nor (2004) stated that there is difficulty in calculating post-harvest fish losses due to economic losses but estimate of annual net losses amount to USD10-20 billion yearly. The losses could not be determined due to difficulties of loss assessment method application by researchers. Food and Agricultural Organization (1992) estimated post-harvest losses at the range of 20 to 25 percent and as much as 50 percent rarely. In Korea, post-harvest losses estimate to 10 percent of the fish production (Organization for Economic Cooperation and Development OECD, 2000).

In Indian, studies show that fish losses are high during wet or humid situation. This is as a result of high blowfly populations and slow drying rate. Estimate of 10 percent of dried fish is lost due to activity of blowfly in the south-west Indian while excess of 50 percent losses may occur day-to-day (Ward, Schoen, Joseph, Kumar and Cunah, 1998). Damages caused by the blowfly larvae are subjected to rate of drying, fish size and whether the fish is a salted one. Blowfly larvae destroy the soft tissue-causing problem for the fish processors (Walker & Wood, 1985; Wall, Howard & Bindu, 2001). Wall et al. (2001) estimated that post-harvest weight losses are between 10 – 60 percent during wet season based on observation of infestation level depending on species of fish landed. This has led to a serious issue along the production chain. It was revealed that once the point where losses are huge is identified, improvement in technology in this aspect would lead towards more availability of produce. Not only that, it will help in providing quality produce for consumers, improve the livelihood of the fisher folks and guarantee food security of the country (Nor, 2004; Jha, Vishwakarma, Ahmad, Rai & Dixit, 2015).

In order to address this problem of post-harvest losses, steady and up-to-date data on extent of post-harvest losses of different crops and livestock produce were collected at all India level in the year 2005 – 2007 by all India Coordinated Research Project on Post-Harvest Technology. The report provided data on estimates of harvest and post-harvest losses but the channels where massive losses occur are not known and there is need for identification for technological intervention (Jha et al., 2015; Sivagnanam, 2016).

In Africa, post-harvest loss assessments were put at 20 to 25 percent and occasionally as much as 50 percent (Ames et al., 1991). According to FAO (1992), report shows that post-harvest losses occur due to spoilage of fresh fish, insect infestation during drying process and breakages during transportation. In 1970's, losses were estimated to 30 percent which was reduced to about 10 percent in 1992 through improved smoking ovens. Equally, Kumolu-Ndimele and Johnson (2011) stated that losses during post-harvest activities are as high as 50 percent in the fisheries sector. Also, Olusegun and Matthew (2016) opine that the enormity of losses account to 30 – 50 percent of total catches.

In Vietnam, Ngoan (1997) carried out a research on the current status of post-harvest fisheries technology describing the numerous infrastructures available for fish processing and storage for export. It was reported that only 30 percent of the catches are industrially processed while the remaining were consumed fresh. Recommendations was suggested that the fisheries sector should focus on decreasing post-harvest losses, providing infrastructures and providing fish products of good quality.

In Gambia, post-harvest fish loss is also a serious issue in the processed fish industry and estimated at 20 - 30 percent. Cured fish is the major fish produced in the artisanal fisheries sector and about 40 percent is being marketed. The sector supply about 90 percent of the domestic fish production in the fishing industry and employs a larger percentage of the Gambians (Njai, 2000). Several studies show that fish is the lowest-price of animal protein that is affordable and traditional fish processing is the major form of ensuring that fish is available for consumers purchase (Njai, 2000; Mzengereza, Sawasawa & Kapute, 2016).

In Ghana, report shows that over 100,000 tonnes of fish are lost yearly due to poor treatment, unhealthy management and lack of technologies for processing and preservation (Ibrahim, Kigbu, & Mohammed, 2011; Boohene, & Peprah, 2012; Cliffe & Akinrotimi, 2015). Fish needs proper processing due to autolytic and bacteria reaction that occur immediately after fish dies. Anon (2008) stated that consumption pattern of fish as food is roughly 75 percent of the total catch of artisanal fishing and majority desire smoked form due to taste.

In Malaysia, roughly 49 percent of the whole animal protein and 12 percent intake of protein is provided by fish in the Malaysian diet. The availability of fish is determined by the number of fishing boats and quantity of fish caught per boat. Studies have estimated losses in the fish processing industries to amount to 30 percent of the total landing that is as a result of poor handling, transportation and storage facilities. To reduce these losses, fish are salted and dried since that is the simple form of fish preservation. Despite this, the need for improved technology and further research is required to support the development of the processing industry (Abdullah & Idrus, 1978; Shiriskar, Khedkar & Sudhakara, 2010).

During harvesting in Kenya, fish are sold in fresh form while a substantial amount is processed for consumption later. Huge post-harvest losses arise due to absence of infrastructures, poor hygiene, deficiency of storage facilities and it has been estimated to 20 – 30 percent and 50 percent during rainy season (Ofulla, Jondiko, Gichuki & Masai, 2007; Owaga, 2011). Poor infrastructural facilities such as lack of cold storage, distribution facilities and lack of suitable sanitation practices has made it difficult for the subsistence small-scale fishery communities to use local fish preservation methods such as salting, smoking and sun-drying (Owaga, Mumbo, Aila & Odera, 2011).

In Bangladesh, small-scale/artisanal fisheries sector is faced with serious post-harvest losses yearly due to lack of unawareness and carelessness of individuals involved in various phases from capture to consumers. Investigations have shown that there is lack of data in quantity and quality on post-harvest fish losses in the country. Therefore, it is difficult to make plans concerning the issue of post-harvest losses at fisheries sector and country level (Ward, 2000; Srinath, Nair, Unnitha, Gopal, Bathla & Tauqueer, 2008; Nowsad, 2010). Studies in Bangladesh show that 25 – 30 percent of fish is lost yearly due to numerous reasons. This is as a result of government focusing on how to increase production of fish while neglecting reduction of fish losses along the production chain. Huge loss in this sector is creating massive burden on securing food in the country and speedy attention is required (Nowsad, 2007; Srinath et al., 2008; Hassan, Rahman, Hossain, Nowsad & Hossain, 2013). Likewise, Nowsad (2010) stated that if 50 percent of fish losses is reduced, it will save Tk.8,000 – 10,000 crores yearly.

According to Wibowo, Utomo and Kusumawati (2016) opine that in Indonesia post-harvest fish loss is very high and estimated as 30 – 40 percent. Despite all efforts to reduce fish loss, there are no changes yet. Unproductive development on fish handling could be the cause of high loss. In addition, the figures of post-harvest fish loss needs to be assessed and updated since the figures were based on estimation and have been used years back since 1970s. Proper assessment will help to obtain information regards to causes of losses and coping policies. All these can be achieved if fisheries researchers carry out adequate survey on the problem.

Furthermore, Nowsad (2005) stated that post-harvest losses are high throughout the production stage that is processing, storage and conveyance of fish. It was also discovered that 30 percent loss of fish occur as a result of fish that has been sun-dried which is attacked by beetle larvae and blowfly while 70 percent of fish were loss due to harmful insecticides which is considered unfit for human consumption.

Moreover, Ward (1996) stated that historically there has been dearth of accurate quantitative data regarding post-harvest loss in the fisheries sector. This has made policy and fisheries planner difficult to address the issue due to lack of availability of data. In 1992, Strategy for International Fisheries Research (SIFR) held a meeting and it was concluded that more research should be carried out towards developing efficient approach to fish loss assessment. Research on post-harvest losses still shows deficiency of quantitative data. It was discovered that detailed estimate of losses has not been done accurately along the distribution chain. This has made post-harvest planning difficult at the fisheries sector and country level.

Ward (2000) stated that meeting was held in Paris, 1991 by the International Fisheries Research (IFR) on the necessity of prioritized estimation of losses in post-harvest fisheries on trial method and confirmed estimation of fish loss. Ever since, practical and methodological tools improvement for loss estimation and planning for alleviation processes have been the main attention in countries experiencing high losses (Cheke & Ward, 1998; Ward 2000; Ward & Jeffries, 2000; Nowsad, Hossain, Hassan, Sayem & Polanco, 2015).

Based on the manual developed by FAO and NRI, a study was conducted in Tanzania from 2006 to 2008 by FAO to test the three loss assessment methods on the field. The study concentrated on dagaa fishery of Lake Victoria and marine fisheries. Types of losses along the whole chain of fishing, processing, storage, transportation and marketing were identified. From the data obtained using IFLAM, result shows that high quality and physical losses in the study area occur regularly in small-sized fish especially dagaa. Quality losses due to deterioration are over 50 percent; likewise, type of losses and gender of operatives shows a significant relationship. The study revealed that men incur physical and quality losses while women experience market losses.

However, Nor (2004) opine that post-harvest fish losses worldwide with respect to economic losses are challenging to calculate but estimate of net losses value amount to USD 10 – 20 billion yearly. In Africa, post-harvest fish losses have been estimated from 25 percent to 50 percent. In Latin America and Caribbean, shrimp by-catch discarded at sea is around 80 percent, which is estimated at over one million tons yearly. In Korea, considerable estimate of postharvest fish losses account to 10 percent of total fish catch (Campbell & Ward, 2003; FAO, 2004). Similarly, Iceland report in 1993 stated that demersal fish discarded is from 1 to 6 percent of the total fish catch. Due to reformed policy management, changed of technology and better understanding of capturing planning by fishers improved the fisheries sector. With the ever increasing population and know capture fisheries increase, prospect of food security from marine fisheries is threatened (Nor, 2004). Therefore, improved handling practices and post-harvest fish losses reduction is of vital significance.

Table 2.2
Post-Harvest Losses issues in Different Countries

Countries	**Percentage losses**	**Chain of Occurrence of Losses**	**Source**
Africa	20 - 50	Landing	Kumolu-Johnson and Ndimele (2011)
Bangladesh	20 - 30	Landing	Nowsad et al., (2015)
Gambia	20 -30	Processing	Njai, 2000
India	10 - 50	Processing	Wall et al., (2001)
Indonesia	30 - 40	Landing	Wibowo et al., (2016)
Kenya	20 - 30	Landing	Ofulla et al., (2011)
Korea	10	Landing	OECD (2000)
Malaysia	30	Processing	Shiriskar et al., (2010)
Nigeria	30 - 50	Landing	Olusegun and Matthew, (2016)

2.4 Post-harvest Fish Losses situation in Nigeria

Post-harvest losses in small-scale/artisanal fisheries sector in Nigeria have become a serious problem that needs urgent attention. Olusegun and Matthew (2016) stated that losses occur at several stages from point of capture to selling stage. Small fishing communities are encountered with huge post-harvest losses valued at 35-40 percent total weight of catch. Losses have a serious contrary effect on income of communities involved in fishing especially those that depend on post-harvest activities (Kolawole, Awujola & Williams, 2010; Ekpo & Essien-Ibok, 2013; Siddique, Biswas, Salam & Islam, 2014; Adam, Al-hassan & Akolgo, 2016).

Eyo and Mdaihili (1997) estimated loss of over 80 million worth was valued through poor handling, processing, preservation and storage. Likewise, FAO (2010) opines that losses as a result of spoilage sum up to about 10 to 12 million tonnes per year while fish worth of 20 million tonnes are rejected at sea in a year. Information from Bolorunduro et al. (2005) shows that though 70 percent of total production per year is from captured fisheries, the huge losses in this sector has been assessed at 30-50 percent of total catches.

According to Ward and Jefrries (2000), post-harvest losses take place at various stages from point of capture to the final stage of fish marketing. Supply of fish has not been able to meet up with the high demand of fish due to increased population. In order to increase fish production and bridge the gap between supply and demand, high postharvest losses should be significantly reduced through improved management, fish handling, processing, storage and distribution (Ghaly et al., 2010; Kolawole et al., 2010; Olaoye, Idowu, Omoyinmi, Akintayo, Odebiyi, & Fasina, 2012;). Over the ages, great post-harvest losses in fisheries sector have been publicised through several studies in Africa (FAO 1982; Getu et al., 2015). Also, research indicates 40 percent post-harvest losses in Lake Chad in mid 1970s, which was abridged due to proper improvement processing methods and good road networking system to around 10 percent on the lake (FAO 1982; Ibrahim et al., 2011).

Furthermore, Olusegun and Matthew (2016) carried out post-harvest study in Tagwai Lake, Niger state, Nigeria. The aim of the research was to assess fish post-harvest losses along the production chain in and around the lake. Six fishing sites were used for the study and questionnaire-targeting losses were calculated at all the level of production. Findings stated that high fish spoilage occurs at the landing sites compared to other stages. Fish are already spoilt before removal from the fishing gears and in bad shape. Estimate of post-harvest losses was indicated to be 53.34 percent on average along the production chain. This amount is enormous and harmful to Nigeria fish production. Recommendations such as improvement in conventional fish handling, form of processing and marketing system in the Lake to ensure availability of fish in the country. Further research was suggested to find ways of reducing post-harvest losses to ensure food security in the country.

According to Eyo and Mdaihili (1997); FAO (2010); Adeshinwa et al. (2005); Tesfay and Teferi (2007) studies revealed that huge post-harvest fish losses is detected at the landing site but previous literatures have not been able to confirm if the estimated value (30-50 percent) is true. Therefore, need for further research is necessary and in due time. Based on increase in post-harvest systems and food security in Nigeria, assessment shows that post-harvest issues have huge risk and economic consequences for food security in the country. According to Nigerian Institute of Food Science and Technology report, food deterioration resulting to abundant losses due to quality, weight and financial terms has great impact on social and economic wellbeing of the individual in Nigeria. Quantitative loss assessment have been challenging because of extremely variables and lack of appropriate loss assessment method (Olarinde, Okunola & Anifowose, 2007).

2.5 Small-scale/Artisanal Fishers

Artisanal fisher folks simply mean small-scale fishers. They are called small-scale fishers because they make use of low capital and low production output due to equipment used (Sunde & Pedersen, 2007; Ogunremi, 2016). Small-scale or traditional and industrial fisheries are guided by principles, which vary according to national features of the fisheries. Furthermore, the size of boat or outboard engine power describes their mode of operation also, the zone distance to operate for the artisanal/small-scale is based on principle, e.g. in Guinea Bissau, small scale fishing cannot operate beyond the first 6 nautical miles from the coastline (O'Riordan, 2005). Ogunremi (2016) stated that fishers in this sector are guided by policy and management approach whether artisanal or commercial while the policy provides the devices to ensure that fishers can benefit from new opportunities (Akintola & Fakoya, 2017).

In Nigeria, coastal small-scale/artisanal fishers make use of fishing gears such as cast nets, hand lines, basket traps, gill nets, beach seine, purse seines and long lines while pirogue which is 3-18 metres length or traditional dug-out canoes are also used (Inoni & Oyaide, 2007). Small scale fishers operate within the range of 20 metres depth contour to a maximum depth of 40 metres and make use of lower running costs, fuel consumption for outboard engine (15 and 45 horse powers) and less man power (Olaoye et al., 2012).

Studies carried out by other researchers define artisanal fisher folks as small scale fisheries that make use of thorough manual labour during harvesting, fish processing and supply technologies to explore resources in the inland fishery (Allison & Ellis, 2001; Sowman, 2011; Bartley, de Graaf, & Valbo-Jørgensen, 2016). Fisheries activities is usually carried out on individual basis performed at inshore base with manually operated fishing net devices and the basis of the activities includes source of revenue for the family (Oladimeji et al. 2013; Tesfay & Teferi, 2017).

According to Dhanuraj, (2004), small-scale/artisanal fisher folks encompass the whole members of the family who get means of survival by engaging in post-harvest activities such as gathering, processing of fish into different forms and selling of fish products to consumers. Bako (2005); Omwega, Abila and Lwenya, (2006) and Akintola and Fakoya (2017) are of the opinion that fisher folks comprise of fishermen, women in fish processing and marketing engaging in fisheries activities for their means of livelihood.

Furthermore, Ayotunde and Oniah (2012) and Bennett, Blythe, Tyler, and Ban (2016) opine that fishers in fishing communities in Nigeria are poor and vulnerable. Similarly, Adelekan and Fregene (2015) in their study revealed that coastal fishing communities in Nigeria are among the poorest in the country due to lack of infrastructural facilities. According to Divakarannair (2007) findings revealed that poor condition can be defined by low level income. When production level is low, definitely income level will be low. Oladimeji et al. (2013) stated that lack of access to social amenities such as basic health facilities, good schools, toilet facilities, good portable water, communication system; infrastructures such as processing facilities, storage system, road network, marketing system which will help boost their production level are not available in the fishing communities. In addition, Pertiwi, Haluan and Sari (2002) indicated that small-scale/artisanal fishers need information in terms of technology to use in production, marketing structure and good roads for transport of produce to urban market.

According to Mayhew (2016), fishers operate mainly in family units instead of forming viable cooperative societies, which will attract assistance. As a result of this, they are exploited by the middlemen who purchase their products at low prices. In addition, Emere and Dibal (2013) stated that income level of the fishers is affected which leads to adverse effect on their livelihood and decrease the availability of animal protein level in terms of quantity to greater part of the people.

2.6 Related Theories

In the context of this study, three (3) theories namely Goldratt's theory of constraint, theory of infrastructure and livelihood theory and one (1) model; generic predictive model designed by Technologies and Practices for Small Agricultural Producers under FAO initiative (TECA-FAO) for researchers who want to assess fish losses was used. Goldratt's theory of constraint concentrated on productivity happening along all the stages of production. In order to increase the productivity of an organization, the constraint or weakest link affecting production must be identified first. Then, thinking process takes place in order to find an approach to solve the problem identified and proffer solution for implementation. Theory of infrastructure by Frischmann (2004) opines that economists have observed the role of investing in infrastructure towards economic development mainly in the developing countries. It shows the role of infrastructures and how vital it is to economic growth. Similarly, Agenor (2010) stated that theory of public infrastructure plays a major role as the engine of growth. Lack of infrastructures such as road, electricity and storage in the rural areas limit productivity among the rural people because it hinders transportation of farm products to urban areas. Availability of infrastructures increases productivity, which results to more income and boost the livelihood of the people. Livelihood theory according to Chambers and Conway (1992) focus on poverty alleviation among the rural areas. The theory shows the importance of economic growth towards reduction of poverty and explained further that poverty does not mean low income but include illiteracy, poor health and lack of social services. The poor people understand what they are lacking and needs to be included in the government policies to improve their standard of living. The theory also involves ensuring that rural people have the ability to provide for themselves and bring themselves out from poverty. The generic predictive model/fish loss model is designed by Technologies and Practices for Small Agricultural Producers (TECA-FAO initiatives) which concentrate on physical and quality losses. This model categorizes fish occurrence from point of capture to different stages of production until it gets to the consumer. This model is designed for researchers who intend to identify where losses occur and provide loss intervention. The three (3) theories and one (1) model are explained in details below.

2.6.1 Goldratt's Theory of Constraint

This theory came into existence by an Israeli physicist named Dr. Eliyahu M. Goldratt who focused on business world through books. In early 1980, Goldratt introduced a software manufacturing scheduling method as Optimized Production Timetables (OPT) which was later improved to Optimized Production Technology. A publication entitled 'The Goal' was wrote by Goldratt, which was used to teach the world on how to manage limitations (Goldratt, 1990; Dettmer, 1997). The book was about a plant manager who was searching for a way out of keeping his plant afloat and seeking on how to develop the performance of the plant. The plant manager achieved this through the assistance of old colleague professor and the manager was able to increase the plant performance and also learn how to solve problems to achieve a mutually beneficial state.

Theory of Constraints (TOC) by Goldratt concentrated on the productivity happening along the entire process instead of focusing on effectiveness of single phase of the process. This simply means that the feeblest link controlling the rate of production and the whole system must be identified. Goldratt's TOC indicated that weakest link brings about limitation to the overall performance of an organization. This weakest link or constraint must be firstly identified if an organization wants improvement in productivity (Goldratt, 1990; Rahman, 1998).

Theory of Constraints has two main modules. The first one deals with beliefs, which support the TOC opinion. It comprises of five stages that focuses on development, scheduling method of drum-buffer-rope (DPR) and buffer management data system called TOC's 'logistics' model. The next one is an approach developed by Goldratt called 'Thinking processes. This is the major section that underpins other parts of method through studying, examining and solving business problems. Thinking process is like a logic tree that gives a direction for modification through finding an approach towards these three simple problems of things to change, things to change to and how to effect the change. Thinking process direct through identification of the problem, finding solution, identification of obstruction that needs to be overcome and solution implementation (Mabin, 1990; Rahman, 1998).

Below are five stages concentrating on how to solve challenges faced in an organization for progress continuity:

1. **Recognise the constraint:** This simply means the weakest link causing set back in terms of productivity in the system must be identified firstly. These constraints may be physical such as machines, people and materials of managerial in terms of policy.

2. **Exploit the constraint:** Decision must be made on how to realise the best output from the constraint. Restrictions causing constraint should be removed in order to reduce non-productive time.

3. **Subordinate other activities to the constraint:** This simply means that output of other component needs to be attuned to suit the usefulness of constraint. Ensure a smooth workflow in the system.

4. **Elevate the constraint:** Ensure severe effort towards improvement of constraints if they still exist in the system in order to improve productivity.

5. **If a limitation is slightly changed from the earlier stages, start from step one:** Apathy must not be allowed to become the next constraint. First step of addressing continuous improvement makes TOC a continuous process. Second step indicate that policy changes based on the situation of constraint (Goldratt, 1990). Figure 2.1 shows the process of on-going improvement.

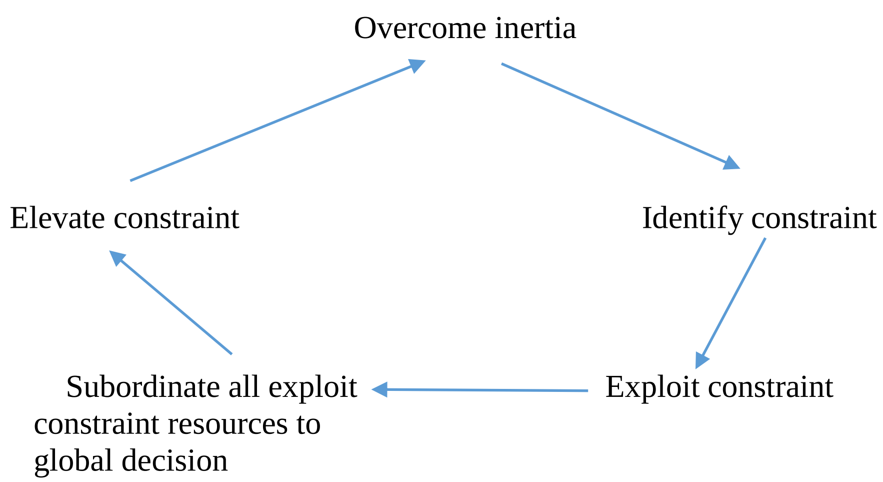

Figure 2.1
Process of On-going Improvement
Source: Adopted from Goldratt (1990)

Taylor and Esan (2012) applied Goldratt's theory to the problem related to method of transportation, storing and transaction of fresh fruits and vegetables in Nigeria. It was discovered from the study that recent practices used for tilling, handling, gathering, conveying of fresh fruits and vegetables resulted to huge damages due to perishable produce. Also, due to huge harvest excess produce are wasted due to lack of storage and processing facilities. Study revealed that lot of problems exist such as method of handling produce, facilities used and so on. This research used Goldratt's Principle of Constraints as well as thinking method to identify the main problem of losses and wastage, provide useful information that will help to improve the situation at present and reduce the losses faced which will help the traders, consumers and the economy at large.

For the study, thinking process of what to change was first identified. It stated that the main issue needs to be determined and eradicated. Cause and effect is also identified to get to the root of the main problem. Goldratt's theory stated that in order to know the true main problem, it is good to note in a diagram arrangement of the present state.

This will explain logically on the situation. The study highlighted a list of undesirable effects within the range of 10 – 12 based on Goldratt (1994). The study identified 18 undesirable effects (UDE) of conveyance, storing and sale of fresh fruits and vegetables in Nigeria. Out of the 18 UDE listed, 16 undesirable effects of archaic/insufficient propagation, shipping, processing and preservation methods used was identified as the main difficulty.

This main issue was positioned at the tree foot through which other UDEs generate from it to form current reality tree. Goldratt (1990) stated that since the core problem has been identified, then eliminating it would involve the use of a tool called 'Evaporating Cloud (EC)'. This tool is used to find solution that will solve the problem in order to realise appropriate form of processing and preservation approaches and transportation in the industry. The practice of EC shows that to achieve appropriate conveyance, handling and preservation methods in the production sector, educating of individuals becomes paramount and they must be prepared to learn also extension organisations should play their duty by training individuals in the industry.

In order to cause the change, Future Reality Tree (FRT) was the technique used for this research. Approving Goldratt (1993), FRT is one of the thinking methods that allow a solution to be constructed. It suggested that if modern processing technique, preservation practices and transportation is made available through provisions of government loans then post-harvest losses will be meaningfully reduced.

Another study using Theory of Constraint is by Heron (2011) who explore alternative models of localisation in food supply chains in United Kingdom. The research was carried out to identify problem faced in given proper definition of what local food is and what it can be developed into. Qualitative case study method was used for this research using a group of producers of similar products (23) but different supply scales across England. Prototype analysis was used in this research for extraction of data, which suggest a way forward to existing and future stakeholders. This research covers afar supply chain metrics by identifying problems where answers are not provided. Goldratt's Theory of Constraint was used to assess definitional issues of difficulty and uncertainty in order to understand local foods and its main producer. Constraints identified for this research include nature of the market, institutional constraints, supply chain relationship constraints, skills constraints and personal belief constraints. Adapted Theory of Constraints was presented for this research to examine and analyse short food supply chain and local food.

2.6.2 Theory of Infrastructure

Frischmann (2004) stated that theory of infrastructure is a promoter of growth, which helps in development based on availability of public infrastructures. Economists have examined the role of investment in infrastructure in developing countries towards economic development. Inadequate of infrastructure has restricted the growth and development of many countries of low-income. Provision of infrastructure by government leads to effectiveness of public investment, which results to direct and indirect development impact. Direct impact includes productivity of private inputs, rate of return on capital and lower cost of production while good access to water, good health facilities, access to education and access to electricity while indirect impact leads to increase productivity (Estache, 2008; Agenor, 2010). According to Wagstaff and Claeson (2004), road infrastructure had consequence on health indicators such as mortality rate. Good transportation system especially in the rural areas will make health facilities easier to get.

Kessides (1993) stated that infrastructure boosts quality of life by providing adequate amenities, increase productivity that leads to more profit. Similarly, factors of production are increased. That is, change from manual to modern machinery that decreases time commitment. Furthermore, provision of electricity is of utmost importance in the rural areas. This helps in the aspect of storage of produce for a longer period, reduce losses and attract good price from the consumers (Agenor, 2010). Electricity and good roads work hand in hand in the aspect of production. Good roads must be available for transportation of goods from the rural to urban markets.

According to Agenor (2010), road infrastructure plays a vital role in marketing of agricultural commodities from rural areas to urban market. Lack of roads in the rural areas limits productivity in the areas. Research revealed that cost of transportation consists of 30 – 40 percent of market prices. Good access to road networking system reduce distance from farm to market and make produce to be of god quality (Kessides, 1993; Kumudu, William, & Lakshmanan, 2008; Sengupta, Coondoo & Rout, 2007). Equally, Faiz, Faiz, Wang and Bennett (2012) posited that rural road is the solution to meet food supply of growing population globally. Good roads create happiness to the rural dwellers, which affect their well-being positively and boost their production level. Findings from Zaid and Popoola (2010) indicated that rural dwellers livelihood is on the low side. This is due to lack of basic amenities such as good water source, health care centres, electricity, roads and so on by the government.

2.6.3 Livelihood Theory

The sustainable livelihood idea suggests a clearer and integrated method to poverty. Sustainable livelihood approach is as a result of the old Integrated Rural Development (IRD) approach, which was also extensive and multi-sectoral. The vital change is that the sustainable livelihood approach does not aim to address all aspects of the livelihoods of the poor. The purpose is to employ a general view in livelihood analysis to detect those problems where an intervention is essential for real poverty reduction, either local level or at the policy level (Krantz, 2001).

Brundtland Commission first introduced the concept in 1987 on Environment and Development, and the 1992 United Nations Conference on Environment and Development expanded the idea. They were in support of sustainable livelihood as a broad goal for poverty eradication. Also, International Institute for Sustainable Development (IISD) define sustainable livelihood as being "bothered with people's capacities to produce and maintain their means of living, enhance their well-being, and that of upcoming generations" (Krantz, 2001; Kanji, MacGregor, & Tacoli, 2016; Laeis & Lemke, 2016). United Kingdom's Department of Foreign and International Development (DFID) definition combines these ideas.

Sustainable livelihood has been defined by Chambers and Conway (1992) as a situation that occur and can be overcome by endurance in order to get over stresses and shocks as well as sustain or improve its capabilities and assets both now and in the future, and also contributes other livelihoods net profits at the local and international levels in the short and long terms. According to Krantz, (2001) the idea of Sustainable Livelihood (SL) should go further than the orthodox definitions and methods to poverty eradication. These have been discovered to be too narrow because they focused only on certain aspects of poverty, such as low income while other vital areas such as vulnerability and social exclusion were neglected. It is now acknowledged that more attention must be directed to the various factors and methods which either constrain or improve poor people's ability to make a living in an economically, ecologically, and socially sustainable manner (Kanji et al., 2016).

Moreover, Allison and Ellis (2001) stated that Sustainable Livelihood Approach (SLA) has become the foremost approach since 1990s to the implementation of advance interventions by major international agencies. Equally, Morse and McNamara, (2013); Laeis and Lemke, (2016) claimed that sustainable livelihood approach has been in trend amongst development specialists and researchers since the late 1990s which was a central concept of the UK's Department for International Development's (DfID) approach during the early years of the UK New Labour government. Emphasis on sustainable livelihoods was established in the 1997 White Paper on international development as follows: change our international development efforts on the elimination of poverty and encouragement of economic growth, which benefits the poor. This will be carried out through support for international sustainable development targets and policies that create sustainable livelihoods for poor people promote human development and conserve the environment (Carney, 2002; Scoones, 1998).

Carney (1998) provided a simpler dream of sustainable livelihood before the publication of the White Paper, which has meaning with the definition of Chambers and Conway (1992). It stated that livelihood comprises the capabilities, assets (including both material and social resources) and activities required for a means of living. Also, Serrat (2008) stated that sustainable livelihood approach is an intellectual way of putting into consideration the aim, opportunity and significance for development activities.

2.6.3.1 Sustainable Livelihood Approach Framework

Sustainable livelihood framework provides a concrete base for understanding rural poverty and the state of people living in poverty in rural settlements (Scoones, 1998; Ashley & Carney, 1999). Also, it is a tool for investigating the impact of regulations on their livelihoods (Krantz, 2001; Adato, & Meinzen-Dick, 2002; Kanji et al., 2016). In addition, it is a form of livelihoods analysis used by researchers and development organizations such as Department for International Development (DfID) of the United Kingdom, United Nations Development Program (UNDP), as well as nongovernmental organizations (NGOs) to analyse causes of poverty, access to resources and their various livelihoods activities (DfID 1997; Adato & Meinzen-Dick, 2002).

The sustainable livelihood framework is divided into 5 aspects which include livelihood assets (natural, physical, financial, social and human), vulnerability context, policies and institutions, livelihood strategies and livelihood outcomes which are interrelated to each other (Chambers & Conway, 1992; Scoones, 1998; DfID, 2000; Serrat, 2008; Morse & McNamara, 2013; Addinsall et al. 2015; Kainji et al. 2016).

a) Livelihood Assets

According to Kollmair and Gamper (2002) and Tafida and Galtima (2016) indicated that there are five sets of livelihood assets which are important to develop people's livelihood strategies in order to strengthen their well-being.

1. Natural Capital

Pretty (2003) stated that natural capital are resources produced by nature. This include natural resources such as land and produce, water and aquatic resources, trees and forest products, wildlife, wild foods and fibres, biodiversity and environmental services (hydrological cycle, pollution sinks etc) (DfID, 2000).

2. Physical Capital

It is defined as the store of human made resources (Pretty, 2003). This can also be called produced capital. It includes infrastructures (transport, roads, vehicles, secure shelter and buildings, water supply and sanitation, energy, communications), tools and technology (tools and equipment for production, seed, fertilizer, pesticides, and traditional technology) (DFID, 2000; Kollmair & Gamper, 2002).

3. Financial Capital

Financial capital can be defined as accrued entitlements on goods and services that built up through the monetary system (Pretty, 2003). It is also called economic capital which include capital base (cash, credit/debt, savings, remittances, pensions, wages) and other economic assets such as basic infrastructure and production equipment and technologies) which are needed for the quest of any livelihood strategy (Chambers & Conway, 1992; Scoones, 1998; DfID, 2000).

4. Social Capital

Social capital can be defined as structure, which aids coordination and cooperation. According to Pretty (2003), social capitals are highlighted by four features which include relation/trust; reciprocity and exchanges; common rules, norm and sanction; and connectedness, network and group. These are social resources (networks, social claims, social relations, affiliations, associations) which people draw when pursuing different livelihood strategies requiring coordinated actions (Chambers & Conway, 1992; Scoones, 1998).

5. Human Capital

Human capital can be defined as the total ability that exists in individual (Pretty, 2003). It involves education (knowledge, skills), people (health, nutrition) and capacity to work (Carney, 1998; Serrat, 2008).

b) Vulnerability Context

According to Kollmair and Gamper, (2002), vulnerability can be defined as the level at which individuals or households is being exposed to risk (danger, shock) and insecurity, and the ability to avert, lessen or survive with risk. Some other researchers defined it to be the external environment in which people exist i.e. it is considered as insecurity in the standard of living of individuals, households, and communities in the face of changes in their external environment (DfID, 2000; Addinsall et al. 2015). Vulnerability context are divided into three which includes shocks such as floods, drought, weather, conflict, illness, death, pests and diseases; critical trends such as environmental change, population, markets and trade, national and economic change, and technology changes; seasonality such as prices, production cycles, employment opportunities and so on (Ashley & Carney, 1999; DfID, 2000; Krantz, 2001; Kollmair & Gamper, 2002; Kainji et al. 2016). According to previous researchers, it has been observed that people have limited or no control over vulnerability context and because of this it has a great influence on their livelihood and on the assets available. Considering an illness in the family, this can lead to selling of valuable assets that has been built over years and also affect their source of income (Chambers & Conway, 1992; Scoones, 1998; DfID, 2000; Serrat, 2008; Morse & McNamara, 2013).

c) Policies, Institutions and Processes

From the DfID framework, livelihoods outcome is formed by policies, institutions and processes from individual, household and international levels. This determines their access to their livelihood assets in pursuit of various livelihood strategies. Researchers have discovered that without policies and institutions, sustainable livelihood framework is incomplete (Morse & McNamara, 2013; Kanji et al., 2016). Policies and institutions are divided into two parts; structures and processes. According to Serrat (2010), public and private sector organizations are structures that establish and implement policy and legislation; deliver services; and purchase trade and execute all issues that affect livelihoods. Processes hold the rules, laws, policies, arrangements of operations, bargains, social customs and practices that in turn regulate structures operation. Effectiveness of these policies and interventions would make the poor less vulnerable, improved well-being and more sustainability (Scoones, 1998; Ashley & Carney, 1999; DfID, 2000; Addinsall et al. 2015; Kainji et al. 2016).

d) Livelihood Strategies

According to Ellis (2001), livelihood strategies can be described as the activities to be put in place to achieve good livelihood outcomes. It is also the measures people choose in order to have access to livelihood assets, policies that will influence their lives positively and how they can cope with their external environment (Krantz, 2001; Addinsall et al. 2015; Pomeroy, 2016). Scoones (1998) stated that livelihood strategies combine activities called livelihood portfolios and this must be subjected to study. Researchers have identified three types of livelihood strategies, which include agricultural intensification or extensification, livelihood diversification and migration (Scoones, 1998; DfID, 2000; Krantz, 2001). This is in line with Carney (1998) and

Ellis (2001) who stated the three types to be natural resource based, non-natural resource based and migration.

e) Livelihood Outcomes

According to Scoones (1998) and DfID (1999), livelihood outcomes is an approach which improves the well-being of people, increase level of income, reduce vulnerability, improve food security and more sustainable use of natural resources. Sustainable livelihood approach is majorly concerned with people. It seeks to understand how people have used their capabilities, social and assets to make a living for themselves. Also, understanding strategies put in place to survive and improve their livelihood. However, sustainable livelihood approach creates the link between people and the environment that affects the outcomes of livelihood strategies (Chambers & Conway, 1992; Scoones, 1998; DfID, 1999; Serrat, 2008).

Sustainable livelihood frameworks are a tool used to improve our understanding of livelihoods, mainly the livelihoods of the poor. It presents the core factors affecting people's livelihoods, and the relationship that exist between them. Researchers have discovered that this framework can be used in planning new development activities and also the contribution to livelihood sustainability as a result of existing activities (Chambers & Conway, 1992; Scoones, 1998; DfID, 1999; Morse & McNamara, 2013; Kanji et al., 2016). The framework provides a list of vital issues and outlines ways in which it links to each other; create attention to main influences and processes; and highlights the several interactions between the numerous factors affecting livelihoods. The purpose of this sustainable livelihood framework, which is specified in Figure 2.3, is to help stakeholders with different perceptions to involve in structured and intelligible debate concerning the various factors that affect livelihoods, their importance and their interaction process. This helps to identify appropriate access for support of livelihoods (Chambers & Conway, 1992; Scoones, 1998; Ashley & Carney, 1999; DfID, 2000; Adato, & Meinzen-Dick, 2002; Addinsall et al. 2015; Pomeroy, 2016).

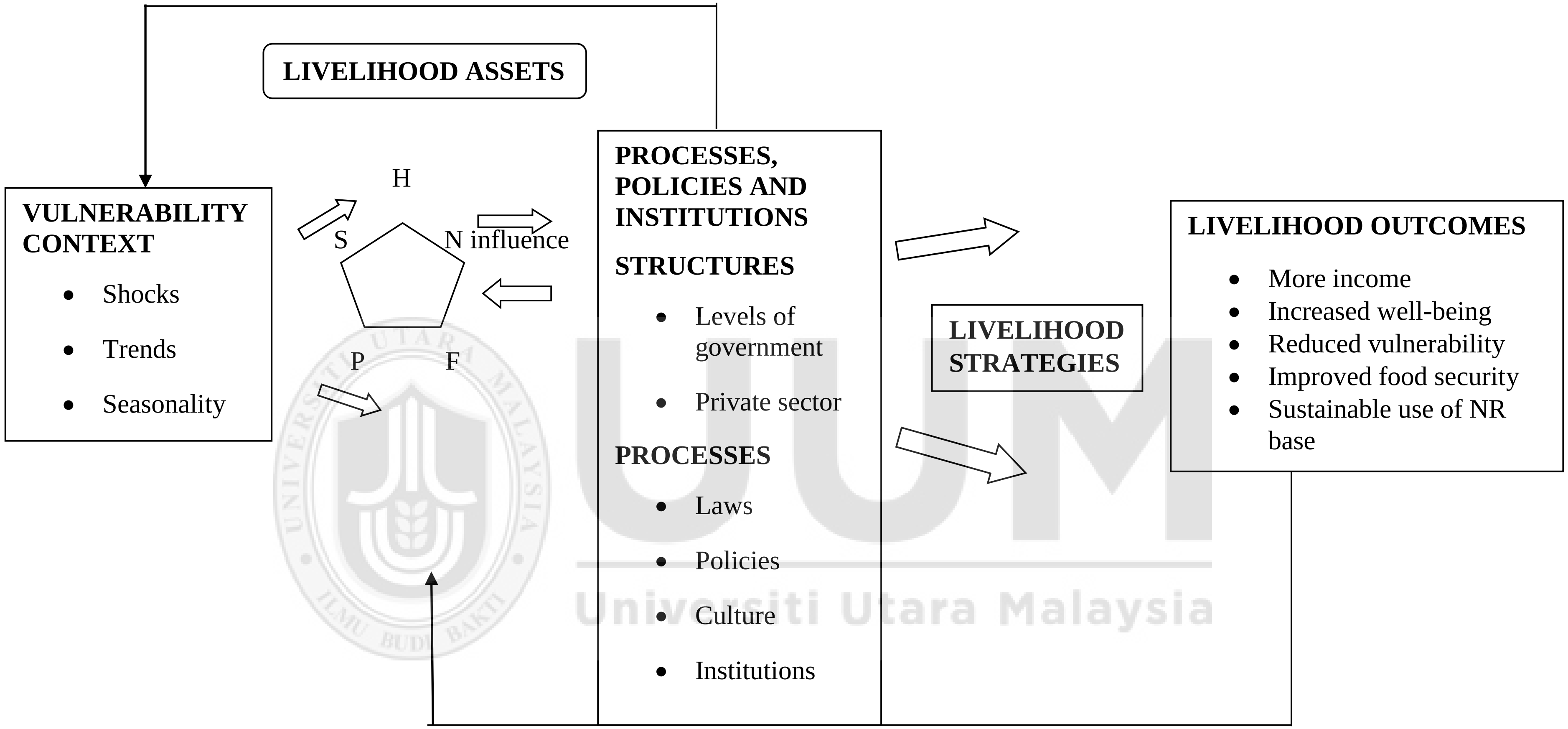

Figure 2.2
The Sustainable Livelihood Approach
Source: DFID, 2001 (Adapted from Chambers and Conway, 1992)

KEYS
H = Human capital   N= Natural capital
S = Social capital   F = Financial capital
P = Physical capital

2.6.4 Generic Predictive Model/Fish Loss Model (TECA-FAO initiatives)

This model focuses on two utmost significant losses; physical and quality post-harvest fish losses. Physical losses deal with discarded fish or fish products, which are not sold due to insect infestation or damage, spoilage of quality loss resulting to value loss. Loss in value is the difference between attained price and fish price had it been the quality is in a good state. Therefore, this model classifies the occurrence of fish from captured time into sequence of stages and assumes transport system between each phase. This helps to link loss data at different points in a production chain. This model is planned for researchers/people who want to imitate fish production chain and discover the reduction loss intervention of the chain. It helps to identify where the main losses occur in the fish production chain and total losses for the whole production chain.

For use of this model, certain vital data are needed for stages in the distribution chain such as percentage of fish sold at a reduced price, percentage of fish loss, price of fish in good quality, price of fish of low quality, total weight of fish and local currency to US$ exchange rate. Data collected may denote some certain fish sample or average of numerous samples to signify the mean loss on each phase of the production chain. Exactness of the data used will be associated to correctness of the model prediction. This is linked to the application and data collection method used. This model will serve as a guide to categorise interventions for which analysis on cost and benefit and technical evaluation be conducted. The model was developed for single fish species data rather than diverse fish catches with different loss and prices varies according to fish species. Additionally, the model is planned for running data on a chain and single fish product (Published on TECA http://teca.fao.org).

2.7 Empirical Studies on Different Techniques involved in Small-scale/Artisanal Fisheries Sector

The role of good technique in fishing communities towards abundance of food in the national level cannot be underestimated (Solomon, Okomoda & Egwumah, 2016). Technique can be defined as the approach applied during fishing to ensure that nutritional requirements of consumers are met after harvesting, processing, preservation, packaging, storage, transporting and marketing of fish (Mungai, 2014). The purpose of these techniques is to reduce post-harvest losses in the small-scale/artisanal sector and add value to fish products, which leads to new market opportunities, boost production level in artisanal fisheries sector and provide adequate nutrient requirement for the ever-rising population (Tamil Nadu Agricultural University, 2008). In order to address post-harvest issues, different stages that take place in the artisanal fisheries sector must be looked into. These stages include handling, processing/preservation, storage, transportation and marketing (Odongkara & Kwangwa, 2005; Olusegun & Matthew, 2016; Tesfay & Teferi, 2017).

2.7.1 Fish Handling Practices

According to Eyo (1997) and Bako (2005) describe handling as proper treatment given to the catch from the point of landing until it gets to the end users. Delays do occur from the time fish are captured until when they are landed on deck. Along the line, fish die inside the net before being removed and the risk of spoilage is high. Similarly, fish are wrongly handled when removed from the fishing gear. Some of the handling practices include using boats that are dirty, unclean equipment, using of dirty water to wash the fish, placing fish on dirty surfaces and fish are thrown or trampled which leads to bruised fish flesh paving way for entering of bacteria leading to spoilage (Eyo, 1997, Diei-Ouadi & Mgawe, 2011).

Immediately when fish dies, rigor mortis set in which is the stiffness of the fish muscle. This starts after the death of the fish between 1 to 7 hours. Due to this, fish needs to be handled carefully prior to rigor mortis (Wilkinson, Paton & Porter, 2008; Santoso & Yasin 2010; Ogata, Koike, Kimura & Yuan, 2016). Fish quality and safety is the greatest concern of consumers and in order to achieve this, there is need for good hygienic practices among fish handlers and fish processors (Balasubramaniam, Charles & Krishna, 2009; Singh et al., 2012). Kantor, Lipton, Manchester and Oliveira, (1997) opine that to ensure freshness of fish post-harvest handling becomes paramount in the sector while Das, Kumar, Debnath, Choudhury and Mugaonkar (2013) specified that quality of fish depends on the handling technique on board, during processing, storage, packaging and transporting.

Study of Odongkara and Kwangwa (2005) was on hygiene, handling and processing of fish within fishing communities in Uganda. The aim of the study is to improve sanitation, handling of fish and fish processing condition in the fishing communities. Data collection was done through qualitative and quantitative method. Total of five hundred and seven (507) respondents were interviewed. Focus group discussion was done for qualitative method while data collected from quantitative method were analysed using SPSS. Result shows that majority of fishermen do not cover the fish rather they exposed it to the sun at the landing site. Also, it was discovered that a larger percentage of processors keep their fish in a dirty place. Lack of awareness and facilities have serious influence on the fish processors. It was also observed that at most landing sites, social amenities like electricity, sanitary facilities, potable water and ice are lacking. Ssali and Masette (2001) opined that in the absence of these facilities, fishers are left with no choice than to use shoreline water for cleaning of fish, fishing gears and other facilities used for handling. Another serious issue is the poor state of repair of access roads to the landing sites. Recommendations include sensitization of fish processors on adequate hygiene and fish handling. Improvement of transportation system and provision of facilities will help the processors. Further research was posited in order to know extent of losses of fish for adequate intervention.

Furthermore, Amos et al. (2007) using sensory analysis to examine fish handling points where deterioration of quality occurs and upgrading suggestions in Uganda and Iceland. This was carried out through examination of qualities of chemical, physical and bacteriological of cod (*Gadus morhua*). Post-catch sensory outcomes indicated high worsening of quality of cod between 7 – 11 days when compared to 1 – 7 days. Subjected fish to mechanical load revealed more loss of physical quality and greater bacterial flesh amounts and lesser amounts on the skin. Based on the findings, decline quality of fish in this location is as a result of growth of microbes. Recommendation was stated that long keeping of fish beyond 6 hours should be avoided to meet market demand.

Additionally, Singh et al. (2012) carried out a research on hygienic fish handling practices adoption among the mechanized fishermen of Thoothukudi district in Tamil Nadu, Indian. The aim of this research is to study the adoption level amid fishermen on improved hygienic practices on fish handling and identify problems in order to proffer solutions to them. Data was collected through personal interview through random selection of 120 fishermen. Findings show that though the fishermen carried out hygienic practices based on their own knowledge but the technical aspects of hygienic practices on fish handling to achieve good quality fish are still lacking. Recommendations made include adequate training on hygiene practices and provisions of storage facilities to avoid fish spoilage are necessary.

Studies of Badiani, Bonaldo, Testi, Rotolo, Serratore, Giulini and Gatta (2013) investigated on ensuring worthy catch handling procedures and impact of timely icing on freshness of cuttlefish quality. Two hundred and forty three (243) cuttlefish samples were treated with three icing after post-harvest. For treatment 1, fish samples were stored underneath 15-mm concentrated level crumpled freshwater ice (Ice cover), treatment 2 samples were stored using ice carpet of thick level of crumpled ice of 15-mm and treatment 3 with no ice contact, placed in polystyrene boxes in the refrigerator under the same temperature for 6 days. Sensory evaluation using Quality Index Method (QIM) and Torry meter for freshness determination. Experiment revealed degradation of adenosine triphosphate was slowed down from treatment 1 and 2. Physical appearance such as colour of the eyes, clearness of eyelid and dorsal part of the fish were worsened in treatment 1 compared to treatment 2. Therefore, treatment 2 was recommended for this study.

Another study on hygienic practices during handling carried out by Das et al. (2013) on adoption of hygienic practices in fish markets of Tripura in India. The study was conducted among fish retailers in four retail markets from Tripura state. A total of 77 fish retailers were selected using proportionate random sampling. Primary data was used through semi-structured interview for collection of information. Data were analysed using descriptive statistics, correlation and multiple regression with statistical packages for social sciences (SPSS version 23). Result from multiple regressions done on seven independent variables against adoption of hygienic practices shows that only education has positive relationship. In conclusion, consumers' indicated that improvement should be done in the aspect of hygienic conditions in marketing of fish. Also, providing informal education to marketing personnel and training will improve the adoption rate of hygienic practices among fish marketers.

2.7.2 Processing and Preservation Techniques

Curing (drying, salting and smoking) which is a process of fish preservation has been in existence for a long time than any other method of preservation. Bones of marine fish were found in a cave, occupied over 20,000 years in the past, which took days of walking from coast of Spain. On these bones, forms of curing were observed perhaps open air-drying. Ever since then, drying, smoking and salting have been used for fish (Horner, 1997). Fish processing is the most common method used to preserve fish for consumption and ensure fish is in marketable conditions in rural fishing communities (Odongkara, & Kyangwa, 2005). Processing has been defined by several authors as application of technique to fish starting from harvest point to the utilization phase (Okorley & Kwarten, 2000; Akinola *et al.*, 2006). Processing can also be described as the transformation of fish into different fish products for the purpose of human consumption (Abowei & Tawari, 2011). According to Ghaly et al., (2010), due to increase in world population, preservation techniques arose in order to increase the shelf life, nutritional value and prevent spoilage of fish.

Processing and preservation of fish are very important because it prevents economic losses due to high susceptibility of fish to deterioration immediately after harvest (Okonta & Ekelemu, 2005; Ayuba & Omeji, 2006; George et al., 2014). Also, it discovers ways by which fish wastage is prevented to give fish product a longer shelf life (Silva, Adetunde, Oluseyi, Olayinka & Alo, 2011). Fish processing into structures for consumption by human as animal food supplement has been ignored in practices of fish culture. This might be because of ignorance of different processing methods of people in the fish production and high innovation level involved in the procedures. Each processor must attempt to use technique which is the best during handling of fish for revenue maximization on processing venture (Odongkara, & Kyangwa, 2005; Kolawole et al., 2010). Smoking is the most prominent traditional fish processing method used. It could be due to lack of electricity in most coastal communities for preservation of fish products and processing (Kumolu-Johnson & Ndimele, 2011; George et al., 2014).

Studies in Uganda and some other countries with fishing as major financial activities have shown the traditional methods of fish processing used which include salting, smoking, deep-frying and sun drying. This is as a result of fish that cannot be sold in fresh form due to spoilage (Mukiibi, 2001; Odongkara, & Kyangwa, 2005; Davies and Davies, 2009). Similarly, Njai (2000) and Allou (2012) further argued that though fish smoking is not done mainly because of spoilage but as a result of the fuel woods consisting of chemicals which improves flavour, increases the shelf life of fish, to reduce waste during plentiful harvest, maintain fish quality by preserving it for future use and to increase intake of protein among the people. Likewise, Mutungi et al. (2012) stated that small-scale fish processors make use of smoking, salting and frying to lengthen the lifespan of the small fish before transporting them to markets.

Another study on processing was by Davies et al. (2008) on technologies on fish processing in Rivers state, Nigeria. This study was to establish the processing methods available and to determine the extent fish processors have been capable to address the issue of post-harvest losses in area. Ten (10) local governments were selected and divided into five zones. Moreover, five zones selected were further divided into two (2) locations. One hundred processing sites were visited for this study. Questionnaire was used for data collection for this study. Descriptive statistics and inferential analysis was used for analysis of information using software package SPSS version 11.0. Findings show that the method used in processing fish is very slow and to address this issue impact of technology becomes necessary in fish processing industry. Besides, lack of education also affected the processors in the aspect of fish handling. Based on the findings, recommendations suggested include there is need for research on appropriate technology on processed fish industry, provision of social amenities such as water, electricity, health facilities will help to develop the livelihood of artisanal fisher folks.

According to Kolawole et al. (2010), their study was on indigenous practices of fish processing and preservation among women of Epe, Lagos state. Multi-stage sampling method, which include purposive and random selection were used to select one hundred and twenty (120) women in five fishing communities from the study area. Pre-tested and well-structured questionnaires were used to interview the respondents. Descriptive statistics were used to analyse the socio-economic sections while to define the association between independent variables (age, family size, income etc.) and dependent variable indigenous fish preservation techniques (IFPs), use of Pearson Product Moment Correlation (PPMC) was employed. From the correlation result, it was discovered that being educated and belong to an association could make processors reject the use of indigenous preservation. Also, smoking is the major practice of processing used in the area while capital issue is seen as the major problem.

Recommendations made based on the findings were provision of capital to assist the processors and storage and transportation infrastructures should be put in place.

Moreover, Abolagba and Nuntah (2011) study identified the processing and preservation techniques, packaging technique, different types of distribution channels involved and marketing levels of cured fish which will help to determine benefits attached economically and shelf steadiness. Random selection was done to pick 103 processors for interview. Data were collected by visual thought, Focus Group Discussion (FGD) and interview. Analytical tools include descriptive statistics and chi-square for hypothesis testing. Smoking kiln used in the study area is cut-out half drum while baskets, plastic drums and jute bags were used for storing the cured fishes. Means of transportation of smoked fish include wheelbarrow and station wagon car and bus. Losses occurred due to mould attack, insect infestation, rodent attack and breakage as a result of packing. The following recommendations were suggested which include provision of extension agents to enlighten processors and marketers on real practices and ideas needed, roads that leads to processing communities should be rehabilitated for effective transportation, reduce losses due to breakages and cost of transportation and sensitization programmes should be held on improvement of smoked fish.

Study on technologies in fish processing in Nigeria by George et al. (2014) was done in Ibeju-Lekki, Lagos state. The purpose of this study is to ascertain different technologies used in fish processing and assess efficiency, energy source and effectiveness of smoking of fish equipment in the area. Well-structured questionnaire was used for collection of information. For this study, 97 processing centres were visited while 13 questionnaires were distributed on an average. Factors examined include fish processing equipment, species processed and energy source used. Data was analysed using SPSS version 16. Result indicated that widely practice of processing used is hot smoking in the study area. It was also perceived that products realised from industry of fish processing using traditional method were suitable to consumers and command economic benefits to processors. Smoking kiln used include circular red clay oven and extended drum oven. Major energy source used is fire wood while small percentage (2.0 and 1.0 percent) of coal and electricity were used respectively. Species found in the area include *Ethmalosa fimbriata* (Bonga), *Sphyraena afra* (Guinea barracuda), *Hemiramphus brasiliensis* (Ballyhoo half beak fish), *Tylosurus crocodilus* (Hound needle fish), *Pseudotolithus senegalensis* (Cassava croaker), *Pseudotolithus typus* (Longneck croaker), *Latjanus gorensis* (Snapper) and *Caranx senegallus* (Senegal jack fish). In order to meet with consumers' expectation, fish were smoked-dried by traditional processing technologies.

The study of Jaji, Adegbuyi and Yusuf-Oshoala, (2014) examined the constraints faced by women in processing of fish and extension activities accessibility in Lagos state, Nigeria. Purposive selection was used to select eight villages out of fifty villages in Lagos state. Sampling techniques used was simple random for selection of two hundred and eight fish processors (208 women in fish processing industry). Analysis of data using descriptive and inferential statistics was done. Descriptive statistics such as frequency, percentage, charts were used for the demographic group while relationship among some variables was analysed using chi-square and correlation. Hypothesis was carried out on constraints faced by women in processing and accessibility to improved technologies. From the hypothesis result, significant relationship occurred between extension activities accessibility with age, educational level and contact with extension agents. Likewise, constraints faced by women in processing of fish and accessibility to improved technologies shows a significant relationship. Income realised by women in fish processing and availability of improved fish processing methods was significant. Findings of this study revealed that lack of adequate capital, lack of transportation facilities, lack of loan acquisition and lack of training on financial management are some of the constraints faced by women in fish processing. Recommendation was made through employing more extension agents to support and provide necessary help to the processors and communication level should be improved.

According to Jim-Saiki, Alhaji, Giwa, Oyerinde and Adedeji, (2014), their study focused on factors challenging artisanal fish production in the fishing communities of Ibeju-Lekki local government area of Lagos state. Despite the contribution (85 percent) of artisanal fish production to the country, nation fish demand is yet to be sustained. Questionnaire was used to get information from the 20 respondents who were randomly selected from 5 communities each to give a total of 100 respondents. Descriptive statistics was used for data analysis. Commercially important species found in the area include *Sardinella sp* (Sardines) which constitute about 69 percent, *Pseudotolithus sp* (Croaker) 9 percent, *Cynoglossus senegalensis* (Sole) 2 percent, *Pomadasys sp* (Grunter) 0.9 percent, *Drepane Africana sp* (Spade fish) 0.8 percent, *Vomar setapinnis sp* (Moon fish) 0.8 percent, *Sphyraena piscatorum sp* (Barracuda) 2 percent, *Arius heudeloti sp* (Catfish) 1.6 percent, *Galeoides decadactylus sp* (Thread fin) 2.8 percent and *Paenus sp* (Shrimps) 11.1 percent. Due to the turbulence nature of the water, males only engage in fishing and go to the sea in the area. Result shows that out of 100 members, 74 had their own fishing canoes while 26 hired fishing canoes. Constraints faced in the study area include insufficient capital, fish stock issue, fish sales problem, lack of storage facilities, pollution, militancy and clashes within the community. Serious issue faced by the fishermen is the problem of trawlers intrusions in the area. Fishing companies destroy fishing nets or drag them away. These entire problems have posed a threat to production of fish, income of fishers, livelihood, poverty level of artisanal fishing and investment in fishing. Recommendation suggested was to encourage fisher folks to form themselves into cooperative to have access to credit facilities as a group and enabling environment should be provided by the government for artisanal fishing.

Research on usage of indigenous fish processing practices determinant in Maritime and Inland States of Nigeria was carried out by Adeogun and Adeogun, (2015). The goal of the study is to observe the numerous elements that do not allow level of indigenous fish processing practices (IFPP) utilization in Maritime and Inland States of Nigeria. Two maritime processing states and two inland processing states were selected for this study, which include Maritime states (Akwa-Ibom and Lagos) and Inland states (Borno and Niger). Respondents were selected randomly 74, 34, 34 and 47 respectively from the snowball lists. Primary data was used for this study through interview schedule. Analysis of socio-economic features involve the use of descriptive statistics while to highlight the socio-economic factors which determines the application of indigenous fish processing practices, logit model was used. Logit regression shows a significant level between predictor variables such as income, sex, age, quantity of processed fish, household size, level of education and practices of indigenous fish processing. Findings of the study revealed that in inland states, activities generating income was a major factor that determines utilization of indigenous fish processing practices, while education, household size and traditional processing were factors considered for utilization in maritime states. Conclusion and recommendation for this study is to develop fishery extension unit, educate processors on improving their business and publicizing relevant data on sustainable technology to be used fish processing.

Furthermore, Omoruyi, Abolagba and Tuedor (2015) carried out a research in Ughelli south local government in Delta state to assess the processing and marketing of smoked *Clarias spp*. 120 smoked *Clarias spp* processors and marketers was selected using purposive sampling technique. Well-structured questionnaire was used and 60 were administered to processors and 60 retailers respectively from four communities. Analysis of data was done using descriptive statistics such as tables, bar-chart and pie-charts. Findings revealed that majority of the marketers have no formal education. Majority (73 percent) of the respondents specified that fresh dead catfish could still be kept for 3-6 hours before spoilage while for smoked catfish could stay around 2-5 hours after first smoking before spoilage. Fresh fish for smoking is majorly gotten from the fishermen and women. Smoked fish is majorly done at home by the fish processors, which take them 2-3 hours to smoke their fish. Firewood is the major source of energy used for smoking and fish are degutted and cured before smoking. Re-smoking of fish is the means of preservation of fish in the locations and between 2-4 days fish retailers sell off their fish while it takes some to sell between 5-7 days. Means of transportation is by boats, canoes and public transport. Traditional hot smoking is the most dominant method used for fish processing with smoking duration between 2-3 hours. Consumers' preference for smoked catfish is on the high side, which is profitable. Problem encountered by the fish processors and marketers include lack of processing equipment, poor transportation system and fluctuation of price.

Another study in Malawi by Mzengereza, Sawasawa and Kapute (2016) was on role of women in fish processing at Msaka Beach in Mangochi District, Southern Malawi. The study determines techniques for fish processing and factors influencing women's involvement in processing fish. Total of 89 women were systematically randomly chosen and questionnaire was used for the interview. Data analysis was done using descriptive statistics for demographic factors while cross tabulations was used for relationship between influencing factors for women's involvement in processing fish and processing techniques. From the result, significant differences exist between influencing factors and processing techniques. Study also revealed that sun drying is the major (82 percent) processing techniques used in the study area. However, educational level, marital status and household size were influencing factors of women's involvement in processing fish. Based on the findings, recommendation stated include, regular visit of extension agents to enlighten women on how to increase shelf life of fish through adequate processing. Likewise, improved techniques for fish processing should be introduce to the women to improve the quality of fish produced. FAO (1986) stated three core methods for processing of fish, which are smoking, drying and salting. These forms have continued as preservation practices from stone age to existent (Horner, 1997).

Study on sanitation and handling during processing of fish in Oguta fishing communities and its economic implications was carried out by Nwazuo, Keke, Egeruoh, Nwanjo & Ugoeze, (2016). Three landing sites and six processing centres were visited for this study while fishermen and processors were interviewed.

Assessment of fish processing methods used by fishermen instantly when fish is harvested till it gets to the consumers were done through the use of structured questionnaire, interview and field observation. Variables investigated include socio-cultural practices, sanitation and handling during processing and action put in place to guarantee increased shelf life of fish. Information was analysed using descriptive statistics while observation rating on a scale of 1-5 was used for qualitative data.

Result shows the different path of stages involved from fishermen to wholesaler and consumer or fishermen to wholesaler to processors to retailers and finally to consumers. It was observed that hygienic state during handling of fish from capture to consumption is remarkable. Fish contaminated with dirty water are found in the bottom of the boat while fishing vessels that were unkempt are on the high side, which leads to broken fins, removed scales and blemish on the fish. Fish were put inside baskets, basins or bags at the landing sites but never placed on bare ground. Trays, basins, baskets and tables were equipment used for holding fresh fish during processing. Sac also was used to cover fish from direct sunlight. Findings revealed that most loss is on the fishing ground and at the landing site while processors suffered losses during storage (50 percent small loss, 13 percent many loss and 7 percent total loss of stock). These losses were because of over-drying leading to brittleness, breakage and insect infestation. From observation, fish with bruised part, smoked fish that is broken, fish infected with mould, fish that contains dirt due to fallen during processing are not castoff as waste but sold to poor folks that cannot afford quality fish.

2.7.3 Storage Facilities

Storage facilities are essential in the artisanal/small-scale fisheries sector. It is the process of keeping the quality of fish and averting them from deterioration for a period of time (Kiaya, 2014). The purpose of this is to reduce post-harvest losses during harvest and ensure that only fresh fish that are of good quality are stored (Silva et al. 2011; Adeyeye & Oyewole, 2016). According to Silva et al. (2011) storage facilities helps to store excess fish during harvest period and this leads to higher market price and reduces spoilage of fish.

Furthermore, Mungai (2014) stated that use of ice on board is very important to keep the fish catch in good quality before arrival at the landing site. Failure to use this, the quality of fish is likely to be affected which will attract lesser price at the end of the day. Provision of insulated containers and iceboxes for proper storage during transportation from the fishing ground will ensure good state of the fish.

Eyo (1999) during investigation on consequence of using old-fashioned handling, keeping and processing technique on dried-fish quality realised that processed fish ready for marketing are packaged in either baskets or boxes made of cardboard. Findings show that losses due to disintegration arise from these means of storage which leads to loss of quality and quantity of fish during transportation. Particles from disintegration of fish lead to insects breeding which can affect the whole fish and leading to monetary loss at the end of the day. Different range of storage facilities exist for the purpose of storing fish in good quality. This is essential because the fish product needs to be stored cool (refrigeration or ventilated place) in order to maintain its quality (Kiaya, 2014). Also, need for adequate storage facilities include; improve shelf life of fish products, ensure fish is available all year round, maintaining fish nutritional quality, protect fish from rodent infestation, increase fish processors gain and gives room for exportation (Silva et al., 2011).

Post-harvest losses do occur at the point of storage due to poor storage environment and size of storage facilities, which could not preserve the excess fish products. To achieve good quality fish, provision of adequate storage facilities will contribute immensely to reduce loss (Olusegun & Matthew, 2016).

2.7.4 Transportation System

Bourne (1977) declared that there is need for improved transportation structure to lessen the time between production site and market in most countries. Some of the fishermen protect their fish catch from sun by ensuring that the boat is covered with woven raffia. Eyo (2001) stated that fresh fish that are covered immediately after capture was detected to have good quality compared to those that are exposed to the sun. Before transporting of fresh fish in containers, removal of gut to reduce bacteria must be done on board. After, washing thoroughly before transportation and preservation with the use of ice should be done.

Studies of Jagger and Pender (2001) revealed that rural communities lack good road system, which creates difficulties in transporting of both fresh and smoked fish to the market. The only way that can help the fishers to deliver good quality fish to the market is to ensure improved road networking system. Similarly, Brummett (2000) opine that without appropriate infrastructural facilities for transportation in rural areas, the process of conveying fish products to meet up with the demand in urban areas will be problematic.

However, Brummett (2000) specified that fishers (processors) pay high price on cost of transportation due to long distance from processing point to market place. This may not be achievable economically because there will be reduction in quantity of fish products transported to the urban areas. Equally, Edward (2011) findings stated that some of the problems leading to post-harvest losses are lack of good road network and inadequate storage facilities. Fish processors and marketers live in a far distance where roads are poorly constructed and due to this getting to the market with their products becomes challenging.

Literatures reviewed indicated that distribution of fish involves three main ways. Firstly, small-scale fish traders sell fresh or processed fish to local markets, fishermen sell directly to fish traders at the landing site while fish traders sell to middlemen who convey the fish to rural and urban markets. Mutungi et al. (2012) stated that means of transportation used by small-scale fishermen include public transport, bicycles, trucks, boat or they carry the fish on the head while rail or air transport is used for transporting frozen or chilled fish to urban areas. According to Cugala, Tostão, Affognon & Mutungi, (2012) posited that in Mozambique fish is poorly distributed and faced with lack of appropriate infrastructures for storage and transportation. Due to lack of infrastructure, larger percentage of the captured fish is sold at lesser price to close by markets around the landing sites.

2.8 Review of Empirical Literatures on Post-harvest Fish Losses

From history, it has been discovered that policy makers and researchers have found it difficult to make up-to-date decisions regarding loss levels and reduction actions due to lack of application of loss assessment tools and inaccessibility of roads to various fishing communities. Eyo (1997) assessed post-harvest losses in Kanji Lake fishery.

The study concentrated on quantifying post-harvest losses from fishers, fish processors and traders in the area. Primary data was used for this study. Four different sets of surveys were planned for each phase of post-harvest technology (handling, processing and marketing). Forty-five fishing villages was designated for this study while 668 respondents were picked (317 fishermen, 115 fish processors, 125 fish buyers and 111 fish sellers) while the whole survey was for duration of 24 days. Variables measured for fish handling losses are type of fishing gears used, number and weight of caught fish species, time of setting and checking of fishing nets, quantity of spoilage after hauling and landed time. Variables measured for fish processing include types of fish processing techniques used and measuring of weight and quantity of fish before and after processing. Variables measured for fish marketing for buyers and sellers include weight and quantity of fish purchased by buyer and discarded fish, weight and quantity of spoilt fish, packaging method and causes of spoilage. In order to determine quality loss, organoleptic assessment which includes observing the colour, texture and odour of the gills, eyes, surface and the body of the fresh fish was carried out in the study. Quality loss of processed fish was determined by odour (fresh smoky to putrescent) and texture changes.

Result shows that 43 species weighing 2389.3kg with total number of 24,839 fishes were observed. 10 percent of the total fish catch and 9 percent by weight were already spoilt at checking while 3 percent by weight and 4 percent by number were spoilt at the landing site. Spoilage outcome during handling of catches by fishermen amounted to 14 percent by number and 12 percent by weight. The dominant gear used by the fishermen is gill net (79 percent) recording 95 percent of the total fish catch landing, followed by cast net (9 percent), hooks (7 percent), fish traps (4 percent) and beach seines (1 percent). Smoking of fish was through the use of banda which is the major form of processing done in the area. Other processing method are sun drying which account for 10 percent while fish burning and frying account for 1 percent respectively. It was also discovered that before smoking, fish processors recorded deterioration of 21 percent by number and 15 percent by weight of fish purchased while during process of smoking only 1 percent and less proportion of fish is lost by number and weight respectively. The only fish species sun dried in the study area is the clupeids. Fish spoilage were observed from the different packaging materials (cartons, basins and baskets) used during marketing while pesticide called ‘’Otapiapia’’ reduced the occurrence of insect attack on fish. In conclusion, in order to increase availability of fish, improvement on current traditional handling, preservation/processing and advertising practices must be done. Recommendations include fishing time was suggested to be reduced to the barest minimum because it will ensure that early fish caught remain in good condition and fish should be handled properly on board. Also, provision of storage facilities should be made available in the fishing villages. This study failed to calculate losses for each fish species but summed everything together, which is not according to the loss model.

According to Cheke and Ward (1998), the model was planned for the purpose of assessing interventions designed with the objective to decrease post-harvest fish losses in Tanzania. This study revealed past research that have been conducted on losses at certain stages of fishery, which occur due to spoilage or after drying leading to losses of trawler by-catch in India. Modelling method used is a novel for fishery systems. The model concentrates on physical and quality losses, which happen to be the most important types of fish loss. The model was established to test the results of different possible decisions as primary step to address the problems involved such as introduction of cold storage facilities in cost-benefit analysis of possible involvements in fisheries.

The drive of the model is to assess whether such involvements are valuable and proffer solutions for fisheries authorities to be adopted or recommended to policy makers. Research revealed that modelling a particular fish industry for example the effects of losses at the processing phase on value of the total losses could be imitated. With this, it will help the policy makers to know whether precise interventions might improve or not the economy of the fishery industry. Also, the model will help to derive information on loss assessment on each stage along the chain or effects of losses on smaller scales. The model classifies what occurs to fish from time of capture to different stages involved until it gets to final phase as follows:

Fishing → Landing → Processing → Wholesale storage → Retail storage

The model used data on the weight of the fish (W) entering each stage. At the beginning of the first stage is the catch weight (C) which reduced by physical lost weight (PL) and weight sold off due to spoilage at reduced prices at each stage (SRP) and monetary losses (ML) are calculated by summation. To estimate the values of fish, the actual price per weight (AP) at landing and the best price achievable at each stage (CSBP) are needed with data on reduced prices (RP) and quantity sold at a reduced price. MATHCAD software was used to programme the model for generality, flexibility and expansion. Decay rates estimate and possible interventions e.g. duration of fish in ice, time which fish stayed and temperature in each stage were included.

A model of Nile Perch *(Lates niloticus*) fisheries at Lake Victoria, Tanzania was presented. Main focus of this model is to identify how fresh Nile Perch is processed, transported and marketed. The high value fish is the Nile perch fisheries which data on losses were only available for fishing, processing, storage and transportation stages. The model constructed includes only stages with adequate information. Data used by Ward was collected on monthly basis for duration of two years and focuses on physical losses as a result of discard fish and wastage and financial losses due to quality changes and reduced price of sales of low quality fish. Losses were calculated based on different fishing gears (gill nets, beach seine nets and long lines) used and means of transportation (rail and air). Results showed that fish caught from beach seine nets are frequently much fresher and of good quality than those caught with gill nets and long lines. Also, losses from air transportation are minimal compared to rail transportation. Use of beach seine is suggested for Nile perch due to cost-effectiveness and transportation by air to reduce losses.

Enujiugha and Nwanna (1998) study was on impact of post-harvest handling practices and processing methods on demand and supply of *Clarias gariepinus* and *Oreochromis niloticus*. Findings revealed that over 20 percent of the two fish species harvested were lost due to inadequate handling practices and processing methods. Likewise, Mndeme (1998) also worked on post-harvest fish losses in Lake Victoria and Mafia Island in Tanzania while Gitonga (1998) also carried out study on Nile perch in Lake Victoria in Kenyan waters. It was discovered that fish processing into smoked and salted forms reduced losses to barest level. According to Gitonga (1998) findings, total landings constituted 60 percent Nile perch in the Kenyan waters of Lake Victoria. Fisher folks such as fishermen, traders and processors were faced by post-harvest fish losses of Nile perch. Report indicated that high rate of losses occurred during rainy season. Causes of high losses of Nile perch were infestation of blowfly larvae, fragmentation and bacteria deterioration. Ward et al. (1998) stated that small-scale fishermen in India suffer high level of post-harvest fish losses and more research is required on the issue.

Research on prevention of post-harvest fish losses in Iceland and creation of realistic model in Malaysia was carried out by Nor (2004). The study focused on applying model used to prevent losses in Iceland to improve issues faced by fisheries sector in Kuantan and Malaysia as a whole. The result of this study is to come out with a tool, which will be useful to stakeholders in decision making towards reduction of post-harvest fish economic losses. Kuantan is a district fishery centre, situated in the East Coast, Malaysia in Pahang State. It signifies management of fishery model based on handling practices, fish species and fishing boats sizes. It has a big landing complex which handles over 50 thousand fish tonnes yearly which is equivalent to 33 percent of total fish catch in the State (Nor, 2004). Pahan State denotes 17 percent of the total fish landing out of 11 states in Peninsular, Malaysia (DOFM, 2003). Artificial concrete equipments were shared by the Government along the coastal areas to prevent abuse and safeguard spawning area. Nor (2004) stated that contribution of agriculture to GDP is 14 percent while fisheries contribution to agriculture is 4 percent. Nevertheless, agriculture contributes 15 percent to Iceland GDP which fisheries contribution account to 13 percent.

Fish handling practices and facilities used in Kuantan are in good state. Boats used are well insulated with iceboxes, which keeps fish in good condition. Five fish species were selected for the basis of this study. The weight of each species was collected to get total weight of fish species and weight losses were noted for each species. Squid and Mackerel give high losses score, which shows that they are sensitive to post-harvest losses. Also, fish caught using trawler have high losses and handling practices during fish landing gives high post-harvest fish losses. Result shows that Kuantan is not critical in reduction of post-harvest fish losses and improvement plan will be specified. Overall analysis shows that handling practices on landing site have prospective for development if post-harvest fish losses can be reduced. Delay in unloading of fish catch can expose fish to environment, which is not favourable and leads to fish losses. Suggestions were made to develop model for losses reduction, which include good boat planning to ensure freshness of fish, on shore preparation delay leads to higher fish quality, change people's ideas towards new technology to reduce losses and good handling techniques. Improvement on post-harvest losses reduction will help to ensure food security, good hygienic food for export, nation building by providing job opportunities and increase GDP for fisheries and agriculture sectors. Conclusion state that if this model used is imbibed in Malaysia, many improvements will be achieved in the fisheries sector.

Jeeva et al. (2007) assessed post-harvest losses at different marketing channels in Inland fisheries sector in India. The study was carried out in five field centres and respondents used were selected using simple random sampling and stratified random sampling techniques. Structured interview was used to collect data at weekly intervals from the respondents. Result shows that percentage losses at packaging point, pre-processing points, processing points, wholesale markets, retail markets, vendor point and transportation centres were 0.29, 0.19 to 1.57, 0.15 to 0.54, 1.42 to 10.98, 2.96, 4.10 to 5.52 and 2.22 respectively. Causes of post-harvest fish losses identified in the study include poor handling practices during unloading of fish, fish spoilage due to lack of ice, spoilage due to poor transportation system and market losses as a result of lack of demand. Similar findings from Ward and Jeffries (2000) stated that inadequate preservation and processing methods, poor marketing system, lack of good handling methods and poor transportation system causes losses. Measures identified to reduce post-harvest fish losses include good hygiene practices, good storage facilities, provision of ice, provision of infrastructural facilities, good transportation system and effective packaging materials. If these measures are put in place, peoples nutritional requirements will be met and provision of foreign exchange earnings. These two studies focused on marketing stage and not landing site.

Moreover, Srinath et al. (2008) investigated the harvest and post-harvest losses in marine fisheries in India. Loss was measured by spoilage, physical loss which affects the quantity of marine fish available for consumption. Stages for estimation of post-harvest losses include landing sites, pre-processing, processing and various marketing levels. Selection of samples through the stages was done using stratified random sampling. Findings revealed that in the traditional fishing sector, losses were due to low value fish and juveniles of sardine oil landed for animal feed manufacturing, in motorized sector was as a result of juvenile discard and spoilage due to lack of ice for preservation. Losses occur in pre-processing, processing and marketing due to inappropriate icing, exposure of fish to sun, lack of storage facilities and poor transportation network. Post-harvest losses were calculated based on quantitative estimate to be 14.26 percent. Post-harvest losses are caused by lack of infrastructural facilities such as storage facilities, packaging materials, transportation system and lack of ice. Similarly, proper hygiene state should be employed by fishermen, processors and marketers to reduce post-harvest losses. The gap of this study is that it fails to calculate loss of fish species differently.

Another study on post-harvest losses of sardine (*Rastrineobola argentea*) in Lake Victoria known as dagaa was done by Mgawe (2009) which was evaluated during fishing, handling, processing and transportation to the market using three approaches of field testing fish loss assessment methods; IFLAM, LT and QLAM in the study area. IFLAM can be defined as qualitative approach centred on rapid, interview in form of rural appraisal and field observation. LT is a method that deals with biometric i.e. measurement of weight of losses along the chain while QLAM involves questionnaires administered to fishermen, processors and marketers. Dagaa helps to increase the net revenue benefits and is processed in the rural villages. The fish constitute of nutrients that provides good health to the people. Result from the assessment conducted indicated that losses both physical and quality are on the high side of about 5 percent and 27 percent of the total price respectively. Physical loss as a result of weight is about 3,660 tonnes of dried dagaa. Despite the total production of dagaa, which is around 177, 200 tonnes yearly within 2006 to 2008, the fishery industry is faced with serious loss. Recommendation was made based on provision of infrastructural facilities to prevent physical and quality loss of dagaa in the area. This study failed to calculate the financial loss incurred by the fishermen to know if the amount loss is huge.

Furthermore, Ibengwe and Kristofersson (2010) worked on how to reduce post-harvest losses of the artisanal dagaa (*Rastrineobola Argentea*) fishery in Lake Victoria Tanzania. Dagaa fishery is related with high level of 59 percent physical and quality losses. The main purpose of this study is to recommend strategy for cost effective management for reduction of dagaa post-harvest loss in the area. Cost and benefit analysis was done to see if adoption of drying dagaa will bring about reduction of post-harvest loss. Analysis was set for two groups i.e. private (individual) and public (Government) for 500 fishers. The analysis focused on assessment of all possible dagaa losses, cost reduction of losses, benefits attached to loss reduction, cost evaluation and benefits for determination of net benefit and Net Present Value (NPV) and sensitivity analysis. Analysis shows a positive NPV for drying racks project. As a result of this, suggestions were made for its implementation in Tanzania for reduction of post-harvest loss dagaa. During sensitivity analysis, result shows that sales price changes can affect NPV whereas cost of implementation and investment changes has no effect on NPV. Findings showed that drying on ground would lead to 59 percent post-harvest losses while drying using racks gives post-harvest losses of 30 percent. Usage of drying racks will increase production level, profitability and improve fishers' livelihood as well as increase foreign exchange earnings to the government.

Analytical review and synthesis on post-harvest losses in Africa using Mozambique as a case study was carried out by Cugala et al. (2012). Mozambique is a country blessed with freshwater and marine fishery resources. The fisheries sector contributes about 4 percent to the GDP. Several literatures were reviewed by the authors to identify the methodologies used to assess post-harvest fish losses, identification of the causes of post-harvest fish losses, establish the degree of post-harvest fish losses and generate action strategies for reduction of post-harvest losses. Equally, Adegbola et al. (2012) also conducted a similar research using Benin as a case study but findings revealed that there is no appropriate study on magnitude of post-harvest fish losses except investigations on fish preservation and storage innovations. This shows that information regarding fish losses is still deficient and should be investigated in the future. Effort needs to be intensified to assess the existing and develop new skills to reduce post-harvest fish losses.

A case study was conducted by Wilson and Zitha (2007) as quoted by Cugala et al. (2012) on impact of beach seining on economic, social and environment in Mozambique. The extensively used capture technique in the country is beach seining and Mponha and Petane villages in Nampula region were selected for the study. Beach seine owners, crews, boat builders, net makers and traders were interviewed. Fishing activities were observed, survey on household benefit and measurement of seines were included in data collection. About 70 – 90 percent of income of household is accounted by beach seining. Estimate of average fish losses incurred by fishermen ranges from 600 – 900 kg which is equivalent to 39 – 58 percent as a result of beach seine used as fishing gear. Information on causes of losses were lacking while findings noted the likelihood of losses after capture to be due to poor handling practices, inadequate of lack of good storage and transportation system. Substantial fish losses are expected to occur during handling due to lack of ice and know cold system for storage of fresh fish. Due to various species of fish, need for fish mapping to produce figures of post-harvest losses, which are fair. Based on review, it was discovered that data on post-harvest losses is poor and there exist gaps in several information that needs to be completed. Also, strategies to reduce losses should be put in place for innovations evaluation.

Studies carried out by Hassan et al., (2013) on shelf life of traditionally smoked shrimp products produced and post-harvest loss in Bangladesh. The aim is to explore the qualitative and quantifiable losses of smoked shrimp in different storage form, estimate the shelf-life of smoked shrimp and proffer recommendations for sustainable smoked shrimp trading. For this study, samples of smoked shrimp were collected from three different locations namely Batikhali, Khorule and Shibbari. Sensory quality loss was assessed using quality loss index model. It was used to calculate percentage quality loss of smoked shrimp at various stages of the channel. From the result, qualitative loss in shrimp was 5.8 percent while quantitative loss majorly occurs in storage (18.7 percent) and marketing stages (7.9 percent) which give a total of 30 percent quantitative loss in smoked shrimp. It was observed that the storage time increased the moisture and ash content of traditionally smoked shrimp while storage time decreased the protein and lipid content significantly. After storage of 75 days, Total Volatile Basic Nitrogen (TVB-N) value exceeded 30mg TVB-N/100g of smoked shrimp, which shows deterioration. Hogla bag, which is used to store shrimp, only had 2.5 months of shelf life after which the product was banned. Total bacteria count was calculated on the basis of International Commission on Microbiological Specifications for Foods method. Recommendations was made for improving smoked shrimp product include plastic bags and polythene for proper preservation while training on manufacturing of kiln from locally available materials should be done. Similarly, construction of smoking kiln by using local materials will help to produce high quality smoked shrimp.

Research on effects of post-harvest handling on quality and sensory attributes of sardines using Musoma district in Tanzania as a case study by Nguvava (2013). The main purpose of this study was to evaluate the effect of post-harvest handling of sardines and impact on quality and sensory qualities on finished product. Cross-sectional data was used for data collection and laboratory examination respectively.

For this survey, information was collected from ninety-three (93) respondents to achieve the objectives. Variables measured include fishing practices (fishing equipment), storage practices, estimate of post-harvest fish losses through weight of fish harvested (kg), weight of spoilt fish (kg), processing methods, packaging technique and means of transportation. From the data analysis, unhygienic handling practices, improper cleaning of fishing equipment, inadequate sanitation programme, poor storage facilities, insufficient drying time, poor packaging and poor means of transportation system as the factors contributing to spoilage. Result of laboratory analysis of salt on nutritional composition of dried sardines using both improved and traditional method showed comparatively low microbiological count (3.75-5.02 Log CFU/g) to (4.24-6.13 Log CFU/g). Sensory evaluation result shows that there is no significant difference between improved and commercial sardines in relations of colour, smell, taste and general acceptability. Dried sardines using improved method had higher nutrient contents, higher drying rates, shorter drying time and good quality products than the traditional method ones. As a result of this, improved drying method developed is recommended to fish processors to ensure good quality of final products and reduction of post-harvest fish losses.

Another study on post-harvest losses was in Kenya. It was carried out by Mungai (2014) on assessment of post-harvest losses of Nile Perch (Lates niloticus) incurred by fishermen from Lake Victoria, Kenya. The researcher stated that one major challenges facing Kenya, Uganda and Tanzania (East African states) is the problem of post-harvest fish losses. The objective of this study was meant to estimate the extent of Nile Perch losses as a result of spoilage experienced by fishermen. This was carried out by making comparison between gillnet and long line fishing of Nile perch.

Variables measured include handling practices such as use of ice on-board, covering of fish in the boat, arranging of fish in different compartments in the boat and not stepping on fish in boat; duration of fishing cycle during fishing, physical and quality loss.

Questionnaire Loss Assessment Method (QLAM) was used for collection of data from fishermen on landing of Nile perch fish. Purposive sampling method was used to select eight landing sites along the lake and losses were calculated for 15 days. SPSS version 16 was used for data analysis. Result shows that fishermen prefer gillnets more than long lines. From the Pearson's Correlation result, it shows that the length of fishing cycle determines level of post-harvest losses. T-test result comparing losses between long line and gill net used by fishermen in a fishing cycle shows no significant difference. Similarly, it was discovered that higher losses of 71 percent occurs from long line fishermen as associated to long line fishermen with 27.1 percent losses. Findings, post-harvest losses account to 31 percent along the production chain where 12.1 percent was as a result of quality losses and 18.9 percent as a result of physical losses. Recommendations made was for the fishermen to reduce the fishing cycle length to decrease post-harvest losses, use of ice on board should be encouraged to maintain the freshness of the fish and fishermen should be trained on appropriate fish handling practices. Suggestions stated that more research still needs to be carried out in the aspect of post-harvest fish losses. The gap of this study is that the loss assessment method was not used as proposed by Ward and Jeffries (2000) and Diei-Ouadi and Mgawe, (2010).

Another study on post-harvest loss in Bangladesh was done by Nowsad et al. (2015). The study was on assessing post-harvest loss of wet fish: a sensory indicator assessment using novel approach based. The purpose of this study was to use tool for sensory based assessment to measure the value of wet-fish loss. Four different fish species which include rohu *Labeo rohita*; Ilish *Tenualosa ilisha*, catfish *Pangasius sutchi* and tilapia *Oreochromis niloticus* in various stages of distribution chains were assessed for the study. Standardized point data for sensory quality deficiency with consistent factors of bacteriological and biochemical quality through estimation of interval centred on regression analysis was used. Findings revealed higher value of R^2 goodness of fit which shows that regression model is highly fitted for all the fishes tested with estimated regression coefficients which is highly significant ($p<0.01$). Fish quality loss recorded was 7-16 percent in four major consumed fish in the study area. Assessment shows that quality loss of fish does not take place during handling by the fishermen or landing sites but majorly during transportation from fish agents and higher loss (10 - 19 percent) at vendors' phase due to end-point of the distribution channel.

The research of Olusegun and Matthew (2016) concentrated on assessment of fish post-harvest losses in Tagwai Lake, Niger state, Nigeria. Six sites were selected for this study and structured questionnaires were designed to target losses at each section of the chain (handling, processing and marketing). Questionnaires were administered to fisher folks (handling losses), fish processors (fish processing losses) and fish mongers (fish marketing losses) in the distribution channel. For calculation of post-harvest fish losses, weight of fish (kg), total number of species caught, weight of injured fish (kg) and weight of spoilt fish (kg) were used. Data was analysed using one-way analysis of variance and correlation analysis. The result shows higher level of significant value of loss percentages (number and weight) of post-harvest fish during processing than before processing. This shows that fish are not properly handled before processing. Percentage post-harvest fish loss in number and weight were calculated using average fish weight (kg), total number of species caught and total weight of fish caught (kg). Results indicated that 53.34 percent losses in weight occur along the chain from landing, marketing, after processing and before processing. Findings revealed that poor handling practices by the fishermen led to high fish spoilage in number and weight at the landing sites and displaying of fish in an unhygienic environment amidst swarm of flies. Recommendation was made to improve the existing traditional handling, processing and marketing practices to improve availability of fish and more research on losses should be encouraged. Likewise, time of fishing with obtainable fishing gears should be reduced and not surpass 12 hours prior to checking. If this could be done, fish caught early will be in outstanding state at checking. Additionally, fish should be handled on board efficiently by gutting, washing and storing in clean boxes or containers. This study fails to calculate losses per fish species as stated by Diei-Ouadi and Mgawe (2010) loss assessment manual. Also, the financial losses was not stated which is a major variable for calculating percentage losses.

Another study was carried out by Sivagnanam (2016) on how to evaluate and assess economic losses with respect to inadequate infrastructural post-harvest facilities for fisheries sector in Tamil Nadu, India. The study area is one of the area behind fisheries development in the country. The main objective of this study is to assess the post-harvest infrastructure facilities, suggest policy actions and identify infrastructures needed to eliminate post-harvest fish losses. Three fishing points were selected and wholesalers, processors and retailers were audience for the study. Questionnaire loss assessment method was used for assessing losses in the fish marketing chain. For the purpose of this study, stakeholders were contacted for collection of data needed. Due to cost implication, sampling sites used for this study were restricted and picked based on top position. Result revealed that technique for handling of fish and duration of fishing time from point of capture to the final destination determines fish products nutritionally. Also, where fish is stored determines the quality of fish and selling price. Post-harvest fish losses estimate due to lack of infrastructural facilities is 15 percent. Findings revealed that time taken for fishing was between 6 to 8 hours and icebox was the container used for fish preservation. Fishers use ice for preservation of fish on board and staking was done during hauling of net. This helps to prevent fish spoilage while unwanted species were used for fish meal or sold at a lesser price. Gill net used by fishermen indicates that fish struggles in the net and require adequate handling to prevent losses while hook and line used for fishing still attracts good fish price because fish freshness still stays longer compared to hill and trawl net fishing. Suggestions include upgrading of landing sites with washing facilities to ensure good hygienic fish condition and provision of ice blocks for effective fish preservation at the landing site.

Study of Somanje (2016) on assessment of profitability and post-harvest fish losses along value chain in Baroste floodplain, Zambia. The research applied analysis of gross margin, used Ward and Jeffries method to determine post-harvest fish loss and multiple linear regression to assess causes influencing fish losses. 359 respondents was used for the study and male dominated fishing business in the study area. The result of the study shows that higher losses occur at the processing point while financial loss incurred is more by the fish traders. Also, factors affecting profitability were identified as age, material price, transport price, labour price and capital price.

The study shows that fishing activities is viable. Post-harvest fish losses at trader's point are affected by capital price, age and form of sold fish. The findings stated that capacity building could enhance profitability in management of variable cost and price to guarantee profit growth. Markets of high value should be targeted to increase profitability. Findings of the study stated that fish losses could be reduced through suitable handling approach and processing techniques. The author indicated that there is still need for further study on assessing elements affecting profitability and post-harvest fish losses of fishers and processors.

Research on assessment of fish post-harvest losses in Tekeze dam and Lake Hashenge fishery associations, Northern Ethiopia was carried out by Tesfay and Teferi (2017). The research was carried out to recommend a management approach to decrease post-harvest losses faced by Tekeze dam and Lake Hashenge fishery. The objectives was to identify and measure the type and extent of fish losses faced by the fishery, reasons for fish post-harvest fish losses, assess the attitude and knowledge towards post-harvest fish losses, relate and detect the position of post-harvest fish losses between two water bodies and propose plans for reducing post-harvest fish losses. The study was conducted in two water bodies of Tigray, Northern Ethiopia (Tekeze dam and Lake Hashenge). Tekeze dam is a dam on Tekeze river which is used to supply hydroelectric power. Primary and secondary data was used for this study. Questionnaire Loss Assessment Method (QLAM) was administered to 254 fisher folks out of 302 legal fisher folks. Secondary data used include annual reports and fisheries documents. Observation and discussion with fishermen were used for other information regarding fisheries activities and estimation of spoilt fish losses to the nearest kg. In Tekeze dam, Nile tilapia (*Oreochromis niloticus*), catfish and barbus species were dominant while In Lake Hashenge, the fish species were common carp (*Cyprinus carpio*) and Nile tilapia (*Oreochromis niloticus*).

Data were analysed using descriptive statistics of the explanatory variable using SPSS 16 software. Central tendency such as mean, percentages and frequency were used to represent the result. Findings show that out of 8 associations surveyed, each contained refrigerator and boat with diverse number of nets. Findings shows that almost 95 percent of the fisher folks were males, about 35 percent of them were educated to grade 5 – 8 while 24.3 percent of them are within the age ranges of 20 – 24 years followed by 15.3 percent within 30 – 34 years. Moreover, significant and positive correlation was found between total members of each association and number of boats and owned refrigerator $r = 0.806$, $df = 6$, $p < 0.05$) and ($r = 0.863$, $df = 6$, $p < 0.01$), respectively. Likewise, there is a significant correlation between the yield per year and losses per year with number of boats and yield per year ($r = 0.786$, $df = 6$, $p < 0.05$) and ($r = 0.948$, $df = 6$, $p < 0.01$), respectively. Significantly positive correlation occurred between ($r = 0.938$, $df = 6$, $p < 0.01$) number of refrigerators and number of boats owned.

Result shows that 42.9 percent claimed that the proportion of fish catch that spoils before landing is 1 jerry can out of 10 jerry cans. 46.5 percent stated that 1 – 3 kg out of one sack is lost due to fish load damaged upon reaching the market. Around 52 percent stated that they incur losses especially during storage while almost 30 percent stated that they incur losses during fresh fish handling. Findings shows that 35.8 percent fisher folks store their processed fish for 2 weeks before sending to the market. About 93 percent said they are faced with post-harvest fish losses. Almost 80 percent stated that they have incurred losses due to submerged nettings or sudden fell down of vessels from boat. Respondents (74 percent) indicated that they do not throw fish into the lake before landing as a result of spoilage. 84.3 percent of the fisher folks claimed that they do not get lower price due to low fish quality. From observation and discussion with the respondents, causes of post-harvest fish losses include lack of infrastructure facilities such as refrigerators shortage, transportation system and power fluctuations; late hauling of nets causes fish spoilage, distance and high temperature. Six-point likert scale was used to analyse value statement in the study area. About 68 percent of respondents strongly agree to long hours of settling gear before hauling as one of the causes of post-harvest fish losses.

Almost 65 percent of respondents had fixed times for setting, checking and hauling of their fishing nets. It was discovered that about 80 percent of the respondents do not have practical training relating to fish handling and quality. 66.1 percent of the respondents kept their fish cool during processing by using shading area (under tree or under cave) or using woods and clothes while during transport, 54.3 percent kept their fish cool during transport by putting in the jerry cans and covering them with sack. From observations, data from respondents and secondary data, it was revealed that post-harvest fish losses was significantly higher in Tekeze dam than Lake Hashenge ($t = -3.947$, $df = 6$, $p < 0.01$). The reason is because temperature is relatively high in Tekeze dam and this accelerates fish spoilage causing high post-harvest fish losses while in Lake Hashenge losses was as a result of prolonged to hauling of fish nets. Almost 99 percent of the respondents do not use ice in fish after harvest or before they reach the store. All of them do not use chemicals to maintain quality of fish and do not make use of any fish preservation technique except refrigerator in the study area. In conclusion, serious post-harvest fish losses occurred due to poor handling practices, storage and management problems. This simply indicates that good handling practices and processing is supreme. To ensure reduction of post-harvest fish losses, better fish handling practices, processing facilities, preservation techniques and good transportation systems must be provided in small-scale fisheries. The study did not consider the financial losses aspect.

2.9 The Strength, Weakness and Literature Gaps of Past Studies Reviewed

Based on several literatures reviewed, it has been discovered that technology development and strategies to lessen post-harvest fish losses have become an issue of priority for all fisheries sector of the world. The problem of post-harvest fish losses have become more complicated compared to before due to seasonal factors, fish species, handling practices, storage system, processing technique and transportation system. Urgency to lessen post-harvest fish losses have become paramount due to limited world fish stocks in order to ensure sustainability and best use of available fish resources (Mungai, 2014; Sivagnanam, 2016; Tesfay & Teferi, 2017).

Several reports from funding agencies and international institutes stated that among all food commodities, small-scale fisheries have the highest losses, which requires intervention. Reducing economic losses in fisheries sector due to lack/insufficient infrastructural facilities is vital to the sector in order to meet high demand of fish (Sivagnanam, 2016). Similarly, Ahmed, (2008) and Mungai, (2014) indicated that quantitative loss assessment of the problem must first be identified to reduce post-harvest fish losses. The challenges faced by fisheries researchers are how to quantify post-harvest fish loss and what type of fish loss. Difficulties encountered include different fish species, seasons, fishing gears used, inaccessible and countless fishing communities.

To address the issue of post-harvest fish losses at each fishing chain, Ward developed a tool for estimating of fish losses with collaboration of FAO in West Africa and authorized it for usage in many Asian and African countries, which focuses on loss assessment problem. Appropriate use of this loss assessment tool by fisheries researchers have not been properly used has directed.

According to Eyo (1997), the study quantified losses at the fishers, processors and marketing stages. Different variables was measured under handling practices such as fishing gears used, duration of setting and hauling of fishing net and quantity of spoilt while variables used under processing and marketing include weight of fish before and after processing. Despite using the sensory assessment to identify fish loss, the study failed to calculate losses for each fish separately. Cheke and Ward (1998) further designed model for loss intervention and recommend suitable policies for fisheries authorities. The model put into consideration different stages involved from fishing to marketing point and identified the important data that needs to be collected to run the model effectively in order to achieve its goal. Nor (2004) study simply focused on application of model to reduce losses and proffer solutions to problem faced by the fisheries sector. The model was used to identify the problem faced by the small-scale fisheries and improvements that will be achieved if this model is incorporated to the fisheries sector. Furthermore, Srinath et al. (2008) study investigated losses using quantitiave approach and causes were identified. The study failed to calculate losses of different fish species separately. Mgawe (2009) assessed losses using the three loss assessment methods (IFLARM, QLAM and LT). Quality losses were calculated but the study failed to put into consideration financial losses incurred by the fishermen. Cugala et al. (2012) evaluated losses suffered by fishermen through the use of beach seine and suggested that more research still need to be carried to address the issue of fish losses. The study failed to calculate financial losses but put into considereation fish losses in terms of weight. Also, Mungai (2014) use QLAM for loss assessment and handling practices was used as one of the important variables to be considered in loss assessment. However, the study evaluated losses in terms of weight and different fishing gears used in the study area but the loss assessment method was not used accordingly as stated by Ward and Jeffries (2000).

Diei-Ouadi and Mgawe (2011) opine that the magnitude of post-harvest loss has not been ascertained and recommended a guide, which was developed, by Ward and Jeffries (2000) to assess post-harvest fish loss to solve the problem, which is also similar with TECA fish loss model. Olusegun and Matthew (2016) carried out a research on post-harvest fish losses in Tagwai Lake, Niger Delta, Nigeria but failed to use the proper loss assessment method tools during the survey. Also, the survey did not take into account the financial loss aspect which is very important because it will provide more understanding about the monetary loss regarding quality fish loss and the fishers will be willing to adopt new handling practices and use of ice to help their fishing business. The survey fails to address the issue of different fish species by not stating the fish species caught and their losses individually. Equally, Somanje (2016) opine that less data still exist in the aspect of post-harvest fish losses and factors influencing fish losses.

According to Wibowo et al. (2016) posited that post-harvest fish loss needs to be assessed and updated because the loss figures are based on estimation which have been in use years back. Therefore, assessment and update of post-harvest fish loss is necessary to provide better understanding and information for causes of fish loss and loss reduction intervention. Also, fish loss update will also help to provide data on landed fish catch.

In addition, most of the studies reviewed have not been able to use the appropriate methods and measurement that would quantify post-harvest fish losses; handling practices used among small-scale fishermen and causes of losses have not been addressed properly. Lack of systematic tools for assessing and proper understanding of post-harvest fish losses for secondary stakeholders is deficient which makes interventions and implementation difficult. The identified gaps above has made this study suitable and well-timed to use data that are realistic and full methodology to assess the extent of post-harvest fish losses and causes of losses in small-scale fisheries. This would be a major input to literature mainly in the study area and fisheries sector in the country.

2.10 Summary

From the literatures reviewed, distribution chain in small-scale/artisanal fisheries sector include capturing (handling), processing, storage, transportation and marketing. Findings show that estimate of fish loss at the landing site stated was based on report of several years back. Meanwhile, the actual amount of losses presently at the landing site is not known and if truly such losses occur at that point. This is due to absence of correct quantitative data on levels of fish loss. Attempt to estimate the magnitude of losses in the small-scale fisheries sector is yet to be ascertained due to inaccessible fishing communities and different fish species.

As a result of these, there is need for further study on post-harvest fish losses at the landing site to assess the causes, magnitude and proffer ways of reducing it. Most of the articles on post-harvest losses are majorly extension guide-revealing ways by which losses can be assessed while empirical studies are lacking on post-harvest fish losses in Nigeria. Based on this, the study will fill the gap by providing empirical figures and accurate data to solve the issue of post-harvest fish losses in Nigeria. For adequate planning strategies towards reduction of losses, data on the extent of fish losses is significant. By solving this problem, food security, fishers' livelihood, reduction on fish importation and foreign exchange earnings will be improved. As a result of this, there is need to assess post-harvest losses at the landing site among fishermen in the small-scale/artisanal fisheries sector.

CHAPTER THREE

METHODOLOGY

3.1 Introduction

This chapter focuses on the methods adopted in estimating the magnitude of post-harvest fish losses from the fishing grounds to the landing sites and causes of post-harvest fish losses for urgent interventions. This section includes discussion on the research framework, hypotheses to be tested, measurement of variables, study population and sample size, source of data and the method of data analysis. The chapter is prepared into 9 sections. Section 3.1 consists of the introduction part. Theoretical framework is discussed in the Section 3.2. Section 3.3 discussed the definition of the variables while Section 3.4 presents the hypothesis development. Section 3.5 describes the study area, collection of data and sample size that was used for this research. Unit of analysis, total population and sampling technique that was used for this study were presented in this section. Research instrument is discussed in Section 3.6. Details of each item of research variables to be measured in the questionnaire are presented in the section and formula for validity and reliability checking. In Section 3.7, measurement of variables is stated. Section 3.8 explains the validity and reliability of research instrument. Data analysis technique to be used is described in Section 3.9 while multivariate assumptions test were discussed in Section 3.10. Section 3.11 summarizes the whole chapter.

3.2 Conceptual Framework

This section reveals the key issues detected during review of post-harvest losses. It has been discovered that the main problem facing the artisanal fisheries sector is the issue of post-harvest losses. Based on the literatures reviewed, it is discovered that post-harvest fish losses is at the extreme at the landing site but the extent of losses and causes are yet to be known, as a result of this, intervention becomes difficult towards food security and livelihood of artisanal fisher folks.

Furthermore, this research focuses on estimation of post-harvest fish losses at the landing sites, observing the handling practices used by the fishermen from the fishing grounds to the landing sites and identifying the causes of post-harvest fish losses in order to suggest adequate technology for quick intervention. This study employs the use of post-harvest fish loss schematic description by Ward (1996), Cheke and Ward (1998), Mungai (2014) and Olusegun and Matthew (2016). According to Nowsad et al. (2015) findings, poor transportation system was seen as one of the variables for spoilage of fish resulting to post-harvest losses. Mungai (2014) and Olusegun and Matthew (2016) verdicts shows that poor handling practices is one of the important factor to be considered to assess post-harvest fish losses along the value chain. Good practices will definitely improve the quality of the fish and willingness to pay more by consumers, which result, to more profit for the fisher folks.

As explained in Figure 3.1, the research is based on the post-harvest losses at the landing site. The stages involved in answering the research questions raised include: estimating losses at the landing site, identifying causes of post-harvest fish loss at the landing site, examining the handling practices, storage facilities and transportation system used at the landing site to suggest interventions.

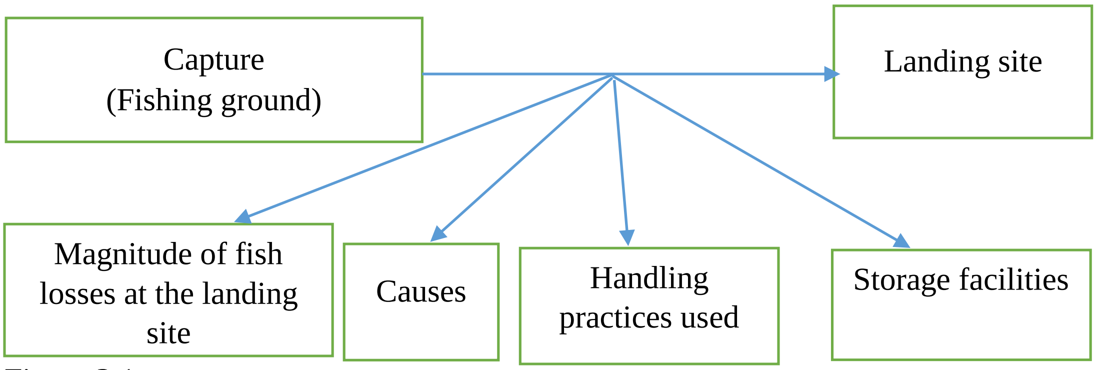

Figure 3.1
Schematic Distribution Channel from the Fishing Ground to the Landing Sites showing the Variables Measured
Source: Adopted from Cheke and Ward (1998)

Model planned by Cheke and Ward (1998) requires weight of fish (W) data moving into each phase. Catch weight (C) is noted at the beginning of the sequence, which decreases gradually due to quality loss weight (QL), and fish price of the good quality and reduced quality fish is noted. Estimation of losses in terms of financial/monetary is done by summarising all the losses. Therefore, for the purpose of this study since a single distribution chain is involve the model for percentage losses from capture to landing site is stated below and the framework is presented in Figure 3.2.

Financial loss in Nigerian Naira (N) = (Weight of low quality fish (kg)*price of good quality fish (N)) – (Weight of low quality fish (kg)*price of low quality fish (N))

Expected income (N) = Weight of fish captured (kg)*price of good quality fish (N)

Percentage losses = Financial loss/Expected income * 100

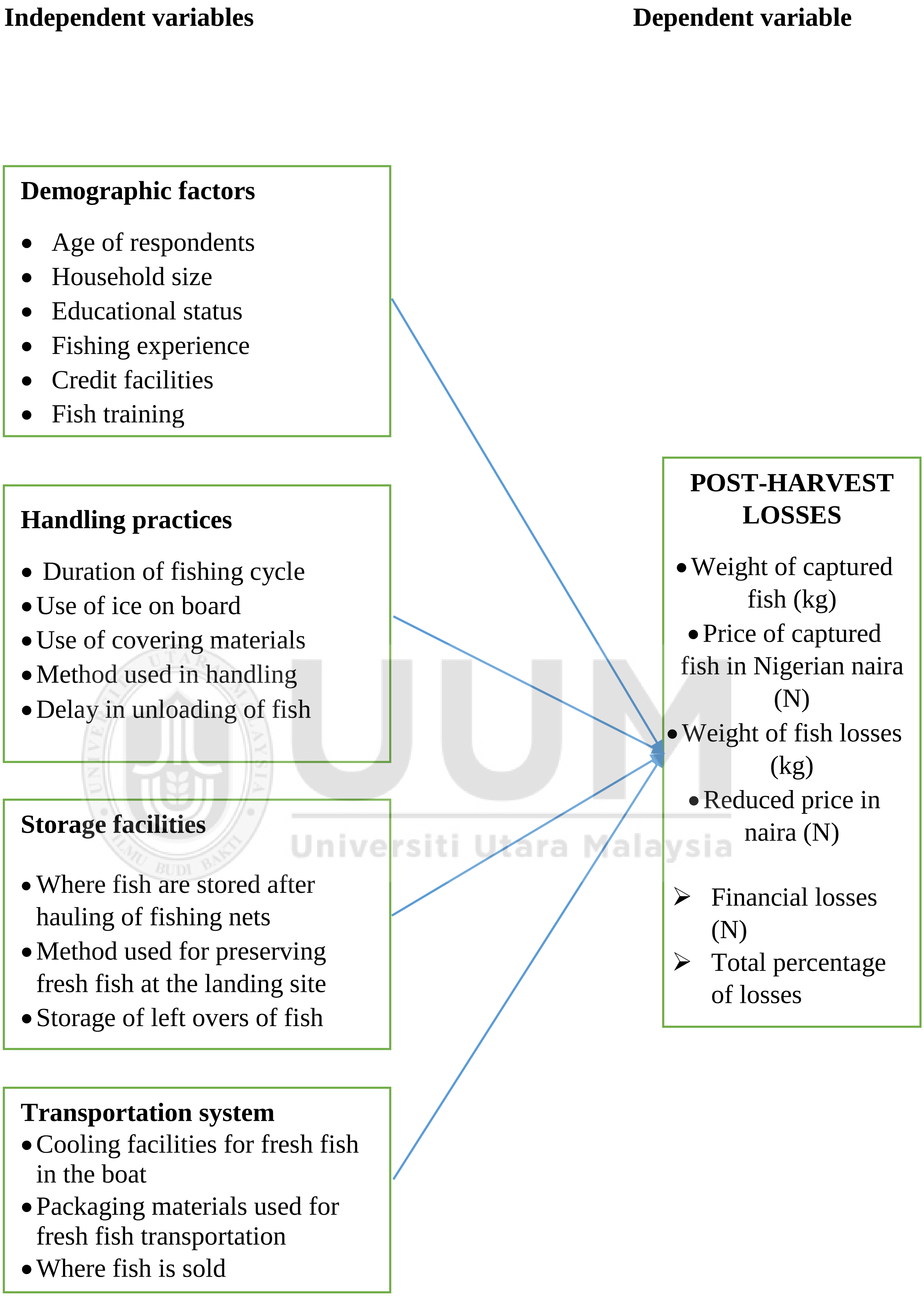

Figure 3.2
Conceptual Framework

From Figure 3.2, the conceptual framework shows that the study deals with relationship. Therefore, this study is a form of associate research. The main tool for analysis in this research is descriptive statistics, fish loss model (generic Predictive Model) and inferential statistics.

3.3 Definition of the Variables

3.3.1 Dependent Variable

According to Sekaran (2006), he stated that dependent variable can also be called criterion. It is the variable which the researcher is much concerned about. The objective of the researcher is to know and be able to explain the dependent variable very well. Understanding and investigating dependent variable will make it easier for the researcher to discover solutions to the problem of the study. The dependent variable is estimated in a mathematical equation while the input to that measurement is the independent variables.

Dependent variable for this study is the post-harvest fish losses. According to Cheke and Ward (1998) model, post-harvest fish losses was calculated on each stage of production but due to literature review which stated that high post-harvest fish losses occurs at the landing site, this research concentrated on fishermen at the landing site after arrival from the fishing ground to identify factors resulting to losses, handling practices used and calculate the extent of post-harvest fish losses. Post-harvest fish losses occur due to poor handling practices or spoilage along the distribution chain from capture until it gets to the consumers. Reduction of post-harvest fish losses will lead to increase in profit, which will improve the livelihood of the fisher folks and provide good quality of fish to consumers.

3.3.2 Independent Variables

An independent variable is a variable that is employed to determine the value of a dependent variable. It describes the purpose of independent variable as the one that influences the criterion either negatively or positively. Rise in independent variable can result to decrease or increase dependent variable (Sekaran, 2006). Independent variables that were used for this research include demographic factors, handling practices, storage facilities and transportation system. Demographic factors used include age, household size, fishing experience and educational level.

Based on literatures, majority of fishermen were discovered to have primary education while few have secondary education. This is as a result of rural areas which lack basic amenities including health facilities, electricity, good road network, schools and communication network. Odongkara and Kwangwa (2005) and Olusegun and Matthew (2016) opine that if fishermen have good education they will be knowledgeable to adopt good handling practices. Poor handling practices have been identified as the major factor influencing fish losses among small-scale/artisanal fishermen. Handling practices variables include use of ice, fishing cycle trip, facilities used for fresh fish, exposure of fish to sunlight and cleaning of fishing equipments (Odongkara and Kwangwa, 2005). Findings from Mungai (2014) indicated that period of fishing cycle is significantly correlated to financial losses. This simply shows that duration of fishing cycle influences post-harvest fish losses which simply implies that the higher the time spent on fishing cycle, the higher the fish losses.

Storage facilities (cold room or refrigerators) and transportation system were another factors highlighted by researchers which contributes to post-harvest fish losses. Poor storage facilities are serious problem facing small-scale fishermen. When large fish catch is caught, they find it difficult to preserve their fish as a result of lack of storage facilities and larger percentage of this catch is lost. Odongkara and Kwangwa (2005) opine that lack of good road network system also causes post-harvest fish losses during transportation of fish to the market. Diei-Ouadi and Mgawe (2011) stated that fishermen find it difficult to transport their fish product to the market and if eventually it is transported, higher percentage is spoilt due to bad roads which leads to disposal or sold at a reduced price.

To accomplish objective 1, Fish Loss Model (load tracking loss assessment method) as stated by Diei-Ouadi and Mgawe (2010) adapted from Ward and Jeffries (2000) with the help of University of Greenwich in collaboration with Food and Agricultural Organization (FAO) and Natural Research Institute (NRI) is used and the following data were collected at the landing site for the calculation of post-harvest fish losses; weight of captured fish (kg), price of good quality fish in Nigerian naira (N), weight of low quality fish (kg) and price of low quality fish in Nigerian naira (N). This model which has post-harvest fish losses as its dependent variable aims at predicting the factors that causes post-harvest fish losses among the small-scale/artisanal fishermen in the study area. Specific demographic variables of the respondents such as age, household size, educational level and fishing experience were included in the explanatory variables. Kabahenda, Omary and Husken (2009) and Diei-Ouadi and Mgawe (2011) opine that when fish are exposed without covering spoilage sets in quickly while Amos et al. (2007) is of the opinion that the longer the fish cycle, the higher the post-harvest fish losses. Mungai (2014) opine that proper handling of fish is very essential in order not to give room for fish spoilage. Storage facilities and transportation system are also factors that need to be considered in post-harvest fish losses.

3.4 Hypothesis Development

According to Akande and Diei-Ouadi (2010) and Nowsad (2010) opine that post-harvest fish losses may be influenced by demographic factors. Some of the demographic factors have been argued to have great impact on post-harvest fish losses. Equally, Addo, Osei, Mochiah, Bonsu, Choi and Kim (2015) indicates that demographic factors such as gender, age, educational level are possible factors to be considered in determination of loss level. Age of fishermen is likely to determine their strength and efficiency used in the fishing activities while educational level helps them to adopt new technologies that will be beneficial to their business. Based on this, the subsequent null hypothesis is formulated:

Hypothesis 1. There is no significant relationship among the demographic factors such as age, educational level, household size and fishing experience with percentage fish losses (croaker, catfish and shrimp).

Post-harvest fish losses which is the dependent variable is also influenced by several contributing factors such as handling, storage and transportation (Rahman, Hossain, Rahman & Alam, 2009). Fish losses can be affected by distance from the fishing ground to the landing site or time taken to get to the market. Nowsad (2010) stated that the quality/freshness of fish is affected by the market distance if fish is sold fresh. The distance length determines the quality of fish while packaging form is affected by method of transportation and time to get to the market. According to Akande and Diei-Ouadi, (2010) posited that packaging of fish is a serious factor that needs to be considered during transportation of fish especially processed fish because it may leads to breakage or skin injury on the fish or accumulation of heat and becomes susceptible to spoilage.

According to Tesfay and Teferi, (2017) storage facilities is very important from production level till it gets to the consumer while Diei-Ouadi and Mgawe (2011) opine that fish spoilage sets in whether ice is used or not over time. If fresh fish is stored in ice container on-board, it keeps the fresh fish in good condition before arrival at the landing site. Ward and Jeffries, (2000) argued that unsuitable processing technique and lack of transportation system as factors influencing fish losses especially for processed fish. Equally, Getu et al. (2015) discovered that fish losses occur during processing, storage and transportation stages while findings of Olusegun and Matthew (2016) posited that processing and marketing stages contributed to post-harvest losses.

In summary, studies majorly emphasize on variables such as duration of fishing cycle, use of ice containers for proper storage of fresh fish on board, use of covering materials from the fishing ground to the landing site and type of packaging method used on board for storing fresh fish during transportation of fish as possible factors that can influence fresh fish losses while unsuitable processing technique, lack of storage facilities for placing processed fish and lack of transportation or mode of packaging as probable factors that can cause processed fish losses. The second objective provides the ground for formulating hypothesis 2 that is the relationship between the independent variables with dependent variable. The theoretical and empirical literature discussed the relationship between variables of handling practices, storage facilities and transportation system with post-harvest fish losses. Thus, the subsequent hypothesis is formulated:

Hypothesis 2: There is no significant relationship between handling practices, storage facilities and transportation system with percentage fish losses (croaker, catfish and shrimp).

3.5 Study Area, Population, Data Collection and Sample Size

3.5.1 Study Area

Ondo State

The coastal area of Ondo state is located on Latitude 50 50'N - 60 09'N and Longitude 40 45'E - 50 05'E. It is positioned in south-west of Nigeria and has coastline of about 180km from northwest to southeast course (Akinwumi, Akinwumi & Ogundahunsi, 2011). Ondo state is a maritime state due to longest coastline and one of the highest producers of fish in the country. Coastal area of the state is situated in Ilaje Local Government Area (ILGA) with around 50 communities living near the river which empty directly into the coast (Adebowale, Agunbiade & Olu-Owolabi, 2008). The local government is near southern part of the state and covers an area of about 1,318 km^2 and shares boundaries with Ese-Odo and Ikales LGAs in the north part; the Apoi and Arogbo Ijaws in the north-east; Ogun- Waterside LGA of Ogun state in the west; and also with the Itsekiris of Delta state near the eastern side, while towards the southern part is the Atlantic Ocean (Fapounda, 2005).

Back in the precolonial years, ILGA has the longest fishing olden times. The producers of fish are majorly located in the fishing communities beside the shoreline. The people are mostly Ilajes and the fishermen are usually males i.e. the male children and father, whereas their female children and wives engage in processing (Adeparusi, Ajibefun & Akeremale, 2003). Eighty percent of the local government is enclosed with flood plains, swamp and water but vegetation of white mangrove *Aucennia africana* and *Paspalum vaginatom* is found around the coastline. The flood plains are enclosed by *Eichornial crassipes* (water hyacinth) and *Typha*, *Avstralis* (Omotoso & Daramola, 2005). Motorized canoes, speedboats and paddled canoes are use for means of transportation.

Due to open access to the sea, fishing is the main occupation of the communities. It is considered as one of the significant fishing areas in the coast which have rich biodiversity that contains various grouping of shellfish (crabs, shrimps, lobster, cephalopoda and gastropods), fish, reptiles and other living organisms. Some of the people also involved in local gin (ogogoro), lumbering, mat making, trading, hunting, boat building and farming (Akinbote, 2016). Fishing communities along the coast include Aberoyo, Igho, Abereke, Ojumole, Udigun-Nla, Ikorigho, Aiyetoro, Jinrinwo, Araromi, Ogboti, Araromi sea-side, Enuamo, Okesiri, Erunna Ero etc as shown in Figure 3.3.

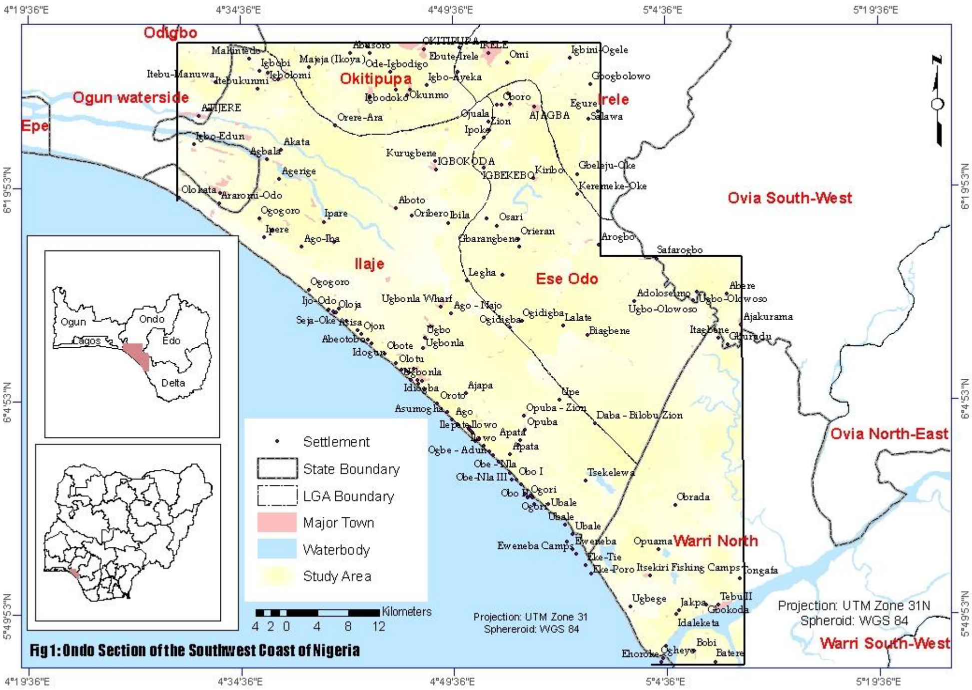

Figure 3.3
Map showing Fishing Communities along the Coastal Areas of Ondo State
Source: http://pubs.sciepub.com/ajrd/2/1/1/index.html

3.5.2 Data Collection Strategies

Quantitative method is used for this research to provide suitable evidence needed for this research. According to Ward, (1996), primary data is the best approach for adequate information for post-harvest losses. Equally, Diei-Ouadi and Mgawe, (2011) and FAO, (2011) stated that post-harvest fish loss assessment methodologies can be achieved using these three methods IFLAM (Informal Loss Assessment Method), LT (Load Tracking) and QLAM (Questionnaire Loss Assessment Method) developed by FAO and NRI under the Fish Loss Model.

Primary data was used for this study with the aid of questionnaire, which was distributed among fishermen from different fishing communities along the coast of Ondo State for this study. The questionnaire used was developed over a period of three months (from November, 2016 to January, 2017). Most of the questions used for the questionnaire were drawn from Kwangwa and Odongkara, (2005); Diei-Ouadi and Mgawe, (2011); Allou (2012); Singi et al. (2012); Nguvava, (2013); Mungai, (2014), Nowsad et al. (2015), Olusegun and Matthew (2016) and Tesfay and Teferi, (2017) studies.

Reconnaissance survey was conducted in the study area to detect the type of losses faced by fishermen and pay courtesy call to the traditional head to seek his permission for the study in his jurisdiction. Sampling frame was provided by the fisheries official in charge of the area for easy selection of respondents based on the population of the small-scale fishermen. The actual survey was carried out from March to July, 2017.

Discussions with the head of fishermen at the landing sites to get vital information on key issues faced by fishermen and post-harvest fish losses was achieved. This gave the fishermen opportunity to discuss important issues which are essential to their fishing operations and livelihood beyond the limits of the questionnaire. Observation checklist method was used which focused on pre-identified sociocultural practices and infrastructural facilities used by the fishermen. These include watching, recording and taking on-spot photographs. Fish loss model was used to quantify losses (financial) at the landing site. Data on total weight of each fish species (three dominant marine fish) (kg), weight of low quality fish (kg), price of good fish (naira) and price of low quality fish (naira) were collected. Secondary data was collected from Ondo State Agricultural Development Agency office, Department of Fisheries in Ministry of Agriculture and Natural Resources Development at both Federal and State levels for more detailed records needed for this research.

3.5.3 Research Instrument

In quantitative research, measurement becomes significant because it aids the connection between mathematical expression and empirical opinion. It also reports several statistics and numerical measurement (Salkind & Green, 2008). Questionnaire is a research instrument which contains different questions related to the objective of research for adequate information needed for the research. Before developing a questionnaire, all research variables must be reviewed first. According to Hadi (1986), before preparation of questionnaire, research variables must be well defined and interpreted. Reviewing all research variables is the first thing to do before developing a questionnaire and must be defined and translated into its constituent and indicator before making the questionnaire.

Questionnaire was administered based on one on one interview format. According to White, Jennings, Renwick and Barker, (2005), questions should be designed not to take more than 30 minutes to avoid non-response rates due to limited time by the fishermen. Mixed (open and closed) well-structured questionnaire format was developed and considered appropriate (Fowler, 2009; White *et al*, 2005). Open-ended questions were included to boost memory of interviewees to recall precise questions and rarely produced unpredicted insights (Huntinghton, 2000). It also gives room for the respondents to express their mind without restriction. Close-ended questions were used to exploit correctness of realistic information (Fowler, 2009; White *et al*, 2005; Gomm, 2004).

The questionnaire was developed over a period of three months during which it was tested on the fishermen in the study area. The questionnaire is presented in Appendix 1 and organized as follows:

Section A: Socio-demographic characteristics of fishermen: Age, gender, marital status, household size, education level, years of experience, other occupation aside fish processing, member of any fish association and source of capital was provided by the respondents.

Section B: Magnitude of post-harvest fish losses for three dominant fish species at the landing site was calculated using fish loss model, which took into account data of weight of the three fish species, price at which good fish is sold, weight of poor quality fish and price of poor quality fish.

Section C: This aspect is on causes of post-harvest fish losses. List of causes were highlighted for the respondent to rate accordingly based on 5-likert scale to know the level of severity of the items.

Section D: This aspect was on fish handling. Respondents provided information on duration of fishing cycle, type of boat used, forms of preservation used for fresh fish from fishing ground to landing site, access to ice on board, covering facilities used during on board and handling method used. Itemize various cleaning practices at the landing site were ticked as appropriate.

Section E: This section focuses on level of fish storage facilities. Questions on storage method used for fresh fish after hauling of fishing net from the fishing ground into the boat, storage method used at the landing site, what is done in case of spoilt fish, do you apply disinfectants before storage, where fresh fish are stored or sold immediately at the landing site and infrastructures available for fish storage were asked from the respondents.

Section F: This section focused on transportation of fresh fish. Type of packaging method used on board for transportation of fish from the fishing ground and at the landing site. Where fresh is sold, mode of transportation system if fresh fish is needed to be taken to the market, if cooling facilities were provided in transportation system and inquiries on losses incurred during transportation.

Section G: Suggestions of measures to be taken on how to solve post-harvest fish losses.

Pilot testing of questionnaire (35 small-scale fishermen) was conducted before commencing the real survey. According to Connelly (2008), opine that pilot study should be 10 percent of the projected sample for the main study. The purpose is to ensure that fishermen understand the context of the questions and provision of adequate data needed for the research. Changes are made afterward on the questions and wordings for easy understanding by the respondents. During the pilot testing, the fishermen were reluctant to provide necessary information needed for the study while some of them were away on fishing trips and on getting back were not interested to participate. To solve this problem, enumerators from the communities were employed to win the heart of the fishermen. Explanations on the questionnaire were discussed with the enumerators and the purpose of research. Also, reconnaissance survey was conducted in the study area to detect the type of losses faced by fishermen and pay courtesy call to the traditional head to seek his permission for the study in his jurisdiction. Sampling frame for accurate number of fishing communities along the coast and number of viable fishermen in each fishing community was provided by the fisheries official in charge of the area. The actual survey was carried out from March to July, 2017.

3.6 Sampling Technique

According to Bungin, (2006) sampling is the method of selection of elements from total population, which makes the sample to denote the population. However, generalization of results can be done back to the population where they were chosen. Since this research involves quantitative approach, probability sampling method (simple random sampling) was used. It is the sampling technique method that gives equal opportunity for every unit of the population to be selected (Sugiyono, 2006).

Krejcie and Morgan (1970) suggested how sample size should be collected. The authors ensure that decision size was made easy by providing a table that guarantees good decision model. Also, sampling design and sample size are considered in determination of sampling decision. Similarly, Sekaran (2006) stated that when a sample size is huge, that is over 500, it could become a problem by making relationships that are weak to be significant.

Unit analysis for this research is active fishermen in the fishing communities along the coast of Ondo State. This study was carried out in two sections for a period of 4 months in order to assess post-harvest fish losses along coastal areas of Ondo state. Multi-stage random sampling was used for the first stage of research. This sampling is restricted to a particular set of people that have the information required for the study (Sekaran & Bougie, 2009). Sample size of the study was determined using Krejcie and Morgan, (1990) table.

Based on reconnaissance survey carried out prior to the research work and sampling frame provided by fisheries officials in the area consisting of list of fishing communities and members of each of the communities that operate on open sea**;** population size of over 1,050 small-scale fishermen were discovered along the coastal areas of Ondo State. From Krejcie and Morgan (1990), a sample size of 278 was selected based on population size but it was increased by 50% to avoid non-responds bias as indicated by Salkind, (1997). This gives a total number of 420 small-scale fishermen that were interviewed for the research work from the sampling frame provided. Purposive sampling was used to select 20 viable fishing communities/landing sites out of over 30 fishing communities along the coast of Ondo State while simple random sampling was used to select active 21 fishermen from each fishing communities based on the sampling frame provided for the study. The questionnaires were administered to 420 fishermen through face to face who were chosen using simple random sampling. This sampling method gives room for equal selection and ensures that fishermen from each fishing communities are well represented.

However, data from only 400 respondents were used for final analysis due to uncompleted information provided by fishermen. Some fishermen were either too busy conducting sales, caring for their gears (fishing nets), were not patient enough to wait for the completion of the questions while some were not willing to participate. These affected their responses and were discarded due to grossly irregular information provided and incomplete information. This is in support with Hair, Black, Babin and Anderson (2010) who stated that case can be dropped were missing information is above 50 percent.

The second stage focused on calculation of magnitude of post-harvest fish losses along the coastal areas of Ondo State. This aspect was a bit challenging because of busy schedule of fishermen and their refusal to allow readings of fish loss (quality loss) due to time frame which may have adverse effect on their fresh fish; but with the intervention of the fisheries officials in the study area the work was made a bit easy. According to Diei-Ouadi and Mgawe (2011), it is very tough to involve all the respondents in a location in Load Tracking (LT) loss assessment method due to time, cost implications and nature of the data. A sample of respondents (25 – 30 percent) is normally selected for this biometric aspect, which represents the entire location. Random sampling method is used to detect potential respondents though not everyone chosen will be willing to take part in the activity and LT should be replicated from 12 to 20 fishing units for adequate data. As a result of this, 25 percent of targeted number of fishermen was used which gives a total of 105 but due to inadequate responses and unwillingness, 100 questionnaires were used for this aspect. Data on three (3) dominant marine fish species landed by fishermen were collected using Load Tracking (LT) method (Fish Loss Model).

Table 3.1
Sampling Frame

	Sampled fishing communities	**Fishermen's population**	**Targeted number of fishermen**
1	Ebijimi	28	21
2	Beku	26	21
3	Erun Ama	30	21
4	Ogungbeje	28	21
5	Ode-Etikan	30	21
6	Holy centre	27	21
7	Okesiri	34	21
8	Aiyetoro	37	21
9	Araromi seaside	30	21
10	Gbabijo	28	21
11	Awoye	35	21
12	Jinrinwo	27	21
13	Ajegunle	31	21
14	Abealala	29	21
15	Abeoroyo	30	21
16	Oberewoye	27	21
17	Abbereke	28	21
18	Ojumole	30	21
19	Ubale	29	21
20	Ilepete	28	21
	Total	**590**	**420**

Source: Field survey, 2017

3.6.1 Characteristics of small-scale fishers in Ondo State

Based on reconnaissance survey and information gathered, small-scale fishers in Ondo State operate on marine water body (open sea) through the use of wooden boat with outboard engine of 45-horse power. They make use of drift net as fishing gear because it is stationary (set net) and easy to capture fish without stress. The choice of fishing gear used by the small-scale fishermen was based on the fishing area. The fishermen interviewed operate on the marine water (open sea) and do not make use of hooks and lines or cast nets due to the high tide in the environment. The women and children in the households operate in the small rivers around the study area by using hooks and lines, traps and cast nets once they spot fish moving in schools for fishing. Women are not allowed to go into the open sea to carry out fishing activities. According to Akinwumi et al. (2011), opine that women generally use nets and traps to catch fish in most of the fishing communities in Nigeria. Furthermore, Adeleke, (2013) and Alhaji et al. (2015) stated that creeks and Atlantic Ocean are the main sources of small-sclae fishing in Ondo State. The females are majorly find in the lagoon (non-ocean) participating energetically while the males exploit the ocean for fishing.

Due to lack of electricity in the study area, fishers in the area do not use ice for preservation of their captured fish neither did they use any cooling mechanism. This is one of the major problem faced by the small-scale fishermen. Fishers opine that they cannot afford ice blocks and due to unsteady electricity, ice blocks are not available. From the observation, the fishing communities use homogenous facilities and gear for their fishing activities. Storage and transportation facilities are lacking in all the communities, which makes them to devise means of storing their fresh fish in order to maintain its quality based on this means of storage and transportation system is homogenous in nature. There is a storage facilities constructed by the government along the coastal area but the project was abandoned due to fund embezzlement. Early last month April, 2018, the government of Ondo State flags off construction of coastline road to link with other coastal states in order to ensure smooth transportation of fish products. According to Alhaji et al. (2015), studies show that small-scale fisheries sub-sector is faced with lack of modern fishing technologies, lack of cold storage facilities and poor road network system.

3.7 Measurement of Variables

For the purpose of this study, variables were measured using different scale such as nominal, interval and likert scale. The questionnaire used can be seen in appendix 1.

Table 3.2
Measurement of Variables

Variables Name/label	Description of Variables
Demographic factors of fishermen	
Age of fishermen (years)	This is a continuous variable and was measured in years (5 groups); ≤ 20, 21 – 30, 31 – 40, 41 – 50 and above 50 years.
Gender of fishermen	This is a categorical variable and measured as a dummy variable (dummy coding 2 groups); Male and Female
Marital status of fishermen	This is a categorical variable measured using dummy coding (4 groups); 1 - single, 2 - married, 3 - widow and 4 - divorced.
Religion of fishermen	This is a categorical variable measured as a dummy variable (3 groups); 1 - Christian, 2 - Islam and 3 - Traditional
Educational level of fishermen (Edu.)	This is a categorical variable measured by the number of years in school (4 groups); 1 - no formal education, 2 - primary education, 3 - secondary education and 4 - tertiary education
Household size of fishermen (HH size)	This is a continuous variable and measured using interval level (3 groups); ≤ 6, 6 – 10, above 10
Fishing experience of fishermen (Exp.)	This is a continuous variable and measured in years (5 groups); ≤ 10, 10 – 15, 16 – 20, 21 – 25 and above 25

Table 3.2 contd.

Other sources of income	This is a categorical variable (2 groups); yes and no
Member of fish association	This is a categorical variable (2 groups); yes and no
Access to credit facilities	This is a categorical variable (2 groups); yes and no
Any form of fish training	This is a categorical variable (2 groups); yes and no
Magnitude of post-harvest fish losses incurred by fishermen	
Weight of captured fish (kg)	This is a continuous variable and was measured in kilogrammes (5 groups); 10 - 20, 21 – 30, 31 – 40, 41 – 50 and above 50.
Best price of fish (Nigerian naira ₦)	This is a continuous variable and was measured in Nigerian Naira per fish species per kilogramme (3 groups); 100 – 300, 301 – 600 and above 600.
Expected income (Nigerian naira ₦)	This is a continuous variable and was measured in Nigerian Naira per fish species (5 groups); < 5,000, 5,000 – 10,000, 10,001 – 15,000, 15,001 – 20,000 and above 20,000.
Low quality fish (kg)	This is a continuous variable and was measured in kilogrammes (3 groups); < 6, 6 – 10 and above 10.
Price of low quality fish (Nigerian naira ₦)	This is a continuous variable and was measured in Nigerian Naira per fish species per kilogramme (4 groups); 50 – 100, 101 – 150, 151 – 200 and above 200
Financial losses (Nigerian naira ₦)	This is a continuous variable and was measured in Nigerian Naira per fish species (5 groups); < 500, 500 – 1,000, 1,001 – 1,500, 1,501 – 2,000 and above 2,000
Percentage losses	This is a continuous variable and was measured in percentage per fish species (4 groups); 1 – 5, 6 – 10, 11 – 15 and above 15
Handling practices	
Duration of fishing trip (hours) (DFT)	This is a continuous variable and was measured in hours per trip (5 groups) 10, 11, 13, 14 and 15 hours
Fishing trips/week	This is a continuous variable and was measured in days per week (3 groups); 4, 5 and 6
Types of fishing gear used	This is a categorical variable (3 groups); drift net, cast net and hooks and lines
Types of fishing boat used	This is a categorical variable (3 groups); plank boat, metal boat and aluminium boat

Table 3.2 contd.

Size of boat used (meter)	This is a continuous variable and was measured in meters (3 groups) < 7, 8 and 9
Did you use ice to preserve fresh fish?	This is a categorical variable (2 groups); yes and no
Other form of handling method used to preserve fresh fish	This is a categorical variable (3 groups); ice method, evaporative cooling method and covering of fish with sack/nylon
Are fish landed and offloaded without delay?	This is a categorical variable (2 groups); yes and no
Where is fresh fish placed at the landing site?	This is a categorical variable (3 groups); on the ground, plastic basin and woven basket
How do you sell your fresh fish at the landing site?	This is a categorical variable (3 groups); basket, hand and basket, per kilogram, hand and basket.
Left overs after sales at the landing site	This is a categorical variable (2 groups); yes and no
Variables of cleaning practices observed by the fishermen at the landing site	This is a categorical variable (2 groups); yes and no
Storage facilities	
Where is fresh fish stored after hauling of fishing net from the fishing ground to the landing site?	This is a categorical variable (4 groups); insulated box with ice, plastic basin, on tarpaulin and placed on the floor of the boat with the fishing net
What storage method is used or available to preserve fresh fish at the landing site?	This is a categorical variable (4 groups); insulated room, container with ice cubes, container with water covered with leaves and container with water covered with tarpaulin
What do you do in case of spoilt fresh fish?	This is a categorical variable (3 groups); discard the spoiled fresh fish, sold at a lesser price, smoke and sold at a lesser price and smoke
In case of left overs, how will you preserve your fresh fish after sales?	This is a categorical variable; smoke immediately and transported to the market
Distance from the landing site to the market?	This is a continuous variable and was measured in metres.
Do you apply disinfectants before fish storage?	This is a categorical variable (2 groups); yes and no
What influences the rate of spoilage of fresh fish from the fishing ground to the landing site?	This is a categorical variable (3 groups); time, excessive sunlight (high temperature) and poor handling of fishing net
Transportation facilities	
Provision for cooling facilities on board	This is a categorical variable
How do you transport your fresh fish from the fishing ground to the landing site?	This is a categorical variable (3 groups); in an open canoe, use of insulated container and use of iceboxes.

Table 3.2 contd.

Spoilage experienced during transportation	This is a categorical variable
Facilities used for fresh fish	This is a categorical variable (2 groups); container, container and basket
Where is the selling point for your fresh fish?	This is a categorical variable (2 groups); landing site or transport to the market
Suggestions	This is a categorical variable
Causes of post-harvest fish losses	This is a categorical variable and was measured using likert scale (5 options); strongly agree, agree, neutral, disagree and strongly disagree

3.8 Validity and Reliability of Research Instrument

There is need to verify questionnaire through validity and reliability test to ensure it is valid and reliable before use. When an instrument measures what is expected to be measured it is said to be valid while reliability simply means to test the level of uniformity of a particular item of the questionnaire by giving a consistent result over time when applied (Sekaran & Bougie, 2013; Kumar, Talib and Ramayah, 2013). Studies of Mueller (1986) reported that for an instrument to be considered valid, it has to possess content validity which refers to appropriateness of the content of research instrument.

Goodness of the test sample items to denote what the test is designed to measure is internal validity while external refers to validation in an empirical form. This is supported by empirical data about the variable and as a result of this; validation of the research instruments can be done (Hadi, 1986). However, in the perspective of this study, the research instrument is adapted from handling practices and post-harvest fish losses studies, which are previously well recognised for similar studies (Cavana, Delahaye & Sekaran, 2001). Research instruments was adopted from Ward and

Jeffries, (2000), Amos, (2007), Akande and Diei-Ouadi, (2011), Mungai (2014), Olussegun and Matthew, (2016) and Tesfay and Teferi, (2017)

The statistical instrument used to examine the validity of data is called Pearson's Product Moment Correlation (PPMC) (Sugiyono, 2006). The degree of validity is represented by correlation coefficient 'r'. When the 'r' value calculated is greater than 'r' table, the likert item is said to be valid. The 'r' table is 0.361 at 0.05 significant level (r >0.361). Reliability test was calculated using Cronbach's Alpha which should be greater than 0.60 and the purpose of the test is to examine consistency of the instrument to ensure it measures what it is supposed to measure (Bougie & Sekaran, 2009; Cavana et al., 2001; Sekaran & Bougie, 2013). From the reliability test carried out on the independent variables, Cronbach's Alpha values of the variables exceed 0.70 which indicated that all the variables of the study met the reliability criterion.

3.9 Data Analysis Technique

Data analysis for this research includes descriptive statistics (frequency and percentage), fish loss model (MS excel model) to calculate percentage losses, 5-likert scale to identify causes of post-harvest fish losses using Statistical Package for Social Sciences (SPSS) version 23 and inferential statistics using Stata 13.

3.9.1 Descriptive Statistics

Descriptive statistics is used for this research to present data obtained for improved understanding of the information, for simplicity and to show features of the sample (De Vaus, 2002). This is used for research objectives 1 and 2. Result for the research variables through the aid of questionnaire are presented in form of percentage, frequency, mean and standard error (Bungin, 2006). Mean is done for the aim of getting average of the sample which was generalized for the whole population. Eberly (2007) stated that descriptive statistics are used on a sample for the purpose of estimating features of a population. Measurement of features is often called variables.

3.9.2 Fish Loss Model/Predictive Model

This model is developed to handle data for single fish species rather than mixed catches where variation may occur in losses and prices according to fish species. Also, the model is planned to run single fish species and chain data at once. This model is used for objective 1. The model concentrates on the greatest vital post-harvest fish losses; quality losses which lead to financial losses and classifies what occurs to fish from capture time into a sequence of stages. It helps to present and connect loss data at diverse stages in a chain; also for researchers who which to identify the key losses and discover the effect of reduction of loss interventions at the different level and whole chain. Essential data which are necessary for the model include weight of poor quality fish, price of poor quality fish, price of good quality fish and weight of good fish. Fish Loss is planned for researchers or people who are concerned in post-harvest fish losses study. It helps to calculate the extent of losses, causes and areas where research has not been conducted (Cheke & Ward, 1998; Ward, 2000, teca.fao.org).

Loss assessment tools include Informal Loss Assessment Method (IFLAM), Load Tracking (LT) and Questionnaire Loss Assessment Method (QLAM). IFLAM is an exploration method used when researchers are ignorant of the problem; LT is used when there is awareness of the problem by doing descriptive assessment through identification and measurement while QLAM is used when the problem is noticeably defined and data on causes of losses are confirmed. Earlier to the study, series of research work have been carried out by Food and Agricultural Organization (FAO) and Natural Research Institute (NRI) of University of Greenwich, effort has been put in place to develop methodologies both systematic and practical assessment for generation of accurate data on post-harvest fish losses. Researchers who want to assess post-harvest fish losses in small-scale and industrialized fisheries community make use of this method. This will help to quantify losses at most parts of the landing, processing or distribution chain (Ames et al., 1991; Ward & Jeffries, 2000; Mgawe, 2009; Diei-Ouadi & Mgawe, 2011). The fish loss model can be used as stated;

Expected Income

The income expected at the landing site from landed fish during this period of study was calculated using the total weight of fish landed and selling price. The following formula was used (Rochester Institute of Technology, 2004; Ibengwe & Kristofersson, 2010 and Mungai, 2014):

$$\mathbf{E_{in} = T_w \times S_m}$$

Where: E_{in} was expected income of fish landed per catch per fish species at the landing site in Naira (₦)

T_w indicates the total weight of fish landed per fish species per catch at the landing site (kg)

S_m was the selling price of landed fish at the landing site in Naira (₦)

Total Percentage Losses

The percentage losses were calculated using actual total losses and expected income per respondent during the period of study. Poor quality fish is identified by colour of gills, scales, eyes and bad smell in the study area (Ibengwe & Kristofersson, 2010; Diei-Ouadi & Magawe, 2011). According to Mungai, (2014) and Somanje, (2016), the formula for calculating total percentage loss is as follows:

Financial losses = (Weight of low quality fish × Best Price) - (Weight of low quality fish × Reduced Price)

$$\text{Total percentage loss} = \frac{\text{Financial losses}}{\text{Expected income}} \times 100$$

3.9.3 Likert Scale Analysis

To determine the causes of post-harvest fish losses, a list of possible losses was compiled by the researcher and investigated under 5-point Likert-type with five response options: strongly agree = 5, agree = 4, neutral = 3, strongly disagree = 2 and disagree = 1. Mean score value was obtained and rated in accordance with Kessler (2006) as cited and used by Nenna and Ugwumba (2014). Any mean score that was equal to or higher 3.0 was perceived as a cause of post-harvest fish losses while mean score lower than 3.0 was perceived as not a cause of post-harvest fish losses.

3.9.4 Multiple Regression

Multiple regression is a statistical technique used to predict value of a variable based on the value of two or more variables (Hair et al., 2010; Kumar et al., 2013). The variable to be predicted is known as the dependent variable/criterion variable while the variables to be used to predict the dependent variable are called predictor or explanatory or independent variables. Multiple regression is used to determine the overall fit (variable explained) of the model and the relative contribution of each of the explanatory variables to the total variance. This is used to determine the effect of the independent variables (demographic factors, handling practices, storage facilities and transportation system) on the dependent variable (post-harvest fish losses). Therefore, the relationship among the variables of this study is used for the multiple regression analysis and modelled in the equation below. The model is as follows:

$Y = f(X_1, X_2, X_3, X_4, X_5, X_6, X_7, X_8, X_9, X_{10})$

$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 X_7 + \beta_8 X_8 + \beta_9 X_9 + \beta_{10} X_{10} + £$

Where:

Y – Percentage fish loss (computes croaker, catfish and shrimp)

β_0 - Constant

β_{1-10} - Coefficient of explanatory variables

X_1 - Age of respondent (years)

X_2 - Household size (HH size)

X_3 - Educational level (Edu)

X_4 - Fishing experience (years) (Exp)

X_5 - Credit facilities

X_6 – Form of fish training

X_7 – Duration of fishing cycle (hours) (DFC)

X_8 – Size of boat (meters)

X_9 - Storage (where fresh is placed after hauling of fishing net from the fishing ground) (ST)

X_{10} – Transportation system (type of facilities use for transportation of fresh fish) (TR)

£ - Error term

3.9.5 Data Sorting and Entry

According to Kumar et al. (2013), this procedure includes arranging, allocating values to collected data and data entry into statistical package for advance treatment. After successful completion of data collection, the questionnaires were sorted into useable and non-useable sets. This is an initial screening to ensure that questionnaires to be entered in the statistical package are useable. Hair et al. (2010) also recommended that were missing information is above 50 percent a case can be dropped. Afterward, each item under the variables were assigned a code and then keyed into SPSS software package for analysis. This is in line with Creswell (2014) who stated that all items in the research instrument should be coded during entry of data in other to make analysis easy. Thus, all items were correctly coded before data entry.

3.9.6 Missing Data

According to Hair et al (2010), missing data were data which were not made available due to missing information from the respondents. Missing data can occur in two ways either because of incomplete information provided by the respondents or through errors during entry of data. Missing data is a serious problem during analysis and can lead to inaccurate results. Questionnaires were vetted to ensure adequate completion of information by respondents. Then, some questionnaires with more than 50 percent unfinished information was dropped (Hair et al., 2010). Cases of minor missing data were identified with the use of descriptive statistics (frequency and percentages); afterward, to provide remedy for missing values mean replacement was done.

3.10 Multivariate Assumptions Test

Before analysis is carried out, multivariate assumptions test must be met. These assumptions include normality, linearity and multicollinearity. According to Hair et al. (2010), data for multivariate analysis must ensure that these assumptions test are not violated because any violations could lead to contrary effects on analysis of data and results. Thus, normality, homoscedasticity, linearity and multicollinearity tests were multivariate assumptions tests carried out.

3.10.1 Normality

Normality can be defined as statistical or graphical assessment of the degree to which collection of data conforms to a normal distribution (Hair et al., 2010). Skewness and kurtosis is used statistically to examine normality and the critical values are either ±2.58 or ±1.96 at 0.01 or 0.05 levels of significance respectively. Normality can also be examined graphically through the use of histogram, normal probability plot, steam-and-leaf plot and box plot.

3.10.2 Homoscedasticity

This is an assumption indicating that the dependent variable should show equal variance across various independent variables (Hair et al., 2010). This is used for variability assessment in variables scores. Heteroscedasticity is said to exist where exhibition of significant dispersion occur across the variables. To test assumption of equal variance among variables Levene test was used.

3.10.3 Linearity

Pearson product-momentum correlational (PPMC) analysis was used for this test. This studies the association among variables and it is important for multivariate analysis because any deviation could have effect on the correlation among the variables (Hair et al., 2010). According to Pallant (2007), the correlation values among the independent variables should not exceed 0.70. Similarly, Piaw (2012) stated that correlation coefficient of ±.91 to ±1 is very strong; ±.71 to ±.90 is strong; ±.51 to ±.70 is average; ±.31 to ±.50 is weak and correlation coefficient of ±.01 to ±.30 is very weak. Correlation values of r = 0.1 is considered to have a weak relationship, r = 0.3 have moderate association while strong association is considered to be r = 0.5 and above (Acock, 2014).

3.10.4 Multicollinearity

This examines the values of correlations between independent variables in a multi-regression model. Findings revealed that statistical power of a variable is reduced by multicollinearity (Hair et al., 2010). Multicollinearity test was conducted by using Pearson product-momentum correlational (PPMC) analysis. Similarly, variance and inflation factor (VIF) and tolerance were used for multicollinearity detection from the collinearity statistics. Rule of thumb by Hair et al. (2010) states that a variable with VIF value greater than 10 may worth more examination. Tolerance is well-defined as 1/VIF, is used to check on the degree of collinearity by many researchers. A tolerance value which is lower than 0.1 is comparable to a VIF of 10.

3.11 Summary

This chapter describes the methodology used for this study, data collection strategies, sampling technique and how data collected were treated. Cross sectional data via questionnaire was used for the study. Similarly, descriptive and multiple regression analysis were discussed in the chapter as the data analysis method used for this study. The next chapter provides the descriptive statistics and the results of data analysis used in the study.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Introduction

This chapter presents and discusses the respondents' demographic characteristics, how the magnitude of post-harvest fish losses was calculated along the coastal areas of Ondo state, handling practices used by the fishermen and causes of post-harvest fish losses. The chapter is classified into the following sections: Section 4.2 enumerates the demographic factors of the sampled respondents. This shows the frequency table, mean and standard deviation of the variables. Section 4.3 presents the results obtained from magnitude of post-harvest fish losses in form of bar-chart, mean and standard deviation. Section 4.4 describes the handling practices used during fishing, storage techniques and transportation method during fishing. Section 4.5 discusses the results on effect of handling practices, storage facilities and transportation system on post-harvest fish losses at the landing site. Causes of post-harvest fish losses were presented in Section 4.6. The outcomes of observations at the landing sites and discussion with heads of fishermen were presented in Section 4.7. Hypothesis of the study were presented in Section 4.8 while the summary of this chapter is presented in Section 4.9.

To review, the study used cross-sectional data collected through structured questionnaire administered to fishermen along the coastal areas of Ondo state of Nigeria. Ondo state is the coastal state with the longest coastline of about 180km in Nigeria. A total of 420 questionnaires were administered face to face out of which 400 are usable for the analyses due to incomplete information provided by the fishermen. In order to get the magnitude of post-harvest fish losses in the study area, 105 fishermen were simple randomly selected from the 420 interviewed fishermen due to the nature of data collected, time factor, accurate information and fishermen's work schedule but 100 questionnaires were found useable.

4.2 Demographic Characteristics of Respondents in the Study Area (n = 400)

This section focuses on the demographic characteristics of the fishermen. Table 4.1 presents the results of the descriptive statistics of the respondents' demographic factors. Frequency and percentage are used for the interpretation of the result for each variable while mean and standard deviation are provided for numeric values.

Table 4.1
Description Statistics for Demographic Factors of Respondents (N = 400)

Variables	Frequency	Percentage
Age (years)		
Less than 20	0	0.0
20 – 30	32	8.0
31 – 40	229	57.2
41 – 50	132	33.0
Above 50	7	1.8
Mean ± standard deviation (std.)	**38.60 ± 5.64**	
Sex		
Male	400	100.0
Female	0	0.0
Religion		
Christianity	400	100.0
Islam	0	0.0
Traditional	0	0.0
Marital status		
Single	5	1.3
Married	391	97.8
Divorced	1	0.3
Widowed	3	0.8
Tribe		
Hausa	0	0.0
Igbo	0	0.0
Yoruba	400	100.0
Household size		
Less than 6	108	27.0
6 – 10	288	72.0
Above 10	4	1.0
Mean ± std.	**6.45 ± 1.44**	

Table 4.1 contd.

Variables	Frequency	Percentage
Educational qualification		
No formal education	13	3.3
Primary education	144	36.0
Secondary education	243	60.7
Fishing experience (years)		
Less than 10	88	22.0
10 – 15	80	20.0
16 – 20	112	28.0
21 – 25	62	15.5
Above 25	58	14.5
Mean ± std.	**17.61 ± 6.82**	
Other sources of income aside fishing		
Yes	176	44.0
No	224	56.0
If yes, state other source of income		
Boat building	21	11.9
Farming	75	42.6
Repair of out-board engine	34	19.3
Tailoring	8	4.5
Transportation	38	21.6
Member of fish association group		
Yes	330	82.5
No	70	17.5
Access to credit facilities		
Yes	145	36.2
No	255	63.8
Any form of fish training		
Yes	372	93.0
No	93	7.0

Source: Field survey, 2017

As indicated in Table 4.1, all of the respondents were male adults aged between 20 to 50 years. Most (57.2 percent) of them fall within the age range of 31 – 40 years while small percentage were above 50 years. Mean age is 39 years from the findings. In order words, the results indicated that respondents were in their economical, productive and active age range. Fishers' age is very important due to difficulties in fishing operations, which takes hours and some have to go fishing at night. This finding coincide with the statement of Mungai (2014) that fishermen fall within the age bracket 21-45 years and needs to be agile due to stress involved in fishing business.

All (100 percent) the respondents were males, Christians and Yoruba speaking people by tribe. Based on the result, it shows that fishing is mainly done by males (100 percent) in the study area. Almost 98 percent of the fishermen were married which shows that they have more hands to assist in the fishing activities. Results showed that majority (72 percent) of respondents household size fall within the range of 6-10 people while the mean value is 7 people per household.

With respect to education, findings showed that majority (60.7 percent) of the respondents have secondary education, 36 percent have primary education while 3.3 percent have no formal education. Based on their educational status, it implies that fishermen will be willing to adopt new innovation of handling practices to improve their fishing activities. Also, fishermen with higher education tends to take high risk in fishing which may cause or reduce fish losses. According to Nguvava, (2013) educated personnel could use appropriate fish handling practices during fishing reducing post-harvest fish losses and quality improvement. The socio-demographic table indicates that 28 percent of the respondents have fishing experience within 16-20 years, 20 percent have below 10 years while the mean value indicates 17 years of fishing experience. This has important implication, because there is no doubt that years of fishing experience has influence on post-harvest fish losses due to the knowledge of fishing. Experience simply indicated that the longer fishermen have been into fishing activities, the more knowledge acquired to run the fishing business effectively and reduce post-harvest fish losses. About 56 percent of the respondents said they do not have any other source of income aside fishing while 44 percent said they have other sources of income. Majority (42.6 percent) of the respondents are into farming, 21.6 percent are into transportation business, 19.3 percent are engaging in repairing of out-board engine, 11.9 percent are into boat building while 4.5 percent are engaging in tailoring as other sources of income. Results showed that 82.5 percent of respondents belong to fishermen association group while 17.5 percent do not belong to any group. Despite being a member of fish association, the fishermen's association have not been benefiting from government assistance. This is because allocation released to them by the government do not get to the fishermen or part is being released to them. Fishermen are now encouraged to revive their cooperative in order to assist themselves. Majority (93 percent) of the fishermen indicated that they have one form of fish training by the fisheries officials while 7 percent do not have any form of fish training. This implies that fisheries officials occasionally organize training for the fishermen which is not effective according to the fishermen in the study area.

4.3 Magnitude of Post-harvest Fish Losses of Three (3) Dominant Marine Fish Species; Croaker (*Pseudotolithus spp.*) (Bowdich, 1825), Catfish (*Arius spp*.), (Valenciennes, 1840) and Shrimp (*Nematopalaemon spp.*) (Aurivillius, 1898) along Coastal Areas of Ondo State (n = 100) per catch per day

This section answers research objective one (1) of the study. Table 4.2 presents the magnitude of post-harvest fish losses of three (3) dominant marine fish species in the study area. Magnitude of post-harvest fish losses for each species was calculated using fish loss model. This model/load tracking loss assessment method was developed by Ward and Jeffries, (2000) in collaboration with Food and Agricultural Organization (FAO) and Natural Resources Institute (NRI) of the University of Greenwich for researchers that want to calculate fish losses in fish species and production chain.

Using the load tracking loss assessment method involves collection of essential data for calculation of fish losses. The formula for calculating total percentage losses is as follows:

$$\textbf{Percentage losses} = \frac{\text{Financial loss}}{\text{Expected income}} \times 100$$

Financial loss in Nigerian Naira (₦) = (Weight of low quality fish (kg) × Price of good quality fish (₦)) - (Weight of low quality fish (kg) × Price of low quality fish (₦))

Expected income in Nigerian naira (₦) = Total weight of fish landed at the landing site per catch per specie per day (kg) × Selling price of fish in Nigerian Naira (₦) per specie.

The landed fish by the fishermen was sorted in terms of freshness into best quality and low quality while the selling price and weight of each grade was captured. Based on observation, fishermen use colour and signs to distinguish between good and low quality fish. Signs such as bad smell as a result of spoilage and changes in colour of the gills, fish scales, eyes and texture were used for fish quality sensory assessment. Low quality fish is noted when the skin or fish flesh turns green in colour, appearance deteriorates and texture becomes soft and whitish. Also, the fish eyes becomes dull and gills turns brown or yellowish brown.

Table 4.2
Descriptive Statistics for Magnitude of Post-Harvest Fish Losses of Croaker, Catfish and Shrimp

Variables	Croaker		Catfish		Shrimp	
	Freq.	**%**	**Freq.**	**%**	**Freq.**	**%**
Weight of captured fish (kg) per catch per day						
10 – 20	10	10.0	13	13.0	16	16.0
21 – 30	26	26.0	24	24.0	20	20.0
31 – 40	32	32.0	29	29.0	26	26.0
41 – 50	19	19.0	16	16.0	20	20.0
Above 50	13	13.0	18	18.0	18	18.0
Mean ± std.	36.28 ± 12.3		36.15±13.52		37.27±13.70	
Best Price (₦)						
100 - 300	1	1.0	24	24.0	0	0.0
301 - 600	99	99.0	76	76.0	57	57.0
Above 600	0	0.0	0	0.0	43	43.0
Mean ± std.	370 ± 25.7		342.50±27.87		683±97.50	
Expected income (₦) per catch per day						
Below 5,000	3	3.0	5	5.0	0	0.0
5,000 – 10,000	20	20.0	30	30.0	5	5.0
10,001 – 15,000	43	43.0	36	36.0	16	16.0
15,001 – 20,000	24	24.0	23	23.0	14	14.0
Above 20,000	10	10.0	6	6.0	65	65.0
Mean ± std.	13,511.77± 4895.79		12,455.50±49 14.25		25,672±10,56 4.79	
Low quality fish (kg) per catch per day						
Below 6	50	50.0	88	88.0	84	84.0
6 – 10	48	48.0	12	2.0	16	16.0
Above 10	2	2.0	0	0.0	0	0.0
Mean ± std.	4.65± 2.14		4.02±1.61		3.81±1.84	
Reduced price of low quality fish (₦)						
50 – 100	1	1.0	43	43.0	1	1.0
101 – 150	20	20.0	55	55.0	11	11.0
151 – 200	61	61.0	2	2.0	55	55.0
Above 200	18	18.0	0	0.0	33	33.0
Mean ± std.	147.88±32.50		124±26.80		206.04±30.84	
Financial losses (naira) per catch per day						
Below 500	10	10.0	18	18.0	4	4.0
500 – 1000	59	59.0	56	56.0	14	14.0
1001 – 1500	20	20.0	19	19.0	27	27.0
1501 – 2000	7	7.0	7	7.0	22	22.0
Above 2000	4	4.0	0	0.0	33	33.0

Table 4.2 contd.

Variables	**Croaker**		**Catfish**		**Shrimp**	
	Freq.	**%**	**Freq.**	**%**	**Freq.**	**%**
Mean $\pm$ std.	1013.28$\pm$474.93		880.52$\pm$388.06		1,843$\pm$1045.06	
Percentage losses per catch per day						
1 – 5	27	27.0	34	34.0	28	28.0
6 – 10	51	51.0	45	45.0	53	53.0
11 – 15	17	17.0	17	17.0	17	17.0
Above 15	5	5.0	4	4.0	2	2.0
Mean $\pm$ std.	8.15$\pm$4.02		7.76$\pm$3.94		7.57$\pm$3.63	

Source: Field survey, 2017
U.S. $1 = ₦360 (₦ = Nigerian Naira currency)

The result from Table 4.2 shows that captured fish by fishermen falls within the weight of 31 to 40 kilogrammes (kg) for croaker (32 percent), catfish (29 percent) and shrimp (26 percent) respectively. The mean weight of captured fish gives 36.28 kg for croaker, 36.15kg for catfish and 37.27 for shrimp respectively. Majority of the fishermen (99 percent, 76 percent and 57 percent) sells their captured fish (croaker, catfish and shrimp) within the price range of ₦301 ($0.84) to ₦600 ($1.67) respectively. The mean price of fish is ₦370 ($1.03) per croaker, ₦342.50 ($0.95) per catfish and ₦683 ($1.89) per shrimp individually. About 43 percent and 36 percent fishermen stated that their expected income ranges within ₦10,001 ($27.78) to ₦15,000 ($41.66) from sales of croaker and catfish while 65 percent of fishermen states that above ₦20,000 ($55.55) is realised from sales of shrimp if fish are of good quality in the study area. Croaker mean income is ₦13,511.77 ($37.53), catfish mean income is ₦12,455.50 ($34.59) and shrimp income is ₦25,672 ($71.31) respectively. Around 50 percent, 88 percent and 84 percent of the fishermen experience low quality fish below 6 kg per catch per day of croaker, catfish and shrimp respectively.

Furthermore, about 61 percent and 55 percent of the fishermen sold their low quality fish (croaker and shrimp) at reduced price ranges between ₦151 ($0.42) to ₦200 ($0.55) while 55 percent of the fishermen sold low quality catfish at a reduced price between ₦101 ($0.28) to ₦150 ($0.42). Fishermen stated that for low quality of croaker and catfish, around 59 percent and 56 percent of them lose between the amount of ₦500 ($1.38) to ₦1,000 ($2.78) while 27 percent fishermen suffered financial loss between ₦1,001 ($2.78) to ₦1,500 ($4.17) on shrimp. Similarly, 22 percent of fishermen experienced financial losses between ₦1,501 ($4.17) to ₦2,000 ($5.55) of shrimp. The mean value for financial losses experienced by fishermen for croaker, catfish and shrimp is ₦1,013.28 ($2.81), ₦880.52 ($2.45) and ₦1,843 ($5.12) respectively. Overall, differences in the financial losses occur among the fish species. According to Siddique et al. (2014) opine that fish losses have adverse effect on the income derived. Equally, Adam et al. (2016) stated that level of post-harvest fish losses in the fishing communities determines the income level of the fishers.

From the findings, 27 percent, 34 percent and 28 percent of the fishermen experienced percentage losses per catch per day between 6 to 10 percent in croaker, catfish and shrimp species respectively while 27 percent, 34 percent and 28 percent of the fishermen experienced percentage losses between 1 to 5 percent. According to Akande and Diei-Ouadi (2010) posited that different losses occur in various fish species landed at the several landing sites in Uganda, Kenya and Tanzania. Likewise, Diei-Ouadi and Mgawe (2011) opine that greatness of post-harvest fish losses differs from one country to another due to fish prices, different fish species, fish handling practices and different percentage loss level in the landing site. Findings from this study highlighted that lack of ice boxes for proper storage of fresh fish on board after hauling of fishing net and unsuitable fish handling method are the causes of losses.

Results showed that percentage total losses per catch per day experienced by fishermen are 8.15 percent for croaker, 7.76 percent for catfish and 7.57 percent for shrimp. This implies that fish losses still occur at the landing site though not much in the study area. During discussion with the fishermen, they opine that they normally experience huge losses years back because they spend longer hours during fishing trip and this affected their income level. Presently, they have reduced their fishing trip to 11 to 14 hours maximum since they do not have access to ice blocks in order to protect their fish catch and cannot afford to keep losing their fresh fish after the stress and running cost such as fuel, lubricant, oil, maintenance and food for crew (₦11,020/$30.61 per trip per day) incurred during fishing trip. The fishermen claimed they are more knowledgeable in fishing activities and know when to set and hauling of fishing nets by studying the movements of the fishes and do not waste time to transport their fish from the fishing ground to the landing site. They also ensure that higher percentages of their catches are sold immediately at the landing site while the left overs are processed.

The Figures below presents the bar chart representation of the magnitude of post-harvest fish losses per catch per day.

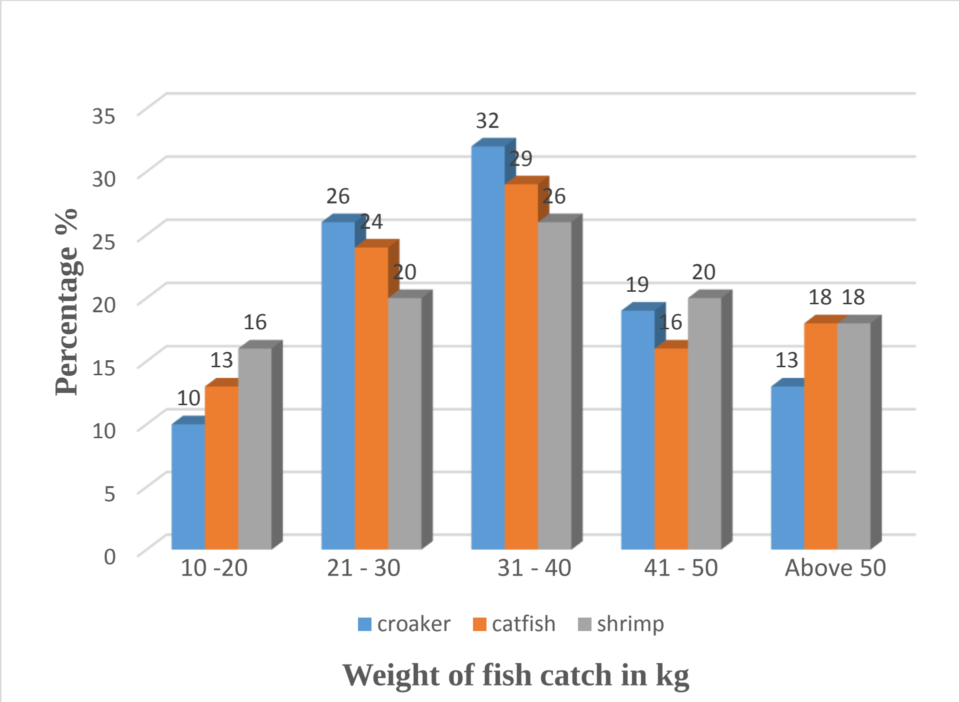

Figure 4.1
Bar Chart Representation of Weight of Captured Fish Species per Catch per Day in kg
Source: Field survey, 2017

Figure 4.1 indicated that 32 percent, 29 percent and 26 percent of the fishermen captured between 31- 40kg of croaker, catfish and shrimp respectively, 26 percent, 24 percent and 20 percent of fishermen captured between 21-30kg of croaker, catfish and shrimp respectively followed by 19 percent, 16 percent and 20 percent of the fishermen captured between 41-50kg of croaker, catfish and shrimp respectively.

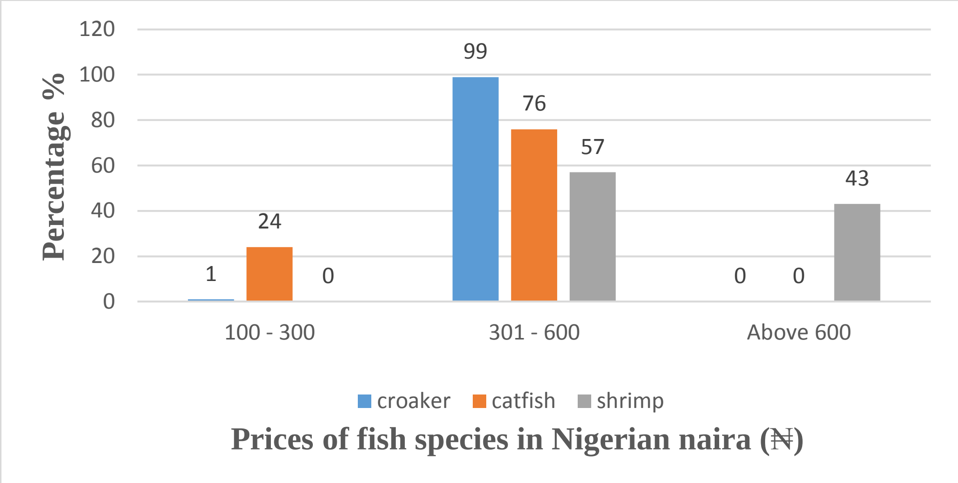

Figure 4.2
Bar Chart Representation of Prices at which Fish Species are sold in Nigerian Naira (₦)
Source: Field survey, 2017

Figure 4.2 presents the prices at which good quality fish species are sold. 99 percent, 76 percent and 57 percent of fishermen sold croaker, catfish and shrimp respectively between ₦301 ($0.84) to ₦600 ($1.67) while only 43 percent of the fishermen sold shrimp above ₦600 ($1.67).

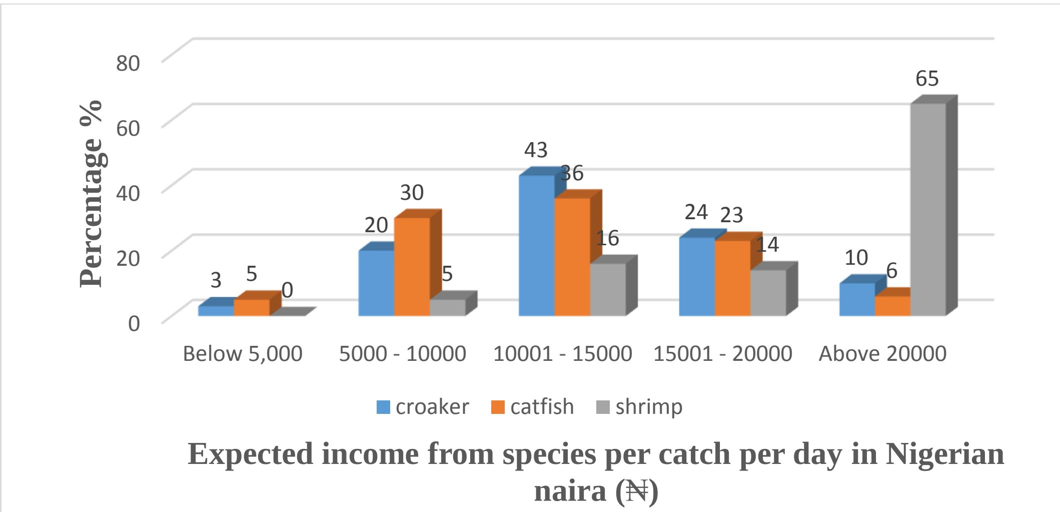

Figure 4 3
Bar Chart Representation of Expected Income from Fish Species per Catch per Day in Nigerian naira (₦)
Source: Field survey, 2017

Figure 4.3 showed that 43 percent, 36 percent and 16 percent of the fishermen stated that their expected income falls between ₦10,001 ($27.78) to ₦15,000 ($41.67), 30 percent, 20 percent and 5 percent of the fishermen indicated that their expected income falls between ₦5,000 ($13.89) to ₦10,000 ($27.78) while 24 percent, 23 percent and 14 percent falls between ₦15,001 ($41.67) to ₦20,000 ($55.56).

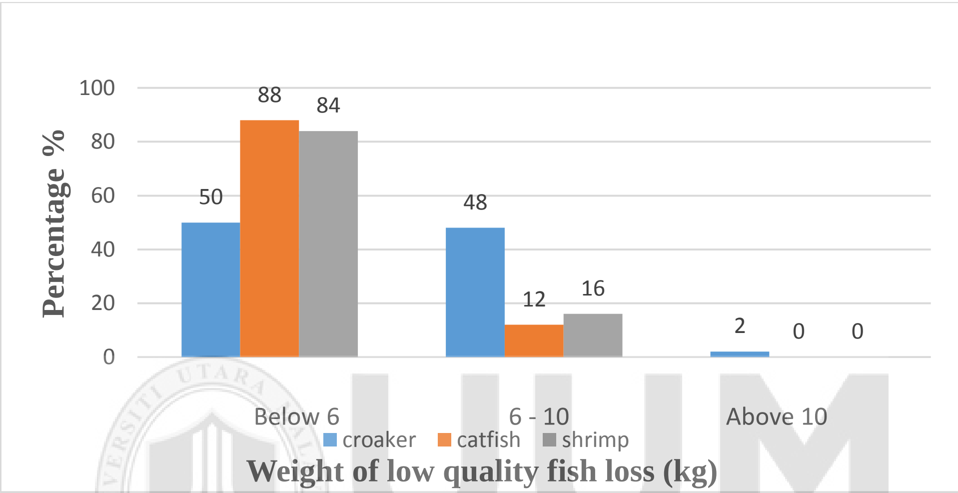

Figure 4.4
Bar Chart Representation of Weight of Low Quality Fish per Catch per Day in kg
Source: Field survey, 2017

Figure 4.4 indicated that 50 percent, 88 percent and 84 percent of fishermen experience poor quality fish loss below 6 kg of croaker, catfish and shrimp fish species respectively while 48 percent, 12 percent and 16 percent experienced poor quality fish loss between 6 to 10 kg of croaker, catfish and shrimp respectively.

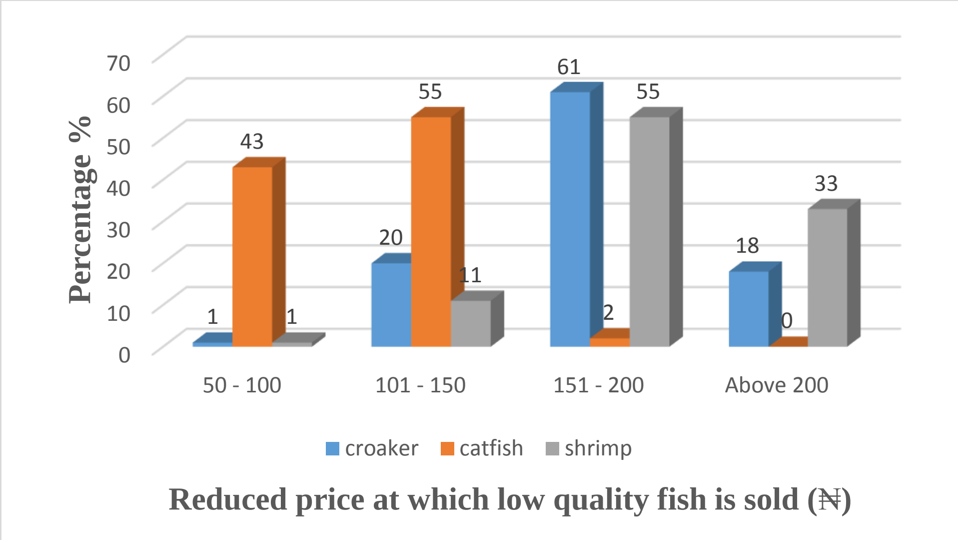

Figure 4.5
Bar Chart Representation of Reduced Price at which Low Quality Fish is sold in Nigerian naira (₦)
Source: Field survey, 2017

Figure 4.5 showed that 61 percent, 2 percent and 55 percent of the fishermen sold low quality fish (croaker, catfish and shrimp) between ₦151 ($0.42) to ₦200 ($0.56); 20 percent, 55 percent and 11 percent of the fishermen sold poor quality fish between ₦101 ($0.28) to ₦150 ($0.42) while 1 percent, 43 percent and 1 percent of the fishermen sold poor quality fish between ₦50 ($0.13) to ₦100 ($0.28) respectively.

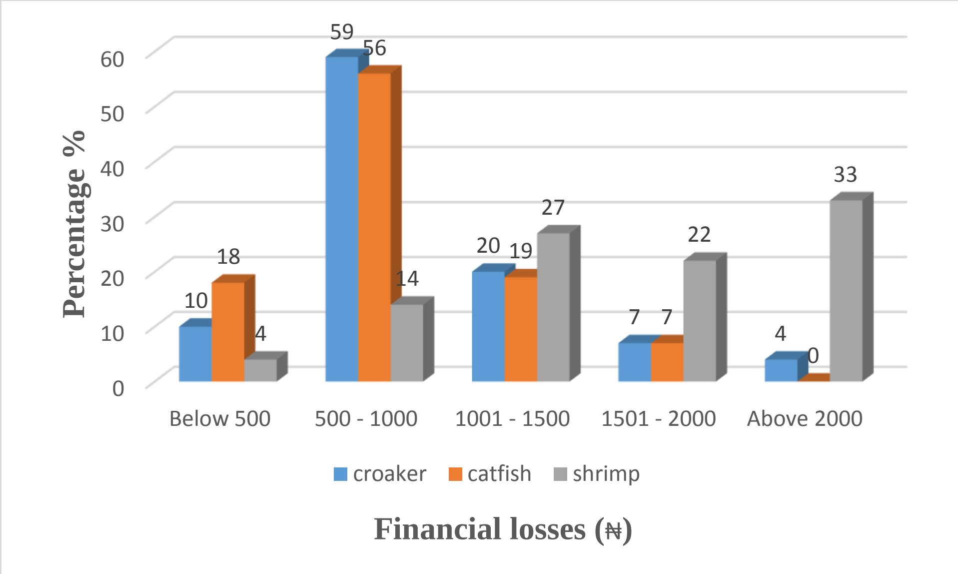

Figure 4.6
Bar Chart Representation of Financial Losses by Fishermen in Nigerian naira (₦)
Source: Field survey, 2017

Figure 4.6 indicated that 59 percent, 56 percent and 14 percent of fishermen experience financial loss between ₦500 ($1.39) to ₦1,000 ($2.78) from croaker, catfish and shrimp respectively while 20 percent, 19 percent and 27 percent of fishermen experience financial loss between ₦1,001 ($2.78) to ₦1,500 ($4.17) of croaker, catfish and shrimp respectively.

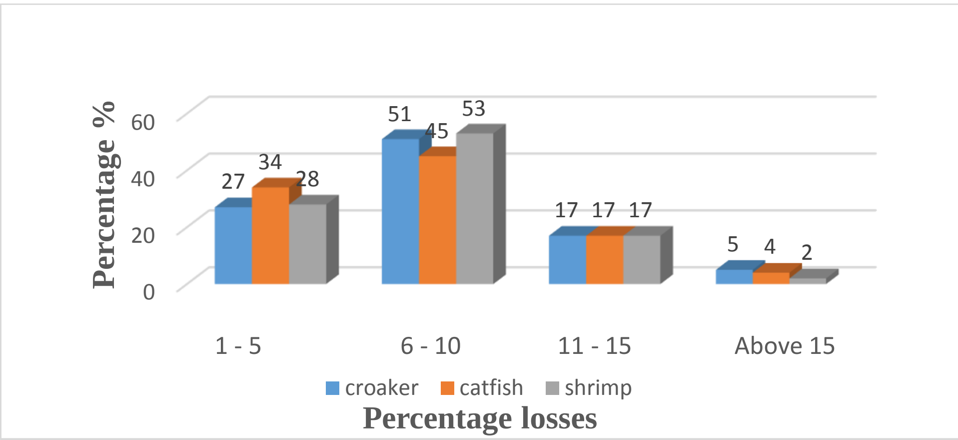

Figure 4.7
Bar Chart Representation of Percentage Losses for each Fish Species by Fishermen
Source: Field survey, 2017

Figure 4.7 revealed that 51 percent, 45 percent and 53 percent of fishermen experienced between 6 to 10 percent losses for croaker, catfish and shrimp respectively; 27 percent, 34 percent and 28 percent of fishermen experienced between 1 to 5 percent losses for croaker, catfish and shrimp respectively while 17 percent of the fishermen recorded between 11 to 15 percent losses for the three fish species respectively. Mean percentage losses for croaker, catfish and shrimp are 8.15, 7.76 and 7.57 percent respectively.

4.4 Handling Practices used at the Landing Sites

Various handling practices used by the fishermen at the landing site were discussed and the analysis also helped to answer the research questions posed in Chapter One. Table 4.3 presents the descriptive statistics results of the various handling practices used by the fishermen.

Table 4.3
Descriptive Statistics for Handling Practices used

Variables	Frequency	Percentage
Duration of fishing trip		
10 hours	13	3.3
11 hours	55	13.7
12 hours	176	44.0
13 hours	136	34.0
14 hours	20	5.0
Mean $\pm$ std.	**12.24 $\pm$ 0.87**	
Fishing trips/week		
4 times	46	11.5
5 times	254	63.5
6 times	100	25.0
Mean $\pm$ std.	**5.14 $\pm$ 0.63**	
Type of fishing gear used		
Drift net	400	100.0
Cast net	0	0.0
Hooks and lines	0	0.0
Types of fishing boat used		
Plank boat	400	100.0
Metal boat	0	0.0

Table 4.3 contd.

	Frequency	Percentage (%)
Aluminium boat	0	0.0
Size of boat used (meter)		
Less than 7	0	0.0
8 meters	43	10.8
9 meters	357	89.2
Do you make use of ice to preserve fresh fish?		
Yes	0	0.0
No	400	100.0
If no, state why		
No electricity	378	94.5
No ice	22	5.5
Other forms of method used to preserve fresh fish from the fishing ground to landing site		
Ice method	0	0.0
Evaporative cooling method	0	0.0
Covering of fish with sack/nylon	400	100.0
Are fish landed and offloaded without delay		
Yes	400	100.0
No	0	0.0
Where is fresh fish placed at the landing site		
On the ground	14	3.5
Plastic basin	311	77.7
Woven basket	75	18.8
How do you sell your fresh fish at the landing site		
Basket	2	0.5
Per kilogram, hand and basket	398	99.5
At the landing site after sales, do you normally have leftovers of fresh fish		
Yes	182	45.5
No	218	54.5
If yes, what do you do?		
Smoke	102	25.5
Smoke and sundry	80	20.0

Source: Field survey, 2017

As indicated in Table 4.3, most (44 percent) of the fishermen spent 12 hours for their fishing trip, about 34 percent spent 13 hours while a lesser percentage (3.3 percent) spent 10 hours on fishing trip. The mean duration of fishing trip in the study area is 12 hours. This implies that the quality of fish is determined by the time of fishing trip. The fishermen goes for fishing on average for 5 days per week which gives minimum of 20 days per month. Fishing cycle indicates time taken in total by the fishermen after departure from the landing site, setting of the fishing nets, removal of the fishing nets and returning of fishing boat to the landing site. Duration makes fish caught early to stay in excellent condition by the time it gets to the landing site. Factors such as fishing method, distance of the fishing ground to the landing site and weather determine fishing cycle. According to Amos et al. (2007) and Mungai, (2014) posited that longer fishing cycle leads to increased post-harvest fish losses due to spoilage.

All (100 percent) the fishermen make use of drift net to carry out their fishing activities with the use of planked boat majorly (89.2 percent) 9m in length which is powered by an outboard gasoline engine (45 horse power) in the study area. This shows that small-scale fishers make use of motorized large dugout wooden canoe craft for their fishing activities. Nguvava (2013) findings also revealed that fishing boats used in the study were powered by outboard gasoline engine. The design of boats and construction are made with smooth surfaces with negligible projections, free of cracks, blunt inner corners to avoid concealing of dirt and microorganisms and enable sufficient drainage.

From the findings, fishermen do not use ice on board or at the landing site for their fresh fish. Lack of electricity and no provision for ice makes it difficult for them to preserve their fresh fish with ice in the study area. As a result of this, fish are offloaded immediately at the landing site. Yohanna, Fulani and Aka'ama, (2011) opine that if fish is not properly handled, there is possibility that deterioration will set in 12 hours after harvest. Other forms of method used to preserve fresh fish from fishing ground to the landing site is through covering of fresh fish with sack/nylon. All (100 percent) the fishermen in the study area used this method to preserve their fresh fish from excess sunlight which can increase rate of spoilage. However, the covering materials were not good enough but it serves the major purpose of usage. Tesfay and Teferi (2017) stated that fish are kept cool by covering them with sack. This is because of lack of ice in the study area and an alternative to ensure good quality of fish from the fishing ground to the landing site was improvised. From the observation, it is an offence which attract penalty fee if fish is not covered while coming from the fishing ground to the landing site. According to Diei-Ouadi and Mgawe, (2011) and Nguvava, (2013) fish exposed to direct sun rays at the fishing grounds increased the spoilage rate by drying off surface of fish. The major reason why fish are being exposed to sunlight is due to lack of covering facilities.

Odongkara and Kyangwa, (2005) sited by Mungai, (2014) that fish transported from fishing ground to the landing site which were placed at the bottom of the boats were covered with leaves or plastic sheets while fish that are not covered resulted in high percentage of losses. With respect to where fish are placed at the landing site, 77.7 percent of fishermen placed fish in the plastic basin, 18.8 percent placed inside woven basket while 3.5 percent placed fish on the ground. This implies that majority of fishermen make use of plastic basin to keep the fish in good quality and suitable for purchase. Majority (99.5 percent) of the fishermen sold through kilogram, hand and basket while a lesser percentage (0.5 percent) sell through the use of basket only. Results showed that 45.5 percent of the fishermen do have left overs of fresh fish after selling at the landing site while 54.5 percent do not have left overs. It was observed that they sell huge part of their fish catch at the landing site and take the left over to their various home for their wives to process immediately to prevent spoilage against the next market day which is usually 3 days interval.

4.4.1 Cleaning Practices by the Fishermen at the Landing Sites

Table 4.4 presents the various cleaning practices observed by the fishermen at the landing sites.

Table 4.4
Descriptive Statistics for Cleaning Practices Observed by the Fishermen

Variables	Yes Freq. (%)	No Freq. (%)
Cleaning of boat after landing	400 (100.0)	0 (0.0)
Cleaning of fish hold and accessories	400 (100.0)	0 (0.0)
Cleaning of fishing gear	400 (100.0)	0 (0.0)
Washing of fish	307 (76.75)	93 (23.25)
Sorting of fish	400 (100.0)	0 (0.0)
Evisceration and removal of gills	0 (0.0)	400 (100.0)
Icing of fish	0 (0.0)	400 (100.0)

Source: Field survey, 2017

Table 4.4 showed that all (100 percent) the fishermen clean their boat, fish holding accessories, fishing gear with clean water and fish are sorted at the landing site while majority (76.75 percent) of them wash their fish along the shoreline at the landing site. Results revealed that fishermen in the study area do not remove gills or ice fish at the landing site which implies that fish will spoil quickly but they ensure that fresh fish are covered to reduce the rate of spoilage on board. According to Enujiugha and Nwanna (1998) fish needs to be degut (removal of gills) in other to ensure good quality fish and prevent spoilage. Similarly, Jeeva et al. (2007) opine that fish that are not degutted are prone to spoilage. Likewise, Mungai (2014) and Olusegun and Matthew (2016) suggested that fish should be degutted on board to maintain its quality and fit for human consumption. Ponte (2005) is of the opinion that cleaning of fishing boats and other fishing accessories is not a daily routine by the fishermen and unclean water is being used for this practice. This occur when fishermen are not knowledgeable about good hygiene practices.

4.5 Storage Facilities used for Fresh Fish at the Landing Sites

Storage facilities are an essential aspect in the small-scale fisheries. This helps to keep the fish in good condition which attracts better price during sales. Table 4.5 presents the storage information used by fishermen at the landing sites.

Table 4.5
Descriptive Statistics for Storage Facilities used for Fresh Fish

Variables	Frequency	Percentage (%)
Where are fresh fish stored after hauling of fishing net from fishing ground?		
Ice box	0	0.0
Plastic basin	2	0.5
Placed on the floor of the boat along with the net	398	99.5
What storage methods do you use to preserve fresh fish at the landing site?		
Ice container	0	0.0
Container with water covered with leaves	294	73.5
Container with water covered with tarpaulin	106	26.5
What do you do in case of spoilt fresh fish?		
Discard the spoiled fresh fish	45	11.3
Sold at a lesser price	183	45.7
Smoke	11	2.8
Sold at a lesser price and smoke	161	40.2
In case of left overs, how will you preserve your fresh fish after sales?		
Process immediately for next market day	400	100.0
What is the distance from home to the market?		
5 kilometres	4	1.0
6 kilometres	135	33.7
7 kilometres	216	54.0
8 kilometres	45	11.3
Mean±std.	**6.76**	**0.66**
Do you apply disinfectants before fish storage		
Yes	0	0.0
No	400	100.0
What influences rate of spoilage of fresh fish from fishing ground to the landing site?		
Time	191	47.8
Excessive sunlight	82	20.5
Poor handling practices	127	31.7

Source: Field survey, 2017

As indicated in Table 4.5, majority of the fishermen (99.5 percent) do not have storage facilities and placed their fishing nets after hauling on the floor of the boat along with the net while 0.5 percent make use of plastic basin. At the landing site, 73.5 percent of the fishermen placed their fish inside jerry can/container with water and covered with leaves after landing while about 27 percent placed their fish inside jerry can/container with water covered with tarpaulin. Tesfay and Teferi (2017) that respondents keep their fish cool in the jerry cans and covering them with sack. This is done in other to prevent exposure of fish to excessive sunray. With regards to spoilt fresh fish at the landing site, 45.7 percent of the fishermen sold at a lesser price, around 40 percent of the fishermen sold at a lesser price and smoke, 11.3 percent discard the spoiled fresh fish while almost 3 percent of the fishermen smoke only. In case of leftover of fresh fish, fishermen indicated that it will be processed by their wives immediately and kept for next market day. Fish needs to be subjected to processing form once it is not consumed within one day of capture in order to prolong its shelf life to become fit for human consumption.

Most (54 percent) of the fishermen specified that from home to market place is within 7 kilometres while almost 34 percent stated that it is around 6 km. Mean value for distance from home to market place is 6.76 km. All (100 percent) of the fishermen do not apply disinfectant or any other form of chemical before fish storage because chemicals will have adverse effect on human’s health. About 47.8 percent of fishermen reported that time is the major factor that influences rate of spoilage of fresh fish from fishing ground to the landing site, 20.5 percent stated that excessive sunlight influences spoilage rate while 31.7 percent of the fishermen indicated that poor handling practices influences rate of spoilage of fresh fish from fishing ground to the landing site.

4.6 Transportation System used at the Landing Sites

Table 4.6 presents the descriptive statistics of means of transportation system used by the small-scale fishermen for their fishing activities. From the survey, it was observed that boat with outboard engine (45-horse power) is majorly used by the fishermen to carry out their fishing activities from the fishing ground to the landing sites.

Table 4.6
Descriptive Statistics for Transportation System of Fresh Fish

Variables	Frequency	Percentage (%)
Is there provision for cooling facilities in the transportation system?		
Yes	0	0.0
No	400	100.0
How do you transport your fresh fish from the fishing ground to the landing site?		
In an open boat	400	100.0
Use of insulated containers	0	0.0
Use of ice boxes	0	0.0
Do you experience any spoilage during transportation of fish to the landing site?		
Yes	246	61.5
No	154	38.5
If yes, state the causes		
High temperature	84	21.0
Excess fish catch with no ice facilities for preservation	162	40.5
Where do you sell your fresh fish?		
Landing site	400	100.0
Transport to the market	0	0.0
What type of facilities do you use for transportation?		
Plastic basin/Container	370	92.5
Basket	30	7.5
Suggestions on measures to be taken in solving post-harvest fish losses		
Effective training on handling practices, provision of storage facilities and construction of good road network	118	29.5

Table 4.6 contd.

	Frequency	Percentage (%)
Provision of ice and training on handling practices	43	10.8
Provision of cold room, good handling practices and provision of storage facilities	38	9.5
Provision of covering materials, training on handling practices and provision of ice for preservation	201	50.3

Source: Field survey, 2017

Table 4.6 showed that all (100 percent) the fishermen states that there is no provision for cooling facilities in the transportation system. All (100 percent) the fishermen transport their fresh fish in an open boat. About 61.5 percent of the fishermen experienced spoilage during transportation of fresh fish to the landing site while around 38.5 percent do not experienced spoilage. Out of the 61.5 percent that experienced spoilage, 21.0 percent stated that high temperature causes spoilage during transportation while 40.5 percent opine that they have excess fish catch a times and spoilage sets in due to lack of ice facilities for preservation. All (100 percent) the fishermen use landing site as their selling point. About 92.5 percent of fishermen make use of plastic basin/container as the facilities for carrying fresh fish in case of left over after sales while 7.5 percent use basket. About 51 percent of the fishermen posited that provision of covering materials, training on handling practices and provision of ice for preservation are measures for solving post-harvest fish losses while almost 30 percent opine that effective training on handling practices, provision of storage facilities and construction of good road network are actions for solving post-harvest fish losses.

4.7 Causes of Post-Harvest Fish Losses

Table 4.7 presents the causes of post-harvest fish losses. This exercise is facilitated by the need to understand the issues on post-harvest fish losses and to have in depth knowledge on the problem faced by fishermen for adequate policy intervention. Various items were compiled by the researcher for adequate investigation from the fisher by rating accordingly using 5-point likert scale (disagree, agree, neutral, strongly disagree and disagree). According to Nenna (2014), 5-point likert scale was used to identify level of severity of problem and a mean score of 3.0 was used as a baseline. This simply indicates that any mean value that is higher than 3.0 are causes of post-harvest fish losses which needs to be addressed while any mean value below 3.0 is counted as not a cause of post-harvest fish losses.

Based on observation, the major problem faced by small-scale fishermen is lack of ice blocks in the study area. This is as a result of lack/unstable electricity in the area. The baot used for fishing does not have insulated container nor ice blocks for preservation. Also, another problem faced by small-scale fishermen in the study area is lack of storage facilities such as cold room. They do not have good storage facilities to preserve their fresh fish both on board and at the landing site and this result to fish losses. Lack of transportation system is another problem encountered by the small-scale fishermen. This hinders them from transporting their fish and fish products to the urban areas where demand is high. In addition, the small-scale fishermen opine that they lack financial assistance from both the state and federal government. They try to improvise by using covering materials despite not suitable but just to keep their fish from excessive sunlight in order to realise good income from it.

Table 4.7
Descriptive Statistics for Causes of Post-Harvest Fish Losses

S/N	Items	Mean value
1.	Duration of fishing cycle to landing site leads to losses	4.61**
2.	Delays in hauling nets result in poor-quality fish resulting to quality loss	4.78**
3.	Use of chemicals in fishing affects the safety and quality of fish posing threat to consumers' health	4.56**
4.	Exposing of fish to high temperature creates favourable conditions for fish spoilage leading to quality loss and affecting price	4.55**
5.	Discarding of by catch at sea because fish is too small or not valuable enough to land for sale	1.87*
6.	Fishing gear used by fishermen causes quality loss	4.73**
7.	Poor handling practices during unloading of fish causes quality losses	4.69**
8.	Lack of covering facilities for fresh fish at the landing site to prevent excess sunlight	4.52**
9.	Failure to use ice and containers result in poor quality fish	4.55**
10.	Insect infestation and animal predation on fresh fish leads to losses	4.58**
11.	Fish spoil easily if not preserved properly with ice during fishing	4.67**
12.	Lack of storage facilities to ensure good quality of fish can lead to losses	4.62**
13.	Lack of good means of transportation for effective movement of fresh fish	4.67**
14.	Unexpected demand and supply situations can affect price	4.34**
15.	Inadequate dissemination of market information can lead to selling of fish at a lower price resulting to market loss	4.34**
16.	High post-harvest fish losses occur during rainy season	4.47**

Source: Field survey, 2017

Table 4.7 revealed that delays in hauling nets result in poor-quality fish resulting to quality loss (4.78) is the major cases of post-harvest fish losses followed by fishing gear used by the fishermen causes quality loss, poor handling practices during unloading of fish causes quality losses, fish spoil easily if not preserved properly with ice during fishing, lack of good means of transportation for effective movement of fresh fish, duration of fishing cycle to landing site leads to losses, use of chemicals in fishing affects the safety and quality of fish posing threat to consumers' health, exposing of fish to high temperature creates favourable conditions for fish spoilage leading to quality loss and affecting price, lack of covering facilities for fresh fish at the landing site to prevent excess sunlight, failure to use ice and containers result in poor quality fish, insect infestation and animal predation on fresh fish leads to losses, high post-harvest fish losses occur during rainy season, lack of storage facilities to ensure good quality of fish can lead to losses, unexpected demand and supply situations can affect price and inadequate dissemination of market information can lead to selling of fish at a lower price resulting to market loss are all causes of post-harvest fish losses while discarding of by-catch at sea because fish is too small or not valuable enough to land for sale is not seen has causes of post-harvest fish losses.

From observation and findings of the result, lack of ice and storage facilities are really affecting the fishermen in the fishing communities and they have to device local means by covering of fresh fish to maintain the quality of their fish. Though the method is not good enough but will safeguard the fish quality.

Based on the observation and discussion carried out in the study area, the following constraints were discovered from the fishermen.

1. Health hazard because of fishing all night, which exposes them to cold and other health issues.
2. Lack of good drinking water.
3. High cost of fuel for fishing: The fishermen states that the amount they spend on fuelling per day is on high side.
4. High cost of fishing equipment: Fishermen make use of equipment that is not sophisticated due to lack of capital to purchase fishing equipments. They cannot afford to buy a better one due to high cost and to secure agricultural

loan is very difficult for them. Fishermen states that fishing equipments which was meant to be given to them at a subsidized rate was sold at higher prices and they could not afford it.

5. Lack of ice and electricity in the study area: This is a serious issue faced by the fish farmers in the study area. It is due to this problem that fish farmers ensure that they come back within 12 hours of fishing trip in order to maintain the quality of fish due to lack of ice for preservation though some do over stay.
6. Lack of storage facilities: The fishermen feels the situation of losses should be improved by provision of cold rooms in strategic areas for them. Also, ice boxes/containers should be provided for them during fishing period. This will improve the quality of their fresh fish and attract good prices.
7. Lack of good road network: The fishermen find it so difficult to transport their processed fish to urban areas where demand is high due to poor state of their road.

4.8 Hypothesis Testing

Chi-square was used to analyse the hypotheses generated. The results of these tests and interpretation are discussed below.

4.8.1 Relationship among variables of demographic factors with percentage losses of croaker species

H_o1: There is no association among demographic factors of fishermen and percentage losses of croaker fish.

Table 4.8 presents the cross-tab showing relationship among demographic factors (age, household size, educational level and fishing experience) with percentage losses of croaker species.

Table 4.8

Cross-tab showing Relationship among Demographic Factors with Percentage Losses of Croaker Specie (n=100)

Variables	**1 – 5 %**	**6 - 10 %**	**11 – 15 %**	**Above 15 %**	**Total**	**χ2**	**df**	**P-value**
Age (years)								
20 – 30	6(6.0)	0(0.0)	0(0.0)	0(0.0)	6			
31 – 40	21(21.0)	35(35.0)	0(0.0)	0(0.0)	56	82.442	9	0.000*
41 – 50	0.0(0.0)	16(16.0)	17(17.0)	4(4.0)	37			
Above 50	0.0(0.0)	0(0.0)	0(0.0)	1(1.0)	1			
Household size								
Less than 6	27(27.0)	5(5.0)	0(0.0)	0(0.0)	32			
6 – 10	0(0.0)	46(46.0)	17(17.0)	4(4.0)	67	97.982	6	0.000*
Above 10	0(0.0)	0(0.0)	0(0.0)	1 (1.0)	1			
Educational qualification								
No formal education	2(2.0)	0(0.0)	0(0.0)	0(0.0)	2			
Primary education	25(25.0)	17(17.0)	0(0.0)	0(0.0)	42	55.776	6	0.000*
Secondary education	0(0.0)	34(34.0)	17(17.0)	5(5.0)	56			
Fishing experience (years)								
Less than 10	14(14.0)	0(0.0)	0(0.0)	0(0.0)	14			
10 – 15	13(13.0)	22(22.0)	0(0.0)	0(0.0)	35			
16 – 20	0(0.0)	29(29.0)	0(0.0)	0(0.0)	29	178.223	12	0.000*
21 – 25	0(0.0)	0(0.0)	10(10.0)	0(0.0)	10			
Above 25	0(0.0)	0(0.0)	7(7.0)	5(5.0)	12			

*Significant ($p < 0.05$)

Source: Field survey, 2017

From Table 4.8, age cross-tabulation count indicated that out of 56 percent of fishermen between ages of 31 - 40 years, 21 percent have between 1 – 5 percent of croaker loss while the remaining 35 percent have between 6 - 10 percent of croaker loss. Out of 37 percent of fishermen between 41 – 50 years of age, 16 percent of them have between 6 – 10 percent of croaker loss, 17 percent have between 11 – 15 percent of croaker loss while 4 percent have above 15 percent of croaker loss. From the findings (χ^2= 82.442), age of fishermen and percentage loss of croaker are statistically related. This indicates that as fishermen increase in age, their energy reduces and they tend to stay longer during hauling of fishing nets which result to high losses by the time they get to the landing site compare to the young fishermen who are still agile. Household size cross-tabulation count indicated that out of 67 percent of fishermen between 6 – 10 people per household, 46 percent have 6 – 10 percent croaker losses, 17 percent have between 11 – 15 percent croaker losses while 4 percent have above 15 percent croaker losses. Out of 32 percent of fishermen with household size of below 6; 27 percent of them have between 1 – 5 percent croaker losses while 5 percent have between 6 – 10 percent croaker losses. This simply shows that household size is statistically related (χ2= 97.982) with percentage croaker loss. Fishermen with more household size tends to stay longer period during fishing activities due to high responsibilities. Educational status cross-tabulation result simply showed that education is statistically related (χ^2= 55.776) to percentage of croaker loss. Out of 56 percent of fishermen that have secondary education, 34 percent of them have between 6 – 10 percent croaker losses, 17 percent have between 11 – 15 percent croaker losses while 5 percent have above 15 percent croaker losses. Similarly, out of 42 percent of fishermen with primary education, 25 percent have between 1 – 5 percent croaker losses while 17 percent have between 6 – 10 percent of croaker losses. This implies that education acquired by the fishermen is not based on fishing activities and more knowledge is still needed. However, education acquired will make them to accept new fish handling practices which will help their fishing activities. The result shows that there is a significant association among demographic factors of fishermen and percentage losses of croaker fish.

4.8.2 Relationship among variables of demographic factors with percentage losses of catfish species

H_o2: There is no association among demographic factors of fishermen and percentage losses of catfish species.

Table 4.9 presents the cross-tab showing relationship among demographic factors (age, household size, educational level and fishing experience) with percentage losses of catfish species.

Table 4.9

Cross-tab showing Relationship among Demographic Factors against Percentage Losses of Catfish Specie (n=100)

Variables	**1 – 5%**	**6 – 10%**	**11 – 15%**	**Above 15%**	**Total**	**$\chi 2$**	**df**	**P-value**
Age (years)								
20 – 30	6(6.0)	0(0.0)	0(0.0)	0(0.0)	6			
31 – 40	28(28.0)	28(28.0)	0(0.0)	0(0.0)	56	84.319	9	0.000*
41 – 50	0.0(0.0)	17(17.0)	17(17.0)	3(3.0)	37			
Above 50	0.0(0.0)	0(0.0)	0(0.0)	1(1.0)	1			
Household size								
Less than 6	32(32.0)	0(0.0)	0(0.0)	0(0.0)	32			
6 – 10	2(2.0)	45(45.0)	17(17.0)	3(3.0)	67	115.189	6	0.000*
Above 10	0(0.0)	0(0.0)	0(0.0)	1(1.0)	1			
Educational qualification								
No formal education	2(2.0)	0(0.0)	0(0.0)	0(0.0)	2			
Primary education	32(32.0)	10(10.0)	0(0.0)	0(0.0)	42	68.993	6	0.000*
Secondary education	0(0.0)	35(35.0)	17(17.0)	4(4.0)	56			
Fishing experience (years)								
Less than 10	14(14.0)	0(0.0)	0(0.0)	0(0.0)	14			
10 – 15	20(20.0)	15(15.0)	0(0.0)	0(0.0)	35			
16 – 20	0(0.0)	29(29.0)	0(0.0)	0(0.0)	29	166.095	12	0.000*
21 – 25	0(0.0)	1(1.0)	9(9.0)	0(0.0)	10			
Above 25	0(0.0)	0(0.0)	8(8.0)	4(4.0)	12			

*Significant ($p < 0.05$)

Source: Field survey, 2017

Table 4.9 showed that age cross-tabulation count revealed that out of 56 percent of fishermen between 31 – 40 years of age, 28 percent of them have catfish losses between 1 – 5 percent and 6 – 10 percent respectively. Out of 37 percent of fishermen between 41 – 50 years of age, 17 percent of them experienced catfish losses between 6 – 10 percent and 11 – 15 percent while 3 percent experienced above 15 percent of catfish losses. This simply shows that age is related to percentage of catfish losses. The higher the fishermen's age, their ability reduces during fishing activities and losses is likely to occur. Household size cross-tabulation count indicated that out of 67 percent of fishermen which falls within 6-10 people per household, 2 percent of the fishermen experienced between 1 – 5 percent catfish losses, 45 percent of the fishermen have between 6 – 10 percent catfish losses, 17 percent of the fishermen experienced between 11 – 15 percent catfish losses while 3 percent of the fishermen experience above 15 percent of catfish losses. This simply showed that household size is statistically related (χ^2= 115.189) with percentage catfish losses. Fishermen with high household size spend more hours during fishing due to high responsibilities at home. Educational status cross-tabulation result simply revealed that educational level of fishermen can give them foresight to adopt good handling practices. Out of 56 percent of fishermen that have secondary education, 35 percent of them have between 6 – 10 percent catfish losses, 17 percent of fishermen experienced catfish losses between 11 – 15 percent while 4 percent have above 15 percent catfish losses. This simply indicated that educational level is statistically associated (χ^2= 68.993) with percentage of catfish losses. Cross tabulation for fishing experience indicated that out of the 35 percent of fishermen with 10 – 15 years of experience, 20 percent of them have catfish losses between 1 – 5 percent while 15 percent have between 6 – 10 percent of catfish losses. Fishing experience has significant relationship (χ^2= 68.993, $p < .05$)

with percentage catfish losses. There is a significant association among the demographic factors with percentage catfish losses. Null hypothesis is rejected while alternative hypothesis is accepted.

4.8.3 Relationship among variables of demographic factors with percentage losses of shrimp species

H_o3: There is no association among demographic factors of fishermen and percentage losses of shrimp species.

Table 4.10 presents the cross-tab showing relationship among demographic factors (age, household size, educational level and fishing experience) with percentage losses of shrimp species.

Table 4.10
Cross-tab showing Relationship among Demographic Factors against Percentage Losses of Shrimp (n=100)

Variables	**1 – 5%**	**6 – 10%**	**11 - 15%**	**Above 15%**	**Total**	**$\chi 2$**	**df**	**P-value**
Age (years)								
20 – 30	6(6.0)	0(0.0)	0(0.0)	0(0.0)	6			
31 – 40	22(22.0)	34(34.0)	0(0.0)	0(0.0)	56	106.951	9	0.000*
41 – 50	0.0(0.0)	19(19.0)	17(17.0)	1(1.0)	37			
Above 50	0.0(0.0)	0(0.0)	0(0.0)	1(1.0)	1			
Household size								
Less than 6	28(28.0)	4(4.0)	0(0.0)	0(0.0)	32			
6 – 10	0(0.0)	49(49.0)	17(17.0)	1(1.0)	67	132.178	6	0.000*
Above 10	0(0.0)	0(0.0)	0(0.0)	1(1.0)	1			
Educational qualification								
No formal education	2(2.0)	0(0.0)	0(0.0)	0(0.0)	2			
Primary education	26(26.0)	16(16.0)	0(0.0)	0(0.0)	42	56.180	6	0.000*
Secondary education	0(0.0)	37(37.0)	17(17.0)	2(2.0)	56			
Fishing experience (years)								
Less than 10	14(14.0)	0(0.0)	0(0.0)	0(0.0)	14			
10 – 15	14(14.0)	21(21.0)	0(0.0)	0(0.0)	35			
16 – 20	0(0.0)	29(29.0)	0(0.0)	0(0.0)	29	144.698	12	0.000*
21 – 25	0(0.0)	3(3.0)	7(7.0)	0(0.0)	10			
Above 25	0(0.0)	0(0.0)	10(10.0)	2(2.0)	12			

*Significant ($p < 0.05$)
Source: Field survey, 2017

As indicated in Table 4.10, age cross-tabulation count showed that out of 56 percent of fishermen between 31 – 40 years, 22 percent of them have between 1 – 5 percent shrimp losses while 34 percent of them have between 6 – 10 percent of shrimp losses. Also, out of 37 percent of fishermen between the ages 41 – 50 years, 19 percent of them have 6 – 10 percent shrimp loss, 17 percent have between 11 – 15 percent while 1 percent of them have above 15 percent of shrimp loss. Age is statistically related (χ^2= 106.951, $p < .05$) with percentage shrimp loss. Cross-tabulation for household size showed that out of 67 percent of fishermen between 6 – 10 people; 49 percent of them have between 6 – 10 percent shrimp losses, 17 percent have between 11 – 15 percent of shrimp loss while 1 percent have above 15 percent of shrimp losses in the study area. Educational status cross-tabulation is statistically related (χ^2= 56.180, $p < .05$) with percentage shrimp losses. Out of 56 percent of fishermen that have secondary education, 37 percent of them experienced shrimp loss between 6 – 10 percent, 17 percent have shrimp loss between 11 – 15 percent while 2 percent have above 15 percent shrimp loss. Fishermen's educational level will make them more enlightened to accept new handling practices which will help to reduce post-harvest fish loss. Cross tabulation for fishing experience indicates that out of the 35 percent of fishermen with 10 – 15 years of experience, 20 percent of them have shrimp loss between the ranges of 1 – 5 percent while 15 percent have between 6 – 10 percent of shrimp loss. Fishing experience cross-tabulation is statistically related (χ^2= 144,698, $p < .05$) with percentage shrimp loss. This indicated that as fishermen's experience increases they have more skills to solve the problem of fish loss.

4.8.4 Relationship between handling practices, storage facilities and transportation system with total percentage losses of fish

H_o4: There is no association between handling practices, storage facilities and transportation system with total percentage losses of fish.

Table 4.11 presents cross-tabulation showing relationship between duration of fishing cycle, storage facilities and transportation system with total percentage losses of fish.

Table 4.11

Cross-tab showing Relationship between Duration of Fishing Cycle, Storage Facilities and Transportation System with Total Percentage Losses of Fish (n = 100)

Variables	10 – 20%	21 – 30%	Above 30%	Total	χ^2	df	P-value
Duration of fishing cycle (hours)							
10	4(4.0)	0(0.0)	0(0.0)	4			
11	16(16.0)	0(0.0)	0(0.0)	16	91.369	8	0.000*
12	18(18.0)	24(24.0)	0(0.0)	42			
13	0(0.0)	12(12.0)	24(24.0)	36			
14	0(0.0)	0(0.0)	2(2.0)	2			
Storage facilities							
Plastic basin	2(2.0)	0(0.0)	0(0.0)	2			
Placed on the bottom floor of the boat with net	36(36.0)	36(36.0)	26(26.0)	98	77.022	2	0.000*
Transportation system							
Plastic basin/container	38(38.0)	36(36.0)	20(20.0)	94			
Basket	0(0.0)	0(0.0)	6(6.0)	6	18.167	2	0.000*

*Significant ($p < 0.05$)

Source: Field survey, 2017

Table 4.11 showed the cross-tabulation of distribution of duration of fishing cycle, where fresh fish is placed after hauling of fishing net, storage facilities and transportation system with total percentage losses of fish. Results indicated that 4 percent of the fishermen that spends 10 hours on fishing trip experience fish loss between 10 – 20 percent, 16 percent of the fishermen that spends 11 hours on fishing trips experienced fish loss between 10 – 20 percent while out of 42 percent of the fishermen that spends 12 hours during fishing trip, 18 percent of them experienced fish loss between 10 – 20 percent while 24 percent experienced fish loss between 21 – 30 percent. Also, out of 36 percent of fishermen that spends 13 hours, 12 percent of them experienced fish loss between 21 – 30 percent while 24 percent experienced fish loss between 21 – 30 percent in the study area. This simply shows that the higher the duration of fishing cycle, the higher the percentage losses of fish in the study area.

Findings from cross-tabulation on storage facilities used in the study area indicated that out of 98 percent of fishermen that placed their fish on the bottom floor of the boat after hauling due to know suitable storage facilities on board, 36 of them experience losses between 10 – 20 percent and 21-30 percent respectively while 26 of them experience loss above 30 percent. There is a significant relationship between storage facilities used and post-harvest fish losses ($p > .05$).

Result from cross-tabulation of means used in transportation system in the study revealed that out of 94 percent of fishermen that used jerry can/container to transport their fish, 38 percent of them experience fish losses between 10 – 20 percent, 36 percent of them experience fish loss between 21 - 30 percent while 20 percent of them experience fish loss above 30 percent. Similarly, 6 percent of fishermen that transport their fish using jerry can/container and basket experience fish loss above 30 percent.

This simply indicates that medium in which fish is transported is significantly associated to percentage losses of fish. From the result, null hypothesis (H_o) is rejected while alternative hypothesis (H_a) is accepted for duration of fishing cycle, storage facilities used at the landing site and means used for transportation.

4.8.5 Relationship between Demographic Factors and Duration of Fishing Trip

Table 4.12 presents cross-tabulation showing relationship between some demographic factors and duration of fishing trip.

Table 4.12
Cross-tab showing Relationship among the Demographic Factors with Duration of Fishing Trip (n =400)

Variables	10 - 12 hours	13 - 15 hours	Total	X^2	df	P-value
Age (years)						
20 – 30	32 (8.0)	0 (0.0)	32 (8.0)			
31 – 40	212 (53.0)	17 (4.2)	229 (57.2)	333.846	3	.000*
41 – 50	0 (0.0)	132 (33.0)	132 (33.3)			
Above 50	0 (0.0)	7 (1.8)	7 (1.8)			
Household size						
Less than 6	108 (27.0)	0 (0.0)	108 (27.0)			
6 – 10	136 (34.0)	152 (38.0)	288 (72.0)	98.286	2	.000*
Above 10	0 (0.0)	4 (1.0)	4 (1.0)			
Educational qualification						
No formal education	13 (3.3)	0 (0.0)	13 (3.3)			
Primary education	144 (36.0)	0 (0.0)	144 (36.0)	165.230	2	.000*
Secondary education	87 (21.7)	156 (39.0)	243 (60.7)			
Fishing experience (years)						
Less than 10	88 (22.0)	0 (0.0)	88 (22.0)			
10 – 15	80 (20.0)	0 (0.0)	80 (20.0)			
16 – 20	76 (19.0)	36 (9.0)	112 (28.0)	318.569	4	.000*
21 – 25	0 (0.0)	62 (15.5)	62 (15.5)			
Above 25	0 (0.0)	58 (14.5)	58 (14.5)			

*Significant (p<.05)
Source: Field survey, 2017

Table 4.12 showed the relationship of demographic factors with duration of fishing trip. Age cross-tab shows that out of 57.2 percent of respondents within the age range of 31 - 40 years old, 53.0 percent of them use between 10 – 12 hours for fishing cycle while 4.2 percent use 13 – 15 hours. Out of 33 percent of respondents between age groups 41 – 50 years old, all the respondents within this age group use between 13 – 15 hours duration for fishing cycle. From the findings of cross tabulation of age, it showed that as fishermen's age increases they tend to spend more hours during fishing. Age is statistically significant (χ^2= 333.846, $p < .05$) with duration of fishing cycle. Cross tabulation for household size showed that out of 72 percent of respondents that have witin the range of 6 – 10 people, 34 percent of them use between 10 – 12 hours during fishing while 38 percent use between 13 – 15 hours. Results showed that the fishermen's with large household size tend to use more time during fishing cycle. Household size is statistically significant (χ^2= 98.286, $p < .005$) with duration of fishing cycle. Cross-tabulation for educational status indicated that out of 36 percent of fishermen with primary education, all of them use between 10 – 12 hours during fishing cycle while out of 60.8 percent of fishermen with secondary education, 21.8 percent of them use between 10 - 12 hours and 39 percent use between 13 – 15 hours respectively. Educational status is statistically significant (χ^2= 165.230, $p < .05$) with duration of fishing cycle. Cross-tabulation of fishing experience showed that out of 28 percent of fishermen that have experienced between 16 – 20 years, 19 percent of them use within 10 – 12 hours during fishing cycle while 9 percent use between 13 – 15 hours for their fishing. Findings showed that the higher the experienced of the fishermen, the higher the duration of fishing cycle. Fishing experience is statistically significant (χ^2= 318.569, $p < .05$) with duration of fishing cycle.

4.8.6 Relationship between Demographic Factors and Size of Boat

Table 4.13 presents cross-tabulation showing relationship between some demographic factors and size of boat.

Table 4.13
Cross-tab showing Relationship between the Demographic Factors with Size of Boat (meter) (n =400)

Variables	8 meters	9 meters	Total	X^2	df	P-value
Age (years)						
20 – 30	0 (0.0)	32 (8.0)	32 (8.0)			
31 – 40	22 (5.5)	207 (51.8)	229 (57.2)	8.671	3	.034*
41 – 50	21 (5.2)	111 (27.8)	32 (33.0)			
Above 50	0 (0.0)	7 (1.8)	7 (1.8)			
Household size						
Less than 6	16 (4.0)	92 (23.0)	108 (27.0)			
6 – 10	27 (6.8)	261 (65.2)	288 (72.0)	2.909	2	.233
Above 10	0 (0.0)	4 (1.0)	4 (1.0)			
Educational qualification						
No formal education	0 (0.0)	13 (3.3)	13 (3.3)			
Primary education	20 (5.0)	124 (31.0)	144 (36.0)	3.463	2	.177
Secondary education	23 (5.7)	220 (55.0)	243 (60.7)			
Fishing experience (years)						
Less than 10	14 (3.5)	74 (18.5)	88 (22.0)			
10 – 15	7 (1.8)	73 (18.2)	80 (20.0)			
16 – 20	3 (0.8)	109 (27.2)	112 (28.0)	19.120	4	.001*
21 – 25	14 (3.5)	48 (12.0)	62 (15.5)			
Above 25	5 (1.2)	53 (13.3)	58 (14.5)			

*Significant (p < .05)
Source: Field survey, 2017

As indicated in Table 4.13, age cross-tabulation count showed that out of 27 percent of fishermen with household size less than 6 people, 4 percent use boat of 8 meters in size for fishing while 23 percent use boat of 9 meters in size for fishing. Age is statistically significant (χ^2= 8.671, p < .05) with size of boat in meters. This shows that age of fishermen determines the size of boat to be used in their fishing activities. Out of 72 percent of fishermen with household size between 6 – 10 people, 65.2 percent of them use boat of 9 meters in size while 6.8 percent use boat size of 8 meters respectively. Household size is not statistically significant (χ^2= 2.909, p > .05) with size of boat in meters. This shows that household size do not determine the size of boat to be used by the fishermen. Out of 60.8 percent of fishermen with secondary education, 55 percent of them use boat of 9 meters in size while 5.8 percent of them use 8 meters boat size for their fishing. Educational status is not statistically significant (χ^2= 3.463, p > .05) with size of boat in meters. This implies that being educated does not determine fishermen's boat size. Fishing experience cross-tabulation indicated that out of 28 percent of fishermen within the fishing experience of 16 – 20 years, 27.2 percent of them use 9 meters boat size while 0.8 percent use 8 meters of boat size for their fishing activities. Fishing experience is not statistically significant (χ^2= 19.120, p < .05) with size of boat in meters. This denotes that fishing experience determines the size of boat used by small-scale fishermen.

4.8.7 Relationship between Member of Fish Association, Access to Credit Facilities and Form of Fish Training with Percentage Fish Loss

Table 4.14 presents the cross-tabulation result showing the relationship between member of fish association, access to credit facilities and form of fish training with percentage fish loss.

Table 4.14

Cross-tab showing Relationship between Member of Fish Association, Access to Credit Facilities and Form of Fish Training with Percentage Fish Loss (n=100)

Variables	10 – 20%	21 – 30%	Above 30%	Total	X^2	df	P-Value
Member of fish association							
Yes	29 (29.0)	31 (31.0)	21 (21.0)	81			
No	9 (9.0)	5 (5.0)	5 (5.0)	19	1.154	2	.562
Access to credit							
Yes	20 (20.00	23 (23.0)	5 (5.0)	48			
No	18 (18.0)	13 (13.0)	21 (21.0)	52	12.589	2	.002*
Any form of fish training							
Yes	17 (17.0)	2 (2.0)	(1.0)	20			
No	21 (21.0)	34 (34.0)	25 (25.0)	80	23.468	2	.000*

*Significant ($p < .05$)

Source: Field survey, 2017

As indicated in Table 4.14, out of 81 percent of respondents that belong to fish association group, 29 percent of them incur losses between 10 – 20 percent, 31 percent incur losses between 21 – 30 percent and 21 percent incur losses above 30 percent respectively. The cross-tabulation results show that being a member of fish association group is not statistically related to fish losses ($X^2 = 1.154$, $p > .05$). Access to credit facilities cross-tabulation shows a statistical relationship with fish losses ($X^2 = 12.589$, $p < .05$). This implies that if small-scale fishermen have access to credit facilities, fish losses will be reduced in the study area. Result shows that out of 52 percent of fishermen that do not have access to credit facilities, 21 percent of them experienced fish losses above 30 percent, 18 percent experienced fish losses between 10 – 20 percent while 13 percent of them experienced fish losses between 21 – 30 percent respectively. Fishermen with credit facilities experienced minimal fish losses compared to those that do not have access to credit facilities. Form of fish training cross-tabulation indicates that out of 20 percent of fishermen that had fish training, 17 percent of them experienced fish losses between 10 – 20 percent, 2 percent experienced fish losses between 21 – 30 percent while 1 percent of them experienced fish losses above 30 percent respectively. Findings show that form of fish training is statistically significant with percentage fish losses ($X^2 = 23.468$, $p < .05$).

4.9 Summary

Findings revealed that small-scale fishing is dominated by males only in the study area. Results showed that percentage post-harvest fish losses for the three dominant marine fish species are 8.15 percent for croaker, 7.76 percent for catfish and 7.57 percent for shrimp respectively per catch per day. These losses affect the income level generated by the fishers in the fishing communities and as a result of this their livelihood is affected. It was observed that major causes of post-harvest fish losses in the study area is due to poor handling practices, lack of ice blocks for preservation of fresh fish on board and at the landing site as a result of no electricity, lack of suitable covering materials, lack of storage facilities and lack of good transportation system. From observation, there is lack of electricity in the study area, as a result of this access to ice blocks for preservation of fresh fish on board becomes difficult for the fishermen. Open boat is used in the study area with no insulated container nor cooling facilities for the captured fish. The results from cross-tabulation analysis showed that demographic factors such as age, household size, educational qualification and fishing experience are statistically significant ($p < 0.05$) to post-harvest fish losses. Also, cross-tabulation analysis of duration of fishing cycle, storage facilities and transportation system with total percentage losses of fish shows a significant relationship with total percentage losses of fish. Similarly, cross-tabulation analysis of demographic factors and size of boat indicates that age of fishermen and fishing experience are statistically significant ($p < 0.05$) with size of boat while household size and educational status are not statistically significant ($p > 0.05$) with size of boat. In addition, access to credit facilities and form of fish training shows statistical significant relationship with percentage fish losses. This implies that if small-scale fishermen are provided with financial assistance and more fish training, fish losses will be reduced. The result revealed that small-scale fisheries sub-sector in Nigeria are yet to experience development due to lack of infrastructural facilities despite its contribution to fish production.

CHAPTER FIVE

REGRESSION ANALYSIS

5.1 Introduction

This chapter presents multiple regression analysis for objective 3 of this study. The model analysed the effect of demographic factors, handling practices, storage facilities and transportation system on percentage post-harvest fish losses (Croaker, Catfish and Shrimp).

5.2 Multiple Regression

This method was used to determine the overall fitness (variable explained) of the model and the relative contribution of each of the explanatory variables to the total variance. The dependent variable for this study is percentage fish losses of the three (3) dominant marine fish species whereas age (years), household size, educational level, fishing experience (years), access to credit facilities, form of fish training, duration of fishing cycle (hours), size of boat (meters), storage facilities (where fresh is placed after hauling of fishing net from the fishing ground) and transportation system (type of facilities use for transportation of fresh fish) are considered as independent variables.

5.3 Descriptive Statistics

Table 5.1 presents the descriptive statistics of independent variables and dependent variable for regression model. Dependent variable is the percentage of post-harvest fish losses which is computed from percentage losses of each of the fish species (croaker, catfish and shrimp).

Table 5.1
Descriptive Statistics of Independent Variables and Dependent Variable for Regression Model (n = 100)

Variables	Frequency	Percentage
Age of respondents (years)		
20 – 30	6	6.0
31 – 40	56	56.0
41 – 50	37	37.0
Above 50	1	1.0
Mean ± std.	38.94±5.37	
Household size (HH size)		
Less than 6	32	32.0
6 – 10	67	67.0
Above 10	1	1.0
Mean ± std.	6.19±1.34	
Educational qualification		
No formal education	2	2.0
Primary education	42	42.0
Secondary education	56	56.0
Fishing experience (Exp) years		
Less than 10	14	14.0
10 -20	64	64.0
Above 20	22	22.0
Mean ± std.	16.33 ± 6.74	
Access to credit facilities		
Yes	48	48.0
No	52	52.0
Any form of fish training		
Yes	20	20.0
No	80	80.0
Duration of fishing cycle		
10 – 12	62	62.0
13 – 15	38	38.0
Mean ± std.	12.16 ± .86	
Size of boat (meters)		
8 m	4	4.0
9 m	96	96.0
Storage facilities		
Plastic basin	2	2.0
Placed on the floor of the boat along with the fishing net after hauling	98	98.0
Transportation system		
Plastic basin/container	94	94.0
Basket	6	6.0
Percentage Post-harvest fish losses		
10 – 20	38	38.0
21 – 30	36	36.0
Above 30	26	26.0
Mean ± std.	23.55± 6.95	

Source: Field survey, 2017

As specified in Table 5.1, age of respondents showed that more than half (56 percent) of the fishermen falls within the age range of 31 – 40 years old while 37 percent falls within 41 – 50 years old respectively. Household size result showed that majority (67 percent) of the respondents have within 6 – 10 people while 32 percent have less than 6 people in their household respectively. Educational qualification showed that majority (56 percent) of the respondents have secondary education while 42 percent of them have primary education respectively. Fishing experience indicates that majority (64 percent) of the respondents have between 10 – 20 years experience. About 48 percent and 20 percent of respondents have access to credit facilities and fish training respectively. Majority (62 percent) of the respondents use between 10 – 12 hours during their fishing activities and 96 percent of them use 9 meters size of boat respectively. Findings showed that majority (98 percent) of the respondents place their fresh fish on the floor of the boat along with the fishing net after hauling of net from the fishing ground while 94 percent of them make use of container for transporting their fresh fish respectively. Based on percentage fish losses, most (38 percent) of the respondents experienced losses between 10 – 20 percent, 36 percent experienced losses between 21 – 30 percent while 26 percent experienced losses above 30 percent respectively.

5.4 Regression Model on Effect of Demographic Factors, Handling Practices, Storage Facilities and Transportation System on Post-Harvest Fish Losses

Multiple regression analysis was done to ascertain the relationship between age of fishermen, household size (HH size), educational level (Edu.), fishing experience (Fishing Exp.), access to credit facilities, form of fish training, duration of fishing cycle (DFC), size of boat (meters), storage facilities used (ST) and transportation system

(TR) on post-harvest fish losses (PHFLs). Table 5.2 presents the results of the multiple regression analysis performed.

Table 5.2
Coefficient Table

Variables	Coefficient	Std. Error	T	P value
Age	-.298	.083	-3.59	0.001*
HH size	.026	.070	0.37	0.709
Fishing Exp.	-1.023	.315	-3.25	0.020*
Edu	-.389	.151	-2.57	0.000*
CF	-.119	.032	-3.72	0.009*
FT	-.514	.241	-2.13	0.001*
DFC	.191	.096	1.98	0.045*
BS	-.398	.217	-1.83	0.070
ST	-1.439	.304	-4.73	0.002*
TR	-0.289	.107	-2.70	0.039*
Cons	0.971	.450	2.15	0.009
R^2	.805			
Adjusted R^2	78.36			
F-value	36.84			
P-value	0.000			

*Significant ($p < 0.05$)
Age of fishermen (years), HH size (household size), Exp (fishing experience in years), Edu (educational level), CF (Credit facilities), FT (Fish training), DFC (duration of fishing trip in hours), BS (Boat size), ST (storage facilities on board), TR (transportation facilities)

As shown in Table 5.2, the Adjusted R-square value was 78.36 percent which indicates that the model for this research accounted for 78.36 percent of the variance in post-harvest fish losses. The *P* value indicated a significant relationship (P = 0.000) which denotes that the independent variables reliably predict post-harvest fish losses (R^2 = .805, F = 36.84, p < .05). Independent variables such as age, fishing experience, educational qualification, credit facilities, fish training, storage facilities and transportation system were found to negatively and significantly (p < .05) influence post-harvest fish losses while duration of fishing cycle was significant and positively influence post-harvest fish loses respectively. Increase in age of fishermen by 1 year, decrease fish losses by .29 percent. As fishermen’s fishing experience increase by 1 year, post-harvest fish losses is reduced by 1.0 percent. Increase in fishermen's educational status reduces post-harvest fish losses by 0.4 percent. Provision of credit facilities for fishermen will help will reduce post-harvest fish losses by 0.1 percent. Increase in fish training among fishermen will reduce post-harvest fish losses by 0.5 percent, provision of good storage facilities will reduce post-harvest fish losses by 1.4 percent while provision of good facilities for transportation of fresh fish will reduce post-harvest fish losses by 0.2 percent respectively. In addition, increase in duration of fishing trip by 1 hour will increase post-harvest fish losses by 0.2 percent due to positive significant influence on post-harvest fish losses.

5.5 Multicollinearity Test

Multicollinearity occurs when independent variables are related, thus preventing assessment of individual effect of independent variables on dependent variable. Multicollinearity test was examined using the variance inflation factor (VIF) and tolerance value. VIF signifies the level at which the standard error was inflated due to existence of multicollinearity problem while the extent of variance of an independent variable that was not explained by the other independent variables is called tolerance value. This result was generated after running regression analysis. Hair et al. (2010) stated that multicollinearity becomes a problem if the VIF value is greater than 10 and tolerance value is lower than 0.1. Thus, the result of multicollinearity test is shown in Table 5.3.

Table 5.3
Checking for Multicollinearity using VIF

Variables	**Variance Inflation Factor (VIF)**	**Tolerance (1/VIF)**
Age	1.23	.813
HH size	1.27	.787
Exp.	2.81	.356
Edu.	1.62	.617
CF	1.23	.813
FT	2.68	.373
DFC	2.24	.446
BS	1.30	.769
ST	1.33	.752
TR	1.17	.857
Mean VIF	**1.68**	

Source: Field survey, 2017
Age of fishermen (years), HH size (household size), Exp (fishing experience in years), Edu (educational level), CF (Credit facilities), FT (Fish training), DFC (duration of fishing trip in hours), BS (Boat size), ST (storage facilities on board), TR (transportation facilities)

From Table 5.3, there was no problem of multicollinearity as VIF and tolerance values for all the variables were less than the cut-off point of 10 and .10 respectively. Similarly, the overall mean VIF (1.68) is less than 10, indicating that multicollinearity issues did not exist.

5.6 Testing for Linearity

This describes the relationship among variables. The Pearson product-moment correlation was used to test the relationship among the variables of the study. According to Pallant (2007), the correlation values among the independent variables should not exceed 0.70. Equally, Piaw (2012) posited that correlation coefficient of ±.91 to ±1 is very strong; ±.71 to ±.90 is strong; ±.51 to ±.70 is average; ±.31 to ±.50 is weak and correlation coefficient of ±.01 to ±.30 is very weak. Correlation values of r = 0.1 is considered to have a weak relationship, r = 0.3 have moderate association while strong association is considered to be r = 0.5 and above (Acock, 2014). Table 5.4 shows the correlations results among the variables of the study.

Table 5.4
Correlations among Variables

Correlations	**Age**	**HH size**	**Exp**	**Edu**	**CF**	**FT**	**DFC**	**BS**	**ST**	**TR**	**PHFLs**
Age	1.000										
HH size	.193	1.000									
Exp	.124	-.065	1.000								
Edu	-.233	-.109	.313	1.000							
CF	-.159	-.101	.161	-.030	1.00						
FT	.146	.075	.374	.317	.020	1.000					
DFC	.065	.051	.476	.172	.257	.391	1.000				
BS	.025	-.140	.390	.112	.213	.408	.159	1.000			
ST	-.167	.055	.074	.410	-.137	.107	.112	-.029	1.000		
TR	.016	-.027	.046	-.254	-.010	-.084	.063	..052	.036	1.000	
PPHFLs	-.156	.086	.043	.312	-.120	.082	-.038	-.095	.131	-.281	1.000

Age of fishermen, HH size – Household size, Exp. – Fishing Experience, Edu. – Education, CF – Credit facilities, FT – Fish training, DFC – Duration of fishing cycle, BS - Boat size, ST – Storage facilities used, TR – Transportation system used, PPHFLs – Percentage Post-Harvest Fish Losses

From the results shown in Table 5.4, it can be deduced that there exist a linear relationship among the variables of the study.

5.7 Normality and Homoscedasticity Test

In order to check for deviation from the assumption, normality test was conducted. Data to be used for multiple regression analysis must be normally distributed (Hair et al., 2010). Statistical and graphical methods were used for testing of normality. For all the variables of the study, skewness and kurtosis were generated as shown in Table 5.5. According to Coakes and Steed (2003) and Hair et al (2010), rule of thumb stated that skewness and kurtosis should not exceed ±2.58 for normal data. The results obtained shows that the variables of the study are normally distributed. The graphical method used for assessing normality in a data was the histogram which showed normal distributed curve graph in Figure 5.1.

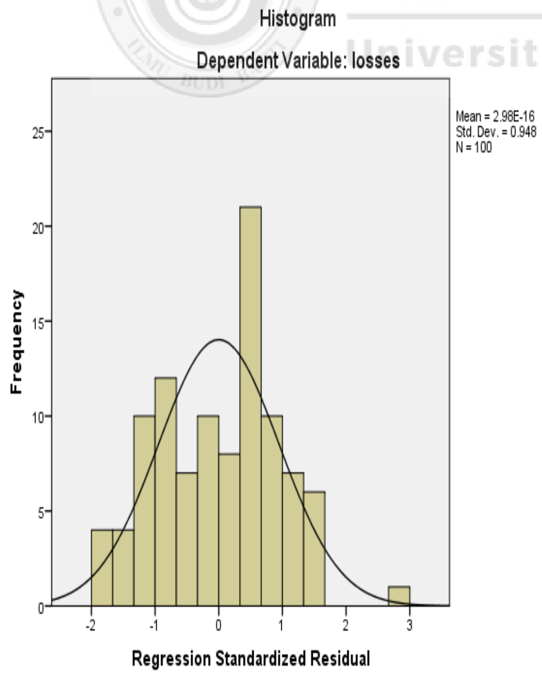

Figure 5.1
Histogram showing Normality of Data

Table 5.5
Normality Test Results

Variables	Observations	Skewness	Kurtosis
PPHFLs	100	.219	-1.381
Age	100	-.016	-.296
HH size	100	-.563	-1.013
Exp.	100	.510	-.504
Edu.	100	-.555	-.902
CF	100	-.081	-.034
FT	100	-1.523	.325
DFC	100	-.511	-.033
BS	100	-.767	.144
ST	100	-.572	-.236
TR	100	-.327	1.237

Note: PPHFLs = Percentage Post-Harvest Fish Losses, Age of fishermen, HH size = Household size, Exp. = Fishing Experience, Edu = Education, CF = Credit facilities, FT = Fish training, DFC = Duration of fishing cycle, BS = Boat size, ST = Storage facilities used, TR = Transportation system used

Moreover, Levene test of equality of variances was carried out among the variables of the study to assess the assumption of equal variance. Table 5.6 shows the results of Levene test. The test indicated that there was no serious issue from non-homogeneity of variance, as there was no significant value ($p > 0.05$) in the test result**.**

Table 5.6
Test for Homogeneity of Variance

Variables	Levene Statistics	df1	df2	Sig.
Age	2.043	2	97	.593
Household size	1.169	2	97	.315
Fishing Experience	1.571	2	97	.213
Educational level	.525	2	97	.135
Credit facilities	.747	2	97	.477
Fish training	.330	2	97	.720
Duration of fishing	1.908	2	97	.154
Boat size	1.379	2	97	.192
Storage facilities	1.641	2	97	.274
Transportation system	.974	2	97	.553

5.8 Summary

The dependent variable used for this multiple regression model is post-harvest fish losses (percentage value) whereas the independent variables include age (years), household size, educational level, fishing experience (years), access to credit facilities, form of fish training, duration of fishing cycle (hours), size of boat (meters), storage facilities (where fresh is placed after hauling of fishing net from the fishing ground) and transportation system (type of facilities use for transportation of fresh fish). From the result, the multiple regression model for this research indicated significant relationship ($P < .05$) and accounted for 78.36 percent of the variance in percentage post-harvest fish losses. Similarly, age, fishing experience, educational qualification, credit facilities, fish training, storage facilities and transportation system were significant ($P < .05$) and influence post-harvest fish losses negatively while duration of fishing cycle was significant and positively influence post-harvest fish loses respectively**.** From the multicollinearity test, result revealed that problem of multicollinearity does not exist based on the VIF and tolerance values. Similarly, correlation result showed that linear relationship exists among the variables. Furthermore, result of levene test of homogeneity of variance indicated that significant value does not exist in the result.

CHAPTER SIX

SUMMARY, CONCLUSION AND RECOMMENDATIONS

6.1 Introduction

This chapter presents the summary of the research findings and evaluates the contributions of the study where policy implications have been derived. The objectives of the study together with data analysis and findings are summarized in Section 6.2. Section 6.3 enumerates the implications of the study. Limitations of the study and recommendations for future research work are discussed in Section 6.4 while Section 6.5 concludes the chapter.

6.2 Summary and Major Findings

In spite of the significance of small-scale fisheries sector, it is challenged with post-harvest fish losses estimated about 30 – 50 percent landed weight (Olusegun & Matthew, 2016). This is a serious issue faced by the small-scale fisheries sector regardless of the high percentage contribution to total fish production. Empirical outcomes on post-harvest fish losses stated that there is deficiency of quantitative fish loss data and the available literature on the assessment of post-harvest fish losses does not provide clear-cut results about the major causes of post-harvest fish losses and are scanty. It was revealed that due to inaccessible road to rural fishing communities, lack of loss assessment method and different fish species have made it difficult for availability of quantitative data to provide the exact amount of fish loss for policy implementations. This situation simply shows that there is need for further research on post-harvest fish losses in small-scale fisheries in Nigeria where there is scanty of full studies on the subject matter. It is based on this affirmation that the current study is set to assess the post-harvest fish losses among small-scale/artisanal fishermen in Ondo

State, Nigeria and estimate the magnitude of post-harvest fish losses, causes and handling practices used by the small-scale fishermen.

The main objective of this study is assessment of post-harvest fish losses among small-scale/artisanal fishermen in Ondo State, Nigeria. Research objectives of this study is to calculate the magnitude of post-harvest fish losses at the landing site, examine the handling practices, storage facilities and transportation system used at the landing site, analyse the effect of handling practices, storage facilities and transportation system on post-harvest fish losses at the landing site and highlight the causes of post-harvest fish losses in the study area.

To accomplish the objectives of the study, primary data were collected between March and June, 2017 from the study area: Ondo State, Nigeria. Simple random sampling technique was used to collect cross-sectional data through structured questionnaire. 420 questionnaires were administered face to face to the small-scale fishermen out of whom 400 were used for the analysis due uncompleted information in the questionnaires by the fishermen. According to Hair et al. (2010) questionnaires with more than 50 percent unfinished information can be dropped. Descriptive analysis of the demographic factors, handling practices, storage facilities and transportation system were carried out. The data analysed revealed that all the fishermen were males in the study area which simply shows that fishing activities is majorly for men. Findings revealed that fishermen were still in their active age (31 – 40 years) and majority of them were married. Results showed that most of the fishermen had secondary education with 17 years of fishing experience on an average.

Calculation of post-harvest fish losses from data collected was done using fish loss model developed by Ward and Jeffries (2000) in collaboration Food and Agricultural Organization (FAO) and Natural Research Institute (NRI) of University of Greenwich. According to Diei-Ouadi and Mgawe (2011), it is tough to involve all the respondents in a location in Load Tracking (LT) loss assessment method due to nature of data, time and cost implications. Based on the difficulties involved, 25 percent sample of respondents is normally selected for this biometric aspect which represent the entire location. As a result of this, 25 percent of the sampled number of respondents for the QLAM (420 respondents) was used for this aspect which gives 105 fishermen while 100 were found useable.

Cross-tabulation (chi-square) was done using some demographic factors variables such as age, household size, educational level and fishing experience with percentage fish losses. Findings showed that there is a significant association between the demographic factors; age, household size, educational level and fishing experience and percentage post-harvest fish losses. Similarly, significant association exist between handling practices, lack of storage facilities and lack of good transportation system with percentage post-harvest fish losses. Furthermore, cross-tabulation analysis between demographic factors with boat size indicates that age of respondents and fishing experience was statistically significant with boat size. Likewise, credit facilities and fish training cross-tabulation results showed significant relationship with post-harvest fish losses. 5 -likert scale point was used to rate the severity of causes of post-harvest fish losses in the study area. This scale point was adopted from Nenna and Ugwumba (2014) which was used to rate the constraints faced by small-scale farmers in Anambra State, Nigeria. In addition, multiple regression model shows that age, fishing experience, educational qualification, credit facilities, fish training, duration of fishing cycle, storage facilities and transportation system were found to be statistically significant ($P < .05$) with post-harvest fish losses.

The findings of the empirical analyses are summarized as follows:-

On objective one which is to estimate the magnitude of post-harvest fish losses in the study area. Fish loss model was used to estimate post-harvest fish losses in the study area. This method was developed by Ward and Jeffries (2000) with the effort of Food and Agricultural Organization (FAO) and NRI for researchers that want to assess post-harvest fish losses in a single fish species and particular value chain. Losses was calculated for three dominant marine fish species and the result revealed that the mean percentage of fish losses per catch per day is 8.15 for croaker, 7.76 for catfish and 7.57 for shrimp respectively. This simply shows that post-harvest fish losses still exist due to lack of ice and suitable storage facilities on board and at the landing site. From information gathered from the small-scale fishermen, they revealed that losses have reduced compared to years back due to acquired fishing skills and reduced time spent for fishing trip but findings still showed that fish losses exist.

Furthermore, fishermen stated that in order to meet up with running cost for fishing trip, they ensure that they return early from the fishing trip due to lack of ice facilities in order for the fish catch to be in good condition and sold at a good price. According to Mungai, (2014) rate of spoilage increases when duration of fishing trip is long. Government needs to pay more attention to the small-scale/artisanal fishermen by providing adequate infrastructures such as ice block assistance, good storage facilities and constant supply of electricity which will help to keep their fish catch in good condition, improve their level of income and livelihood. Also, there is need to assist the small-scale/artisanal fishermen with micro-credit and fishing equipments at a subsidized rate and fisheries officials should provide capacity building for the fishermen.

To achieve objective two, the study further examines the handling practices, storage facilities and transportation system used at the landing site. Descriptive analysis was used for this objective. Results showed that mean duration of fishing trip used by fishermen is 12.22 hours. The fishermen make use of motorized dug-out boat and drift net as fishing gear due to the open sea environment they operate for their fishing activities. Other fishing gears such as traps, hooks and lines and cast nets were majorly used by women and children in the small rivers and lagoons around the communities because women are restricted from going into the open sea. This is in accordance with Akinwumi et al. (2011), that women generally use nets and traps to catch fish in most of the fishing communities in Nigeria. Findings revealed that fish catch where placed along with the net after hauling on the floor of the boat. This is due to lack of storage facilities such as insulated containers or iceboxes in the study area. Covering materials such as sack/nylon was used to cover the fish catch from the fishing ground to prevent direct sunlight to ensure good quality fish by the time they get to the landing site.

According to Namisi, (2005) opine that handling of fish by fishermen was very poor with captured fish being placed in open boats with limited or no use of ice. Lack of ice is a serious problem facing the fishermen in the study area due to lack of electricity. Equally, Mungai (2014) posited that rural fishing communities lack electricity. Due to lack of infrastructures to keep their fresh fish in good condition, fishermen offload their fish catch immediately on getting to the landing site without delay. Also, the fishermen ensure that their left over fresh fish are processed immediately against next market day. Abolagba and Nuntah, (2011) opine that fresh fish needs to be subjected to smoking after one day in order to maintain its quality. Result shows that fishermen do not degut their fish. Fishermen needs to be trained properly in the aspect of degutting to keep the fish in good state. This can increase the rate of spoilage quickly if care is not taken. The medium at which fresh fish is kept for transportation is poor since the fishermen do not use ice blocks in the study area. An open boat is used for transportation which do not consist of insulated containers with ice. However, there is need for government to support the small-scale fishermen by providing storage facilities such as cold room at the landing site, ice containers on board and good covering materials in the study areas. Also, non-governmental organizations (NGOs) should support the small-scale fishermen through their fishermen's associations by rendering assistance to them collectively.

Furthermore, causes of post-harvest fish losses were examined in the study area. List of variables causing post-harvest fish losses were compiled and inspected with 5-likert scale to determine the level of severity. Mean score of 3 point was used as a baseline to rate the severity level. Results revealed that duration of fishing cycle to landing site leads to losses, delays in hauling nets result in poor-quality fish resulting to quality loss, use of chemicals in fishing affects the safety and quality of fish posing threat to consumers' health, exposing of fish to high temperature creates favourable conditions for fish spoilage leading to quality loss and affecting price, poor handling practices during unloading of fish causes quality losses, lack of covering facilities for fresh fish at the landing site to prevent excess sunlight, failure to use ice and containers result in poor quality fish, insect infestation and animal predation on fresh fish leads to losses, lack of storage facilities to ensure good quality of fish can lead to losses, lack of good means of transportation for effective movement of fresh fish, high losses during rainy season, unexpected demand and supply situations can affect price and inadequate dissemination of market information can lead to selling of fish at a lower price resulting to market loss are all causes of post-harvest fish losses. Based on observation and information gathered in the study area, the major causes faced by the small-scale fishermen include lack of insulated container with ice, storage facilities and poor transportation system.

From the cross-tabulation outcome on relationship among demographic factors and percentage losses of fish (croaker, catfish and shrimp), results revealed that age, household size, educational status and fishing experience were all significant. This simply implies that as fishermen's age increases, they become more knowledgeable in their fishing activities and guide against post-harvest losses. Educational level of fishermen create willingness to accept new handling practices useful for their fishing activities. Likewise, the more their household size, the more the responsibility of fishermen and they spend longer period during fishing to cater for their family. As fishing experience increases, the lesser the fish losses because fishermen are more experienced to put in precautions required. Therefore, null hypothesis (H_o) is rejected while alternative hypothesis (H_a) is accepted. In addition, cross tabulation analysis to determine the effect of handling practices, storage facilities and transportation system on post-harvest fish losses at the landing site showed that there is an association ($P < 0.05$) between the duration of fishing cycle, storage facilities and transportation system with percentage losses. This simply implies that H_a (alternative hypothesis) is accepted why H_o (null hypothesis) is rejected. Result indicated that the higher the time spent on fishing cycle the higher the post-harvest losses. This indicates that increase in post-harvest fish losses is associated with increase duration of fishing trip. Findings revealed that if time spends for fishing trip could be reduced, losses will reduce and fish will be in good quality. Also, appropriate storage facilities on board and landing site will keep the fresh fish in good state and attracts good prices. Moreover, cross-tabulation for demographic factors (age, household size, educational level and fishing experience) with boat size indicated that there exist significant relationship ($P < 0.05$) between age of respondents and fishing experience with boat size. This implies that the age of respondents and fishing experience determines the size of boat used for their fishing activities. Likewise, access to credit facilities and fish training cross-tabulations results showed statistical significant with percentage fish losses. This denotes that if small-scale fishermen have access to credit facilities and adequate fish training fish losses will be reduced.

The result of multiple regression model showed that 78.36 percent of the independent variables predict the dependent variable which implies that the model is fit. The model shows that age, household size, educational level, fishing experience, credit facilities, fish training, duration of fishing trip, storage facilities used and transportation were statistically significant ($P < .05$) to influence post-harvest fish losses.

6.3 Implications of the Study

The findings of this study have implications for small-scale fisheries sector, academics, non-governmental organization and policy makers. The study addresses the implications on theoretical and practical aspect as follows:

6.3.1 Theoretical Implications

Small-scale/artisanal fisheries worldwide have been rated as being poor due to lack of infrastructural facilities, low-income level and poor livelihood (Ibengwe & Kristofersson, 2010; Olusegun & Matthew, 2016). According to World Development Report (2008), increase in fisheries sector production can only be accomplished by appropriate technology, which will reduce poverty among the small-scale fishers and improve food security. Previous studies stated that infrastructural facilities are inadequate in many rural fishing communities (Lokuruka et al., 2015 and Olusegun & Matthew, 2016). Likewise, post-harvest fish losses are the main issue faced by small-scale fisheries sector. This study contributes by providing exact amount of percentage fish losses of the dominant marine fish species in the study area, causes of post-harvest fish losses and suggests measures for reduction of post-harvest fish losses in Nigeria.

Odongkara and Kwangwa, (2005) stated that future research should be carried out to observe the financial losses of fish by fishermen while Jeeva et al. (2007) opine that infrastructural system should be looked into in small-scale fisheries sector. Equally, Enujiugha and Nwanna, (1998) suggested more research work on handling and hygiene practices used by small-scale fishermen. Likewise, Ahmed, (2008) and Mungai, (2014) are of the same opinion that in order to reduce post-harvest fish losses, quantitative loss assessment of the problem must first be carried out. Ibengwe and Kristofersson (2010) posited that provision of quantitative data and real information regarding causes of post-harvest fish losses would help in loss intervention. This study was able to calculate post-harvest fish losses and financial losses for three dominant marine fish species at the landing sites and resulted showed mean loss value of 8.15 percent for croaker, 7.76 percent for catfish and 7.57 percent for shrimp respectively per catch per day in the study area. Therefore, this study contributes to the literature by responding to the recommendations.

Furthermore, this study contributes by examining the various handling practices used and causes of post-harvest fish losses for policy suggestion. Findings revealed that small-scale fishermen needs to be trained on proper handling practices on board such as degutting of fish, washing and storing of fish in a clean container from fishing ground to the landing site. According to Mungai, (2014), adequate training on fish handling practices should be given to fishermen. Results showed that mean duration for fishing trip in the study area is 12 hours. This is so in order to ensure that fish is still in good quality before getting to the landing site. It was observed that the longer the length of fishing trip, the higher the losses. Some of the variables causing fish losses include duration of fishing cycle, delays in hauling nets, poor handling practices, lack of storage facilities, lack of covering materials and lack of ice. This simply shows that if these causes are critically worked upon there is every possibility that post-harvest losses will reduce drastically in the small-scale fisheries. Hence, this study contributes to literature by examining the handling practices used by fishermen and highlight the various causes of post-harvest fish losses.

Additionally, research discovers that small-scale fishermen's happiness and improve livelihood rest in the provision of adequate infrastructural facilities in the small-scale fisheries sector. Olusegun and Matthew (2016) and Tesfay and Teferi (2017) posited that role of infrastructural facilities cannot be underestimated in the small-scale fisheries sector. It has been observed that despite efforts of small-scale fishermen in the necessary practices to ensure decrease in post-harvest fish losses, no positive result can be achieved if infrastructures are lacking. Infrastructural facilities such as electricity, ice block machines, good road network and storage facilities should be provided. Once all these are provided, fish losses will reduce, good quality of fish will be achieved which in turn attracts good prices, increase their income level and ensure food security. This study contributes towards improvement of small-scale fishermen's livelihood.

6.3.2 Practical Implications

Based on the results of the study, this study recommends to NGOs stakeholders, government, small-scale fisheries sector and policy makers to encourage small-scale fishermen especially the young ones to participate in fishing and should be well trained on effective handling practices in small-scale fishing. Small-scale fishermen should ensure that fish are handled properly on board by degutting, washing and storing in containers that are clean. Besides, duration of fishing time should not go beyond 12 hours irrespective of the fishing gear. This will ensure fish remain in good condition at the landing site. Post-harvest fish losses is significantly influenced by age of the fishermen, educational status, fishing experience, credit facilities, fish training, duration of fishing trip, storage facilities used and transportation system.

Government should allocate funds for small-scale fishermen or provide them with suitable fishing gears which will help their fishing activities. Resources used by small-scale fishermen are very limited due to lack of financial assistance. Government spent huge money on importation of fish yearly but cannot provide for fisheries sector where untapped resources are lying fallow. Considering the fact that this sector contributes about 80 percent to total fish production, diverting part of the money spent on importation to improve the fisheries sector especially at this time of recession will go a long way. This will increase the local fish production of the country and GDP. There is a need for thoughtful consideration by the government to evaluate budget policy and spend more on small-scale fisheries sector. Similarly, post-harvest fish losses data should be incorporated into collection systems for national data and fisheries department for better policy making.

Information and knowledge on fish handling should be given to the fishers to reduce fish losses during fishing activities. Adequate training and meetings should be organized by the fisheries department to educate fishers more on the basic hygiene required before, on board and after fishing activities. This will give room for discussion and fishers will be able to state problems encountered during fishing activities for proper suggestions to help their fishing business. Similarly, fishers need to be educated about the positive effect of ice on quality of fish. This will make implementation of reduction loss intervention easy through use of ice. Small-scale fishers should be encouraged to form cooperatives and see how to provide ice blocks among themselves for the safety of their fresh fish.

Based on the findings of the study, current study recommends that government, fisheries sector and NGOs stakeholders should increase their spending on small-scale fisheries, their livelihood (good health facilities and educational system) and infrastructural facilities. Policy should be made and allocation of budget on storage and ice facilities that will help to reduce fish losses. Government and other non-governmental organizations should put necessary measures on ground and ensure that these expenditures are distributed accordingly, benefitted by the small-scale fishers and carried out effectively. In addition, government and development agencies should set action plan regarding post-harvest fish losses intervention that covers fishing development in the future.

Government should focus more on providing infrastructural facilities such as construction of good transport system to the markets, storage facilities like cold room, source of power supply, provision of ice and covering materials in order to reduce post-harvest losses among the small-scale fishermen in the rural fishing communities of Nigeria. Taking steps in providing infrastructural facilities to small-scale fisheries will help in terms of economic development, improve fish quality which will attracts good price and improve fishers' standard of living. This study recommends implementation of developmental agenda in order to drive small-scale fisheries to ensure food security.

Furthermore, survey on national living standard should be conducted by Bureau of Statistics at short intervals. This will give continuous check on poverty level in the rural fishing communities in the country and provide recent data for researchers interested in evaluating the impact of intervention programmes such as Millennium Development Goals (MDGs) and National Poverty Eradication Programme (NAPEP) by the government on alleviation of poverty in the area.

Hence, there should be a system design for monitoring and evaluating of post-harvest fish loss. The Federal Department of Fisheries needs to assign fisheries team consisting of Nigerian Institute of Oceanography and Marine Research, Department of Fisheries to establish the monitoring of post-harvest fish loss nationally. State and Local Governments should also be inclusive in the structure by coordinating and providing enumerators to be used.

6.4 Limitations of the Research

This study has some certain limitations since there is no research work that is final and conclusive. The future recommendations of this study are established on the limitations of the present study. In this study, data is collected from Ondo State only and not the whole of Nigeria due to financial constraints, time limitations and inadequate security of the country presently. Studies in the future can take samples from the whole of Nigeria.

This study observes the magnitude of post-harvest fish losses at the landing site on major dominant marine fish species in the study area; future researchers can examine the extent of post-harvest fish losses on processed fish or on other fish species at the landing site.

This study focused on small-scale fishermen who make use of drift net fishing gear for their fishing activities due to the area of fishing operation while future researchers can assess post-harvest fish losses among small-scale fishermen using cast nets, hooks and lines or other fishing gears.

This study is based on small-scale fisheries sector while future researchers can interview the government and non-governmental agencies and design policies that will benefit the small-scale fishers or investigate the impact of financial assistance on small-scale fishers livelihood.

6.5 Recommendations for Future Research

However, studies in future on this subject matter can be extended to the assessment of post-harvest fish losses from the processors to the marketers in the small-scale fisheries sector. This would additionally improve the scope and make the outcomes more strong.

Also, future studies can assess post-harvest losses on other agricultural products. This will help the government to diversify more into various agricultural sub-sectors to improve the economy.

Additionally, futures studies on similar study can cover more zones and different fish species in the country in order to provide more data on post-harvest loss in the fish loss database.

6.6 Conclusion

This study is exceptional in view of its contributions to the development agencies, academics and policy implications. It is also timely to the effect that Nigeria which is blessed with natural resources wants to diversify into agriculture in order to come out of economic recession and ensure food security for the growing population.

Moreover, creation of National Poverty Eradication Programme (NAPEP), which aims at ensuring complete restructuring for better performance especially towards rural areas, should be provided. In order to achieve economic development in the rural areas, projects on rural integration should focus on provision of health facilities, good education system, provision of constant power supply, good storage facilities for produce and construction of good road network. By this, poverty will be reduced among the rural dwellers, minimize migration from rural-urban and reduction of amount spent on yearly importation of fish. If the government can pay more attention on the empirical findings, positive changes in the small-scale fisheries will be achieved.

Based on research, post-harvest fish losses is one of the critical issues faced by small-scale fisheries in all the developing countries in the world. Awareness should be created for the small-scale fishermen on ways by which they can reduce post-harvest fish losses such as good handling practices, use of covering materials, use of ice and insulated containers, appropriate storage facilities and use of suitable facilities for transportation of fish. Also, Fisheries Department should provide capacity building while fisheries officials should organize enlightenment programmes by training fishers on handling practices to be used on the fishing ground to the landing site until it gets to the consumer. Moreover, fisheries officials should ensure that small-scale fishermen's benefits are given to them accordingly. For instance, distribution of fishing gears at a subsidized rate and provision of covering materials that will help to maintain their fish quality.

In addition, significant relationship occurs between demographic factors (age, household size, educational status and fishing experience) and percentage post-harvest fish losses. Also, age and fishing experience showed statistical significant with size of boat used while access to credit facilities and fish training indicated significant relationship with post-harvest fish losses respectively. From the result, 8.15 percent for croaker, 7.76 percent for catfish and 7.57 percent for shrimp respectively were losses incurred by the fishermen per catch per day in the study area. The result of the regression model showed that post-harvest fish losses are influenced by age, educational level, fishing experience, credit facilities, fish training, duration of fishing cycle, storage facilities used and transportation system. Small-scale fishermen do not make use of ice on board but ensures that they cover their fish from excessive sunlight in order to maintain good fish quality. Small-scale fishermen should form cooperatives to assist in buying of ice and storage facilities to store their fish to reduce post-harvest fish losses.

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APPENDIX 1

SURVEY QUESTIONNAIRE

Research Title: An assessment of post-harvest fish losses among small-scale fishermen in Ondo State, Nigeria.

Objective: To determine the magnitude and factors influencing post-harvest fish losses in Nigeria with respect to handling practices, storage practices and transportation system used by small-scale fishermen.

Target: Small-scale fishermen

Dear Respondent

I am a Ph.D. research student in the University Utara Malaysia (UUM), currently conducting a survey on the aforementioned titled research. The following are self-explanatory questions that will not take much of your time to answer. Your kind response would be appreciated as it will significantly contribute towards achieving the objectives of the study. Please note that your response will be treated strictly confidential and for academic purpose.

Please do not hesitate to contact the researcher for any enquiry about this research.

Thank you.

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QUESTIONNAIRE

Instructions: To be completed by enumerator

Please tick (√) your choice and fill in the answer in spaces provided. Your answers will be treated confidentially.

Section A: DEMOGRAPHIC FACTORS OF THE RESPONDENT

1. Location…………………….
2. Age: ……..years
3. Sex: (i) Male ( ) (ii) Female ( )
4. Religion: (i) Christianity ( ) (ii) Islam ( ) (iii) Traditional ( )
5. Marital status: (i) Single ( ) (ii) Married ( ) (iii) Divorced ( ) (iv) Widowed ( )
6. Tribe: (i) Hausa ( ) (ii) Igbo ( ) (iii) Yoruba ( ) (d) Others ………..
7. Household size: …………………….

8. What is your level of education? (i) No formal education ( ) (ii) Primary ( ) (iii) Secondary ( ) (iv) Tertiary ( )
9. How long have you been into fishing?...................years
10. Do you have other sources of income aside fishing? (i) Yes ( ) (ii) No ( )
11. If yes, state …………………………………….
12. Do you belong to any fish association group? (i) Yes ( ) (ii) No ( )
13. Do you have access to credit facilities? (i) Yes ( ) (ii) No ( )
14. Have you had any fishing training before? (i) Yes ( ) (ii) No ( )

SECTION B: MAGNITUDE OF POST-HARVEST FISH LOSS AT THE LANDING SITE

Species	**Total weight of fish catured (kg)**	**Prices of fish (₦)**	**Weight of low quality fish (kg)**	**Price of low quality fish (₦)**

SECTION C: CAUSES OF POST-HARVEST FISH LOSSES
Kindly tick (√) as appropriate

Items	Disagree (1)	Strongly Disagree (2	Neutral (3)	Agree (4)	Strongly Agree (5)
1. Duration of fishing cycle to landing site leads to losses					
2. Delays in hauling nets result in poor-quality fish					
3. Use of chemicals in fishing affects the safety and quality of fish posing threat to consumers' health					
4. Exposing of fish to high temperature creates favourable conditions for fish spoilage leading to quality loss and affecting price					
5. Discarding of bycatch at sea because fish is too small or not valuable enough to land for sale					
6. Fishing gear used by the fishermen causes quality loss					
7. Poor handling practices during unloading of fish causes quality losses					
8. Lack of covering facilities for fresh fish at the landing site to prevent excess sunlight					
9. Failure to use ice and containers result in poor quality fish					
10. Insect infestation and animal predation on fresh fish leads to losses					
11. Fish spoil easily if not preserved properly with ice during fishing					
12. Lack of storage facilities to ensure good quality of fish can lead to losses					

13. Lack of good means of transportation for effective movement of fresh fish
14. Unexpected demand and supply situations can affect price
15. Inadequate dissemination of market information can lead to selling of fish at a lower price resulting to market loss
16. High post-harvest fish losses occur during rainy season

SECTION D: HANDLING PRACTICES

1. What is the duration of fishing trips?...........................hours
2. How many days do you go for fishing per week? (i) 4 times ( ) (ii) 5 times ( ) (iii) 6 times ( ) (iv) 7 times ( )
3. What type of fishing gears do you use for fishing? (i) Drift nets ( ) (ii) Cast nets ( ) (iii) Hooks and lines ( ) (iv) Others specify …….
4. Types of fishing boats used (i) Plank ( ) (ii) Metal ( ) (iii) Aluminium ( ) (iv) Others specify …………
5. What is the size of the boat used? (i) 7 meters ( ) (ii) 8 meters () (iii) 9 meters ( )
6. Are fish iced before and after landing? (i) Yes ( ) (ii) No ( )
7. If no, state why…………………………………………………………………
8. What other forms of method do you use to preserve fresh fish from the fishing ground to the landing site?
   (i) Ice ( )
   (ii) Evaporative cooling method ( )
   (iii) Covering of fish with sack/nylon ( )
   (iv) Others specify ……
9. Are fish landed and offloaded without delay? (i) Yes ( ) (ii) No ( )
10. If no, state why…………………………………………………………………
11. Where is fresh fish placed at the landing site?
    (i) On the ground ( )
    (ii) Plastic basin ( )
    (iii) Woven basket ( )
    (iv) Others specify……………….
12. How do you sell your fresh fish at the landing site?
    (i) Per kilogram ( )
    (ii) Hand ( )
    (iii) Basket ( )
    (iv) Others specify ………………….
13. At the landing site after sales, do you normally have leftovers of fresh fish?
    (i) Yes ( ) (ii) No ( )
14. If yes, what do you do?...

Tick (√) the following cleaning practices at the landing site

Items	Yes	No
1. Cleaning of boat after landing		
2. Cleaning of fishing hold and accessories		
3. Cleaning of fishing gear		
4. Washing of fish		
5. Sorting of fish		
6. Evisceration and removal of gills		
7. Icing of fish		

SECTION E: STORAGE OF FRESH FISH

1. Where is the fresh fish stored after removal from the fishing ground?
   (i) Ice box ( )
   (ii) Plastic basin ( )
   (iii) On tarpaulin ( )
   (v) Placed on the floor of the boat with net ( )
   (vi) Others specify …………………
2. What storage methods do you use to preserve fresh fish at the landing site?
   (i) Insulated room ( )
   (ii) Container with Ice cubes ( )
   (iii) Container with water covered with leaves ( )
   (iv) Container with water covered with tarpaulin ( )
   (v) Others specify ………….
3. What do you do in case of spoiled fresh fish?
   (i) Discard the spoiled fresh fish ( )
   (ii) Mix with fresh fish ( )
   (iii) Sold at a lesser price ( )
   (iv) Smoke ( )
   (v) Sold at a lesser price and smoke
4. In case of left overs, how will you preserve your fresh fish after sales?
   (i) Keep in a container ( )
   (ii) Processing and sold next market day( )
   (iii) Others specify ……............
5. What is the distance from landing site to the market?.......km
6. Do you apply disinfectants before fish storage? (i) Yes ( ) (ii) No ( )
7. If yes, what type?..
8. What influences rate of spoilage of fresh fish from fishing ground to the landing site?
   (i) Time ( )
   (ii) Excessive sunlight ( )
   (iii) Poor handling practices ( )
   (iv) Others specify ………………………..

SECTION F: TRANSPORTATION OF FISH

1. Is there provision of cooling facilities in the transportation system from the fishing ground to landing site? (i) Yes ( ) (ii) No ( )
2. How do you transport your fresh fish from the fishing ground to the landing site? (i) In an open canoe ( ) (ii) Use of insulated container ( ) (iii) Use of ice boxes ( )
3. Do you experience any spoilage during transportation? (a) Yes ( ) (b) No ( )

4. If yes, state the causes?..
5. What type of facilities do you use to carry your fresh fish?
   (i) Container ( )
   (ii) Basket ( )
   (iii) Polythene bag ( )
   (v) Others specify ( )
6. Where do you sell your fresh fish?
   (i) Landing site ( )
   (ii) Transport to the market ( )

Suggest measures to be taken on solving post-harvest fish losses

(1)
(2)
(3)
(4)
(5)

Thank you

APPENDIX 11

PICTURES

Nematopalaemon hastatus ***Parapenaeosis atlantica***

Macrobrachium macrobrachion ***Penaeus notialis***

Fishermen preparing for fishing

Wooden canoe and outboard engine for fishing

Going for fishing

Fishing gear

Wooden plank boats used for fishing