SUSTAINABLE FISHERIES MANAGEMENT PROJECT (SFMP)

Energy Expenditure Survey and Assessment of the Economics of Fish Processing at Anlo Beach

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Cover photo: Heap of fuelwood awaiting bumper season (Credit SNV)

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Spatial Solutions:	http://www.spatialsolutions.co/id1.html

ACRONYMS

Only include acronyms used in the text

CCT	Controlled Cooking Test
CEWEFIA	Central and Western Region Fishmongers Improvement Association
CR	Central Region
CRC	Coastal Resources Center at the Graduate School of Oceanography, University of Rhode Island
CSLP	Coastal Sustainable Landscapes Project
DA	District Authorities
DAA	Development Action Association
DAASGIFT	Daasgift Quality Foundation
FC	Fisheries Commission
FIRR	Financial Internal Rate of Return
FoN	Friends of Nation
FtF	Feed the Future
HM	Hen Mpoano
ICM	Integrated Coastal Management
ICT	Information, Communication Technology
NGO	Non-Governmental Organization
NPV	Net Present Value
PB	Pay Back
SFC	Specific Fuelwood Consumption
SNV	Netherlands Development Organization
SS	Spatial Solutions
SSG	SSG Advisors
UCC	University of Cape Coast
URI	University of Rhode Island
USAID	United States Agency for International Development
USG	United States Government
WR	Western Region

TABLE OF CONTENTS

CONTENTS

LIST OF FIGURES

LIST OF TABLES

INTRODUCTION

The United States Agency for International Development (USAID) has committed funds to the implementation of the Sustainable Fisheries Management Project (SFMP) in Ghana for five years.

The objective is to rebuild marine fisheries stocks and catches through adoption of responsible fishing practices. The project will contribute to the Government of Ghana's fisheries development objectives and USAID's Feed the Future Initiative.

The project is being implemented by the Coastal Resource Center (CRC) of the University of Rhode Islands (URI) through a consortium of international and local partners, including SNV Netherlands Development Organization.

In Ghana, fuelwood use is dominant in rural households: more than 2.2 million families depend on it for cooking and heating, and at least 280 000 of them use it for small-scale processing activities, such as fish smoking, gari making, pito brewing, akpeteshie distillation, pottery making, oil extraction (from palm fruits, coconut, groundnut, shea butter), thus making a significant contribution to food preservation, food security and cash earnings for rural and urban people (FAO, 2010).

Fishing and fish smoking are the major occupations along the coastline and the communities along the freshwater sources with their economic activities highly dependent on wood fuel resources. Fishing occupation is mostly a masculine job but the women concentrate more on how to preserve the fish for the market.

Traditional fish smoking in Africa is essentially a drying process to preserve fish in the absence of refrigeration. On the Ghana coastline, various traditional methods exist for fish preservation and storage which includes sun drying, salting, frying and fermenting and various combinations with smoking being the most dominant one (Brownell B., UNICEF,1983).

One major concern of the fish smoking business is the total dependency on fuelwood resources for energy. According to an assessment undertaken by SNV in 2014, Ghana's coastline and Volta Lake basin is lined up with over 120,000 fish smoking stoves which are in constant use at an average of 5 days per week. This is a clear indication of high reliability and dependence on the forest resources for fish smoking energy needs.

It has been estimated that environmental degradation in the major natural resource sectors costs 5-10% of GDP, with the forest sector accounting for 63% (USD $500 million) of this cost (FORESTRY COMMISSION, 2010b). According to the Food and Agriculture Organization of the United Nations (FAO), 21.7% of land in Ghana (equivalent to 4,940,000 hectares) is covered by forest (FAO, 2010). Of this, 8% (395,000 hectares) is classified as highly bio-diverse and carbon dense primary forest and 260,000 hectares are plantations (FAO, 2010). Deforestation has been identified as a critical environmental issue and Ghana has lost more than 33.7% of its forests, equivalent to 2,500,000 hectares, since the early 1990s (FAO, 2010). Between 2005 and 2010, the rate of deforestation was estimated at 2.19% per annum; the sixth highest deforestation rate globally for that period (FAO, 2010).

Contributing to the high rate of deforestation is the widespread use of inefficient fish smoking techniques. The popular fish smoking stove used in Ghana is the Chorkor stove introduced in Ghana by FAO in 1969. Since then, there has been few improvement attempts with recorded successes as well as some failures. Some of the successful innovations and improvements to the Chorkor stove include the Morrison stove, Frismo/Frismo stove, AWEP stoves among others. This study will investigate and compare the energy budgets and economics of using the various fish smoking techniques. The Anlo Beach community is used as a case study.

PROBLEM STATEMENT

The research is directed at addressing three main deficiencies in knowledge identified in the fish processing business: (1) limited knowledge on energy budget for fish smoking business (2) limited research on the comparative economics of fish processing technologies available (3) gab in knowledge on the mass of fuelwood consumed per annum for effective and sustainable fuelwood planning.

Existing literature provides that, Ghana’s fuelwood consumption is estimated at 20.6 million cubic meters per year while it provides about 71% of the country’s annual energy demand. Wood fuel supports most informal enterprises including bread-baking, processing of oil-palm, local breweries, traditional soap making, fish smoking and traditional food services. About 90% of rural households use firewood or charcoal for cooking. Demand for wood fuel is increasing with oil prices and local government agencies derive substantial revenue from wood fuel taxes and with a potential to increase such revenues if the trade is regularized (Mason, J. NCRC, 2008).

Generally, fuelwood production and marketing in most parts of Africa requires only minimal financial and human resources with the raw material which is the wood often obtained for free. The fuelwood business is thus suitable for the socio-economically rural poor, contributing to their household income as well as providing a safeguard against food shortages, unemployment and other similar poverty-related risks (Obiri et al., 2015).

In Ghana, fuelwood gathering and sale coupled with fuel-based income generating activities are very important livelihoods in forest fringe rural communities (Amuah, 2011). Many of the rural population rely of adjacent forest resources particularly, fuelwood as secondary income source to supplement farm income (Obiri et al., 2014).

According to FAO (2007), studies have only recently begun to address issues such as the income and expenditure potential for households from wood fuel trade.

Ocansey (1985), examined fuelwood exploitation in a village on the outskirts of Accra, and found that the trade to Accra and other urban centers provided important economic activity for most villagers especially during fishing seasons. On the average 50.94 cubic meters of wood fuel left the village every day as compared with an estimated consumption of 1.37 cubic meters per capita per year. As to how much of the wood is been consumed for fish processing is yet to be investigated.

The absence of a comprehensive knowledge of the demand, a fuels substitution policy may lead to undesirable consequences for the national economy. On the other hand, since neither the environmental impact of charcoal and wood fuel use nor the potential for other mitigation policies were assessed, the chance to develop other, more cost-efficient alternatives was lost. It is clear now that wood fuels are produced and marketed with a minimum use of foreign currency (FAO, 2000).

Table 1 Energy consumption and primary sources in Ghana, 2000

Electricity	Oil and derivatives	Charcoal	Fuelwood
7 838 000 MWh	1 095 000 tonnes	1 000 000 tonnes	8 200 000 tonnes

Source; FAO (2000)

According to Obiri et al., (2014), 96% of fish processors along the coast uses fuelwood as the main source of fuel for their business. Materials like coconut shells, and sugar cane husks are normally used to generate smoke.

An assessment by SNV in 2014 revealed that, Ghana's coastline and Volta Lake basin is lined up with over 120,000 fish smoking stoves which are in constant use at an average of 5 days every week. This is a clear indication of high reliability and dependence on the forest wood fuel resources for the energy needs of fish processing business.

The stove improvement attempts to the traditional fish smoking stoves include; Modified Drum Kiln, Morrison Stove, Frismo/Frismo Fish Smoking Stove, SIF-support Improved Fish Smoking Stove Kwarteng, E. (2013). Their efficiency levels, usage information, energy expenditure as well as the economics of choosing a particular stove technology is yet to be investigated.

Objectives of the Study

The overall objective of this study is to compare the energy consumptions levels, expenditure and economics of the available stove technologies to provide an evidence based information on the fish processing business as well as to be able to plan for future energy use and the development of sustainable mitigation measures.

Specifically, the study seeks to;

- Find out fuelwood consumption levels of all available fish smoking processing techniques in Anlo beach.
- Determine the total expenditure on energy per processing technology
- Determine the quantities of fuelwood consumed per season
- Determine the annual wood consumptions and its financial budgets
- Evaluate using financial indicators the technologies that is worth investing in.

Significance of the Study

The purpose for the study is to critically assess the available stove technologies, their economic benefits, and user friendliness and deduce financial indicators to guide selection and promotion. This knowledge will guide fish processors to make informed choices as far as investment is concerned. This will also guide SFMP implementing partners to streamline their stove promotion messages.

Methodology

The analysis required carrying out series of energy efficiency assessments of the available stove technologies, direct measurements and observations. For energy assessment of stoves, the controlled cooking test (CCT) method was used. This method provides information on percentage improvement in energy efficiency of one stove over another using a standard fish smoking process. The CCT is one acceptable method of carrying out such assessments. The test was carried out with assistance of the stove users just as in their normal smoking business; and relevant data was collected. The audit was carried out on the following stoves; Morrison Brick, Morrison Clay, Frismo and the Chorkor stove.

The soft smoking approach was applied in all cases and the information collected included: (1) fuel consumption; (2) time to complete smoking; (3) smoke production; (4) convenience of using the stove. Soft smoking method is specifically employed when smoked fish is not intended to be stored but rather consumed within a short period of time. The average shelve live of a soft smoked fish is 3days. Soft smoking requires less fuel, energy and time. The fuel consumption and time to smoke the fish were measured, the smoke production and the convenience of using the stoves were assessed by questionnaire and observation.

Fuelwood was directly weighed to determine the quantity and price relationships so as to determine consumption levels of each technology.

Twenty-six (26) fish processors were purposively sampled from a population of 190 fish processors from Anlo beach, based on respondents' processing technology as well as accessibility. Structured questionnaires were used to carry out interviews to fetch both generic and specific information on the fish processing business.

FISH SMOKING IN GHANA

Fish is an important source of food and income to many people in the developing world. In Africa, some 5 percent of the population, about 35 million people, depend wholly or partly on the fisheries sector, mostly artisanal fisheries, for their livelihood.

Fish smoking in Ghana is traditionally carried out by women in coastal towns and villages along river banks and on the shores of Lake Volta. Smoking is the most widely practiced method: practically all species of fish available in the country can be smoked and it has been estimated that 70-80 percent of the domestic marine and freshwater catch is consumed in smoked form.

Until the end of the 1960s, the ovens most used for smoking fish in Ghana were cylindrically and rectangular designed with mud or metal. Using these ovens had considerable disadvantages such as excessive handling of fish during smoking, a problem more severe when smoking small species of fish such as anchovies.

The health of women fish smokers was also placed at risk as a result of the smoke entering their eyes and lungs, their fingers being burnt and exposure to direct heat. The smoking procedure was very laborious and poor quality smoked fish of low market value was produced.

In the 1960s and 1970s, several types of traditional ovens were used for fish smoking. They could not cope with the large volume of fish landed, because of their low capacity and laborious operating process.

The ovens had low capacity and were inefficient in fuel usage. Since the fishing season mostly coincided with the raining season, the fish could not be sun-dried. The traditional ovens were inefficient, more firewood than necessary was used for smoking, which contributed to forest depletion. Fish arrangement in the traditional stoves system prevents efficient circulation of heat and smoke since fish is kept in layers with one on top of the other.

The smoking process had to be interrupted frequently to rearrange the layers to prevent fish from charring. In cases where sticks are used to separate the layers, the sticks exert considerable pressure on the fish, often disfiguring the smoked product and reducing its market value.

The Chorkor stove

In the light of lessons learned from the constraints and disadvantages associated with the earlier ovens, an improved traditional fish smoking oven, the Chorkor, was developed and introduced in 1969. This innovative model, developed by the Food and Agriculture Organization (FAO) of the United Nations and the Food Research Institute of the Council for Scientific and Industrial Research (CSIR) in Ghana, has since demonstrated the potential of traditional technologies in meeting smoking challenges such as capacity and processing time.

Figure 1 Chorkor Stove in Use

The Chorkor Stove, named after a small fishing community on the outskirts of Accra, has numerous advantages. It is cheap to construct and can be assembled using locally available materials. Easy to use, with large capacity and produces quality smoked fish. This simple, highly effective fish smoking technology was popularized in Ghana through a number of training programs and promoted using a participatory approach.

Morrison Stove

Morrison Stove is a product of Morrison Energy Limited, a private enterprise that aims at improving the fish smoking industry with new stove technologies targeted at energy efficient and user friendliness. Morrison Energy Limited over the years has come out with some interventions to solve the current high fuelwood consumption and smoke problems associated with the Chorkor smoker. The design has special trays that interlock with one another and prevent smoke escape from the sides of the stove. The stove has a cover with a built-in chimney to direct the smoke above and away.

According to energy assessments conducted by SNV Ghana in 2012, the Morrison stove was 39% more fuel efficient than the Chorkor stove, using 0.38 kg fuel wood per kg smoked fish while the predominantly used Chorkor stove uses 0.62 kg fuel wood per kg smoked fish.

Figure 2 Picture of the Morrison Stove

Frismo Fish Smoking Stove

Frismo stove is an improved fish smoking stove design by the Food Research Institute of the Council for Scientific and Industrial Research (CSIR) with the aim of reducing fuelwood consumption and smoke-causing diseases. Frismo improved fish smoking stove has a chimney that penetrates through a roof. This makes the stove very comfortable to be used under a shed. It has eight metallic trays where fish are arranged for smoking. Frismo stove has two burning chambers located at the lower corners of the stove and a door that prevents smoke escape during smoking as shown in figure 3.

Figure 3 Picture of the Frismo Stove

FISH PROCESSING BUSINESS

Socio-demographic Characteristics of fish Processors at Anlo Beach

Anlo beach is a small fishing community located in the Shama District in the Western region of Ghana. Ewes forms the majority part of the population with Anlo language being their main dialet. Artisanal fishing is the major economic for the men whereas women in the community engage in fish processing activities such as fish smoking, frying, salting and fermentation. The land area of Anlo beach community is elevated at an average of 14 meters above sea level. However the community is occasionally get flooded during high tides.

Gender, Age & Experience

Fish smoking is a women dominated business in Anlo Beach. 99% of the fish processors are women. Both the young and the old between the ages of 31 and 69 engage in the fish processing business with an average age 47 years (Table 2). The average working experience for fish processor at Anlo Beach is 18 years. (Table 3).

Table 2 Age Distribution

Mean	Min.	Max.	Std Deviation
46.6	31	69	10.2

Table 3 Smoking Experience

Mean	Min.	Max.	Std Deviation
18.25	1	40	11.1

Type of stove used and Ownership

Chorkor smoker is the popular fish smoking stove used in Anlo beach with about 600 chorkor stoves installed and in frequent use. 76% of fish processors in Anlo beach use Chorkor stove only, 23% of the processors use both the Chorkor stove and the traditional round clay stove with 1% of the population using the Frismo stove (Figure 4). The average number of stoves per processor is three (3). Eighty eight percent (88%) of fish processors have their own stoves with the remaining 12% of the population depending on other people's stove for their smoking business (Figure 5).

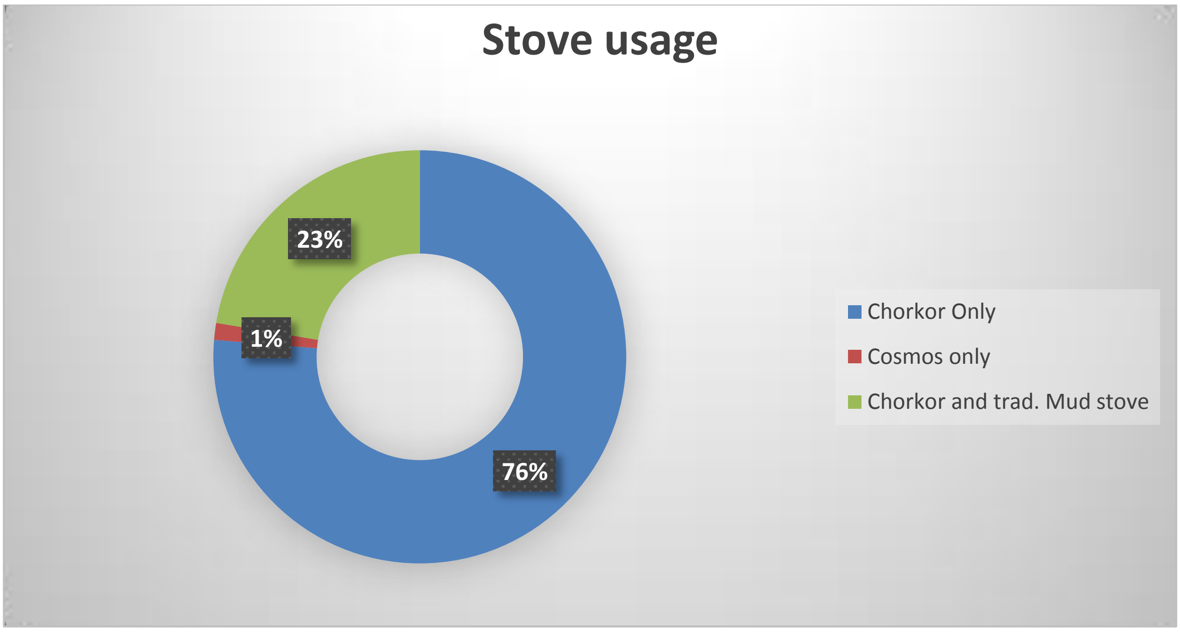

Figure 4 Type of stove popularly used

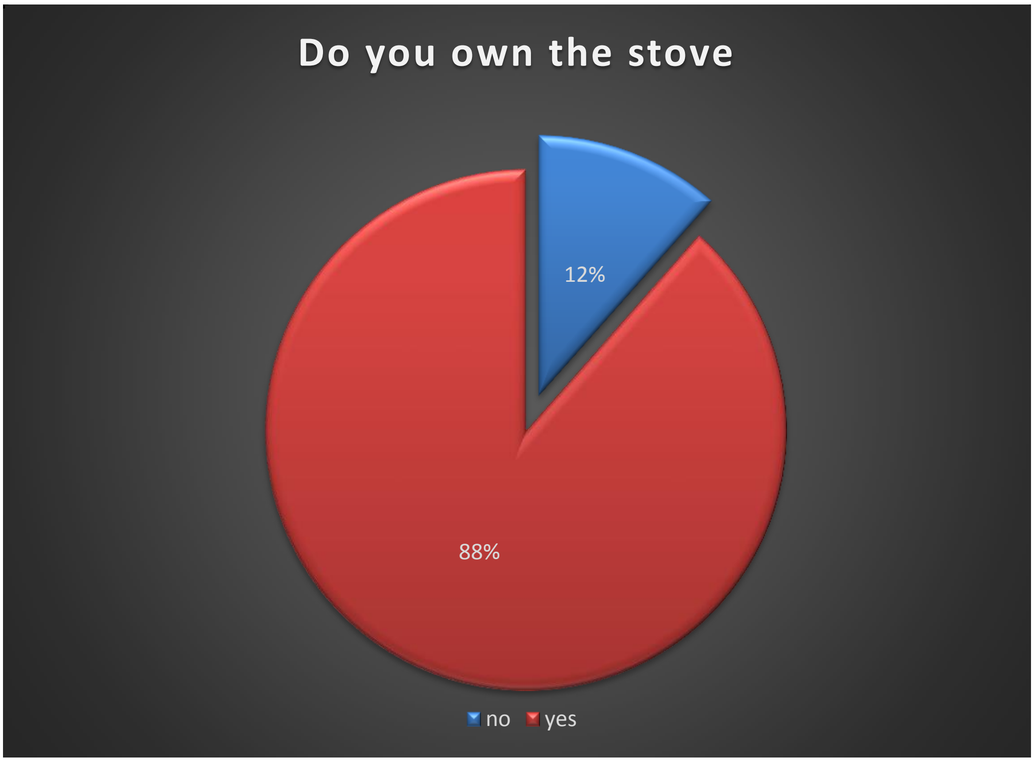

Figure 5 Stove Ownership

Fuel Use

The available stove technologies in Anlo beach use fuelwood as their main source of fuel with combination of coconut husk to generate smoke. 56% of fuelwood consumed in the community are sourced from forest areas which comes in a form of blocks and transported in trucks. 44% of the fuelwood are source from farm offcuts and mangrove areas in nearby communities and are transported to the community in canoes by river. (Figure 6)

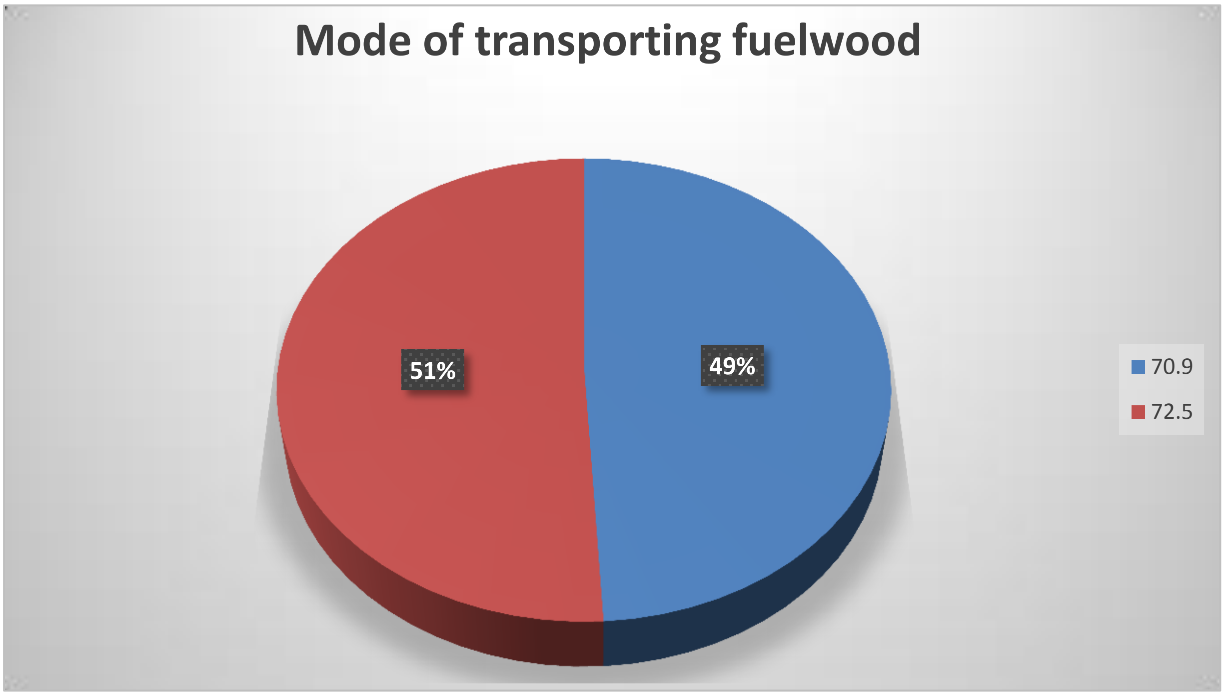

Figure 6 Mode of transporting fuelwood

The surveyed revealed that, 38.5% buy fuelwood in bulk from trucks. These trucks transport the wood from forest zones. 30.8% of the population buys their fuelwood in bulk from canoes dealers. The remaining 30.8% buys their wood from wood traders and retailers in the community (Figure 7).

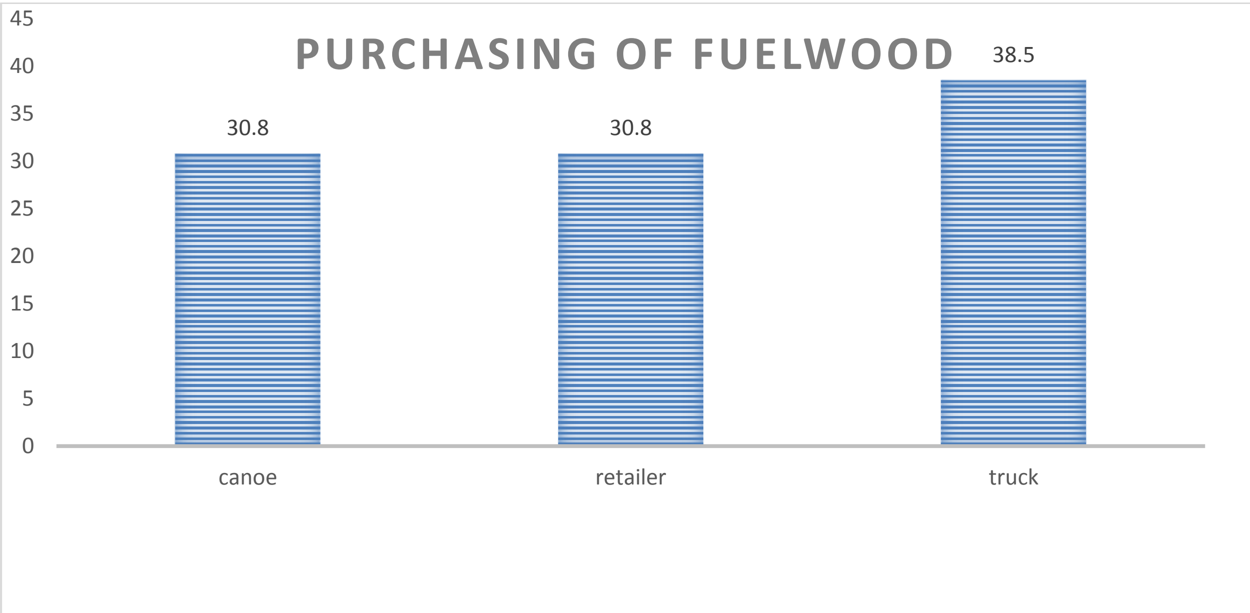

Figure 7 Fuelwood purchase

Smoke generating materials

Coconut husk is widely used (88% of fish processors) as a compliment to fuelwood to generate smoke and to enhance smoked fish color and appearance. 12% of the processors smoke fish with only fuelwood. Coconut husk sales has therefore become a lucrative business for young men in the area.

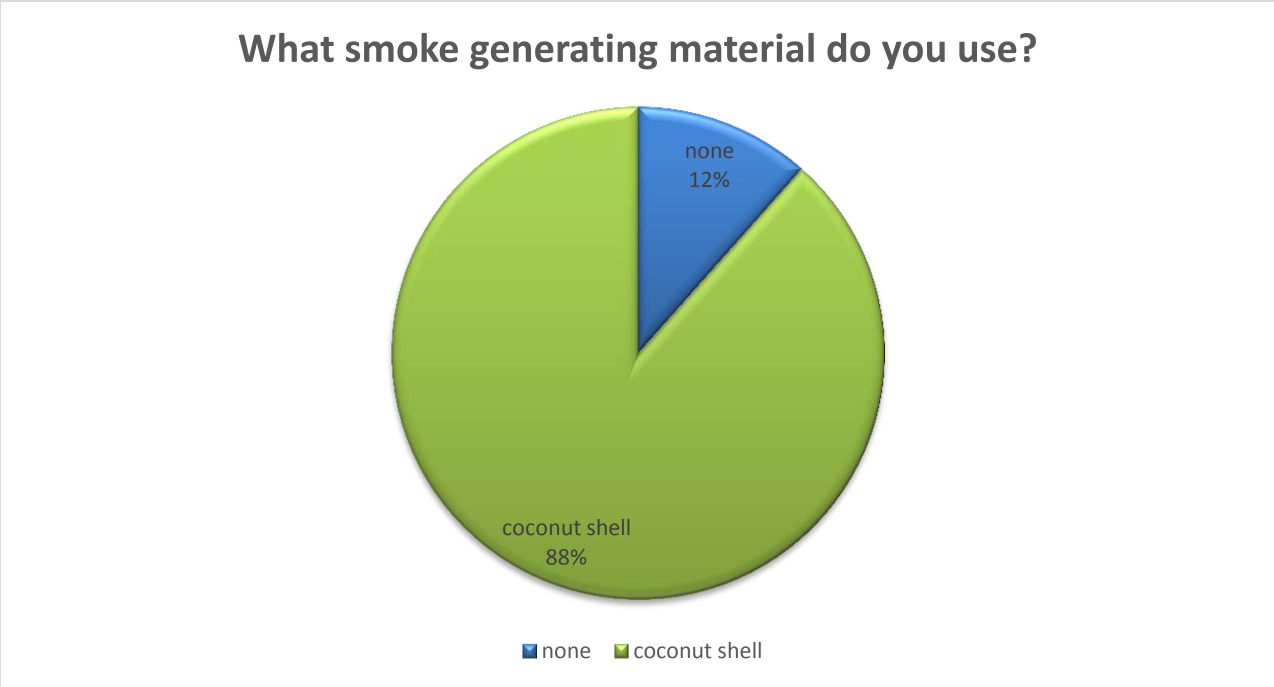

Figure 8 Smoke generating material

Sources of fish

Fish processors in Anlo beach depends entirely on the sea as their source of fish for their business. Less than 1% of the of the population purchase frozen fish from cold stores during the off season. Some processors travel to nearby fishing communities to purchase fish during the lean season. Majority of fish processors go out of business when there is no catch because of the total reliance on the sea. Shrimps, Anchovies, Cassava fish, Silver fish and herrings are the most popular fish species harvested and processed in the community.

Seasonality in the fish smoking business

Just like in any other part of the coastal Ghana, Anlo Beach also experiences the two main seasons; the major (bumper) season and the minor (lean) season. The major harvesting season starts from July and stretches to November with its major peak in August. The minor season continues from December through to April. May and June are used to prepare for the bumper season. Table 4 gives quantitative information on both the lean and the bumper seasons whereas Figure 9 provides a graphical comparison of the seasons.

Table 4 Seasonality effects on fish smoking business

Parameter	Bumper Season	Lean Season
Aver. no. of working days per week	6	3
Aver. No. of batches per day	6	2
No. of months	5	5

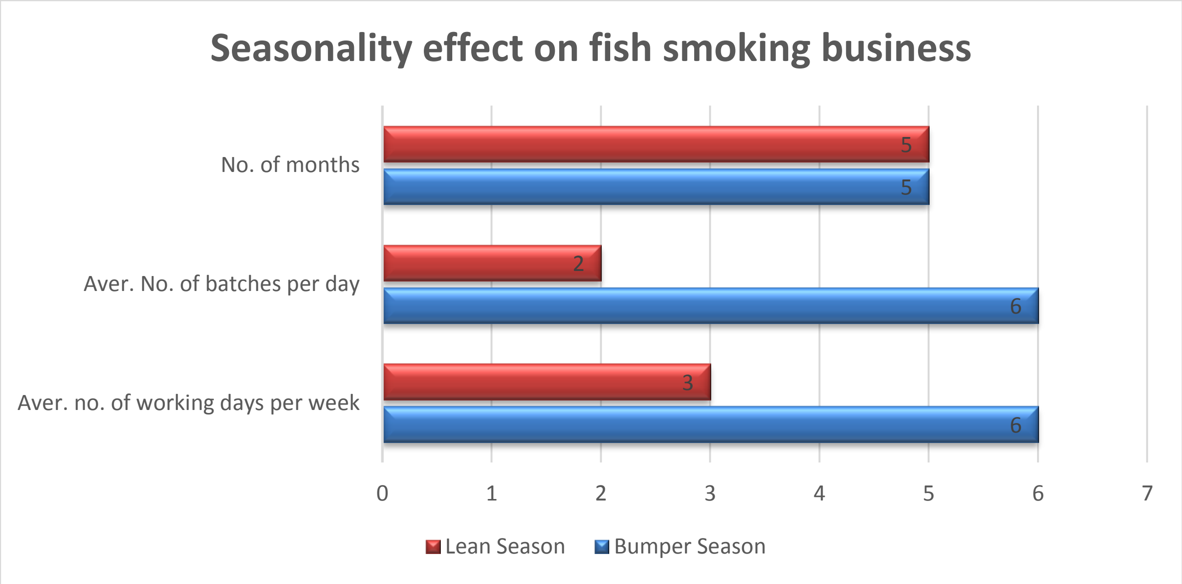

Figure 9 Seasonality effect on fish smoking business

FISH SMOKING TECHNOLOGY AND ENERGY CONSUMPTION

The engineering of every stove technology and materials employed influences the stove's performance. The performance of any stove is mostly measured by parameters such as fuel savings, smoking time, specific fuelwood consumption, drying ability, user friendliness, capacity, emissions and durability. Some parameters have direct bearing on others, for instance; the smaller the specific fuelwood consumption of the stove, the better fuel savings.

Steps for Data Collection

Step 1: The length, breadth and height of both the improved and traditional stoves were measured and recorded.

Step 2: The same type of firewood is indiscriminately selected and weighed for all the stoves. Enough quantity is weighed to go through the entire smoking process. The data is recorded.

Step 3: The total weight of fresh fish is noted for all the stoves. Approximately equal quantities are measure for all the different stoves available.

Step 4: The fishes are then arranged carefully on the trays with assistances from women processors and then systematically arranged on the stove.

Step 5: The fire is then lit and the time at which it was lighted is noted and recorded. This is to note the start time of smoking.

Step 6: The fishes are left on the fire for some time. It is checked periodically and the trays interchanged for even smoking. The trays at the top are brought to the bottom and vice versa.

Step 7: The fish processors determine the cooked time at which can be eaten. This is, the end of soft smoking session. At that point, the time is noted and recorded. The firewood is taken out of the oven, quenched with sand and weight with any other fuelwood left.

Step 8: The weight of the remaining firewood after soft smoking is also weighed and recorded.

Step 9: The soft smoked fish is then rearranged on the trays. This time, the number of trays is reduced to about 4 trays. The fish is therefore arranged in 2 layers per tray. If needed, additional firewood is weighed for the start of hard smoking.

Step 10: The fire is lit again and the time noted as the start time for hard smoking. The fish is allowed to smoke and the trays interchanged as and when needed, until the point where it is hard and dry enough to be stored. This point is determined by the fish smokers.

Step 11: At the point where the fish is dry enough to be stored, the firewood is taken out and quenched with sand. The time is also noted and recorded as the end time for hard smoking. The fish is then taken off the tray and weighed to find the weight of hard smoked fish. This weight is recorded. The dry fish is then put in pans for storage until it is packaged for the market.

Comparing Smoking Time of Stoves

The smoking time of each stove technology in this context is defined as the total time needed to complete one soft smoking process. Table 5 shows the smoking time per each stove technology.

Table 5 Smoking time per stove

Stove	Chorkor	Frismo	Morrison Clay	Morrison Brick
Smoking time (minutes)	159	157	169	176

From the analysis, it was realized that, in terms of smoking time, the Frismo stove and the Chorkor stove are insignificantly better than the Morrison stove (Table 5). Time savings for using the Frismo and Chorkor stove is not very significant as far as smoking activity is concerned.

Comparing Drying Abilities of Stoves

A stove’s drying ability is determined by how much moisture is driven out of the fish within one complete soft smoking period. It is determined by the percentage difference between the wiegth of the fresh fish before smoking and the weight of the smoked fish after smoking. Drying ability of a stove is critical since it determines the shelve life of smoked fish. The Morrison clay stove has a drying ability of 46% and the Morrison Brick stove has 44%. The Chorkor has 42% drying ability with the Frismo stove having 33%. The Morrison stoves dries fish better.

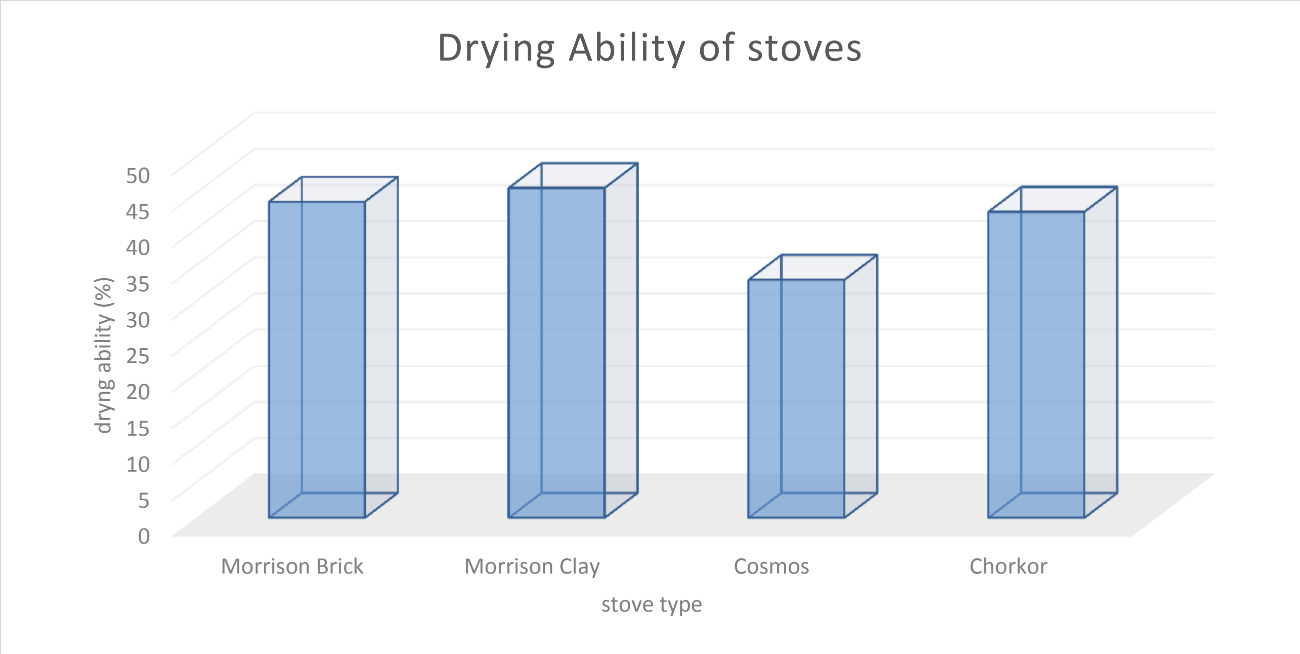

Figure 10 Drying ability of stoves

Comparing Specific Fuelwood Consumption (SFC) of Stoves

Formula:

$$SFC = \frac{Total\ Weight\ of\ Fuelwood\ Consumed}{Total\ Weight\ of\ smoked\ fish\ Produced}$$

The specific fuelwood consumption of a stove is the quantity of fuelwood required to smoke a kilogram smoked fish. The smaller the SFC of a stove, the better the fuel efficiency. Table 6 shows the SFC of each stove.

Table 6 SFC of stoves

Stove	Chorkor	Frismo	Morrison Clay	Morrison Brick
Smoking time (minutes)	1.12	1.34	0.56	0.64

The SFC of the stoves can also be explained as, per every kilogram smoked fish, the Morrison Brick, Morrison clay, Frismo and Chorkor Stoves require 0.64kg, 0.56kg, 1.34kg, 1.12kg of fuelwood respectively.

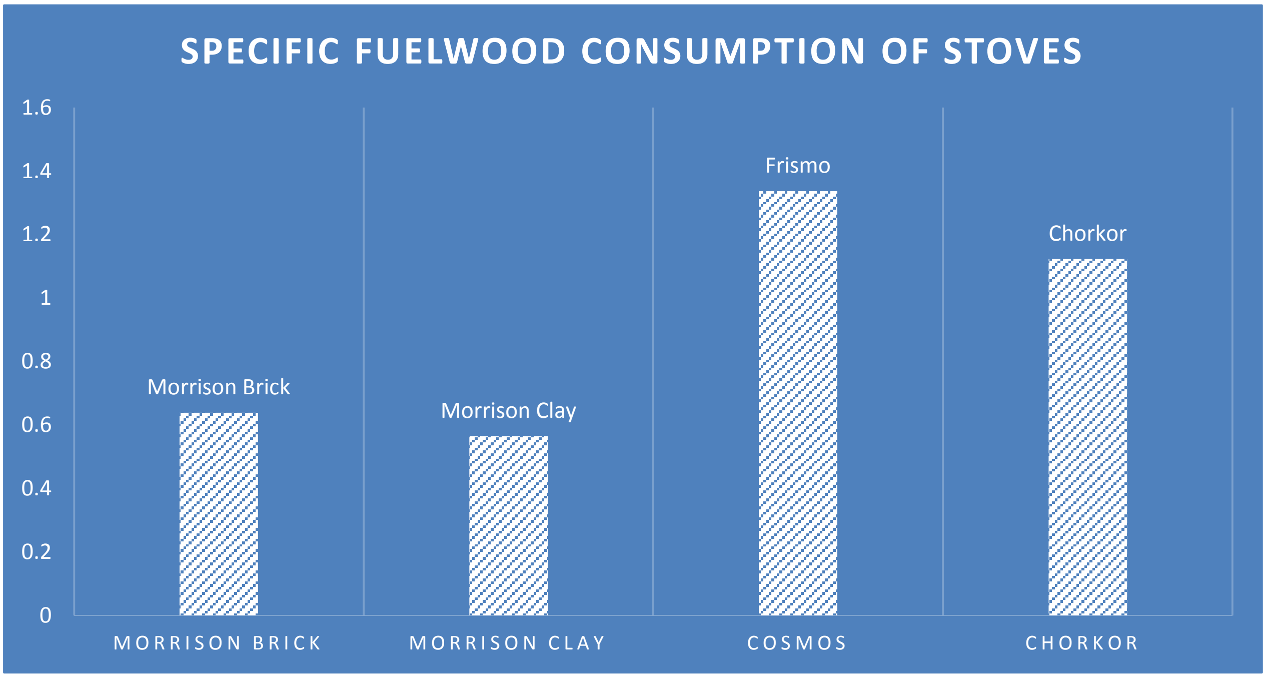

Figure 11 SFC of stoves

Energy Efficiency Improvement of Stove

Formula:

$$EEI = \frac{SFCt - SFCi}{SFCt} \times 100\%$$

Where:

EEI = energy efficiency improvement of stove

SFCt = specific fuelwood consumption of tradition stove (Chorkor)

SFCi = specific fuelwood consumption of improved stove

The Chorkor stoves is used as the baseline to measure the level of fuel efficiency of the improved stoves. Comparing the specific fuelwood consumption of the improved to the Chorkor stove, it can be ascertained that, the Morrison Brick stove and the Morrison Clay stove are 43.1% and 49.7% more efficient than the Chorkor stove respectively. The Frismo stove on the other hand is 19.1% less efficient than the Chorkor stove. This implies that, in terms of fuelwood consumption, using the Frismo stove is more expensive than the Chorkor stove.

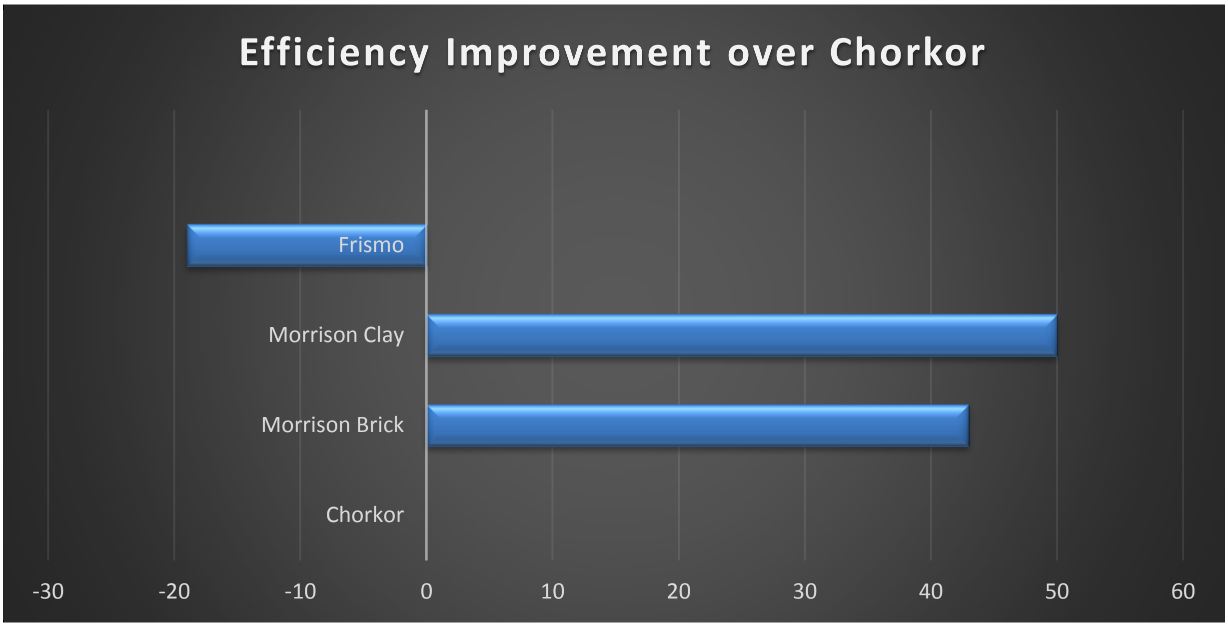

Figure 12 Efficiency improvement of stoves

FISH PROCESSING TECHNIQUE AND ENERGY EXPENDITURE

Cost of acquiring fuelwood and fresh fish forms a greater proportion of the working capital of every fish processor. The amount spent on fuelwood is determined by the processing technology a processor adopts. Different smoking technologies have different smoking abilities and consumption rates. The budget for fuelwood and fish to a greater extent is determined by the fishing seasons. During the bumper seasons, there is more fish catch and fish processors require more fuelwood to process them and therefore a higher energy budget. In the lean seasons, there is less fish catch, less fuelwood is therefore required and less energy budget is required.

Energy Budget for Bumper Season

Using the Chorkor stove, a fish processor in Anlo Beach spends on average Ghc 112.66 on fuelwood per week in the bumper season. It cost an additional GHc 19.46 to process fuelwood into small pieces that can be fed into the combustion chamber. Some processors spend up to Ghc 560 on fuelwood per week in the bumper season whilst other small processor spend as low as Ghc 6.25 on fuelwood per week in the bumper season. An amount of GHc 3 is spent each week on coconut husk for smoking.

Table 7 Cost breakdown of fuel per week

Stove type	Cost of fuelwood (GHc)	Cost of processing wood (GHc)	Cost of smoke generating material (GHc)	Total cost (GHc)
Chorkor	112.66	19.46	3	135.12
Morrison Brick	64.10	19.46	3	86.56
Morrison Clay	56.67	19.46	3	79.13
Frismo	134.18	19.46	3	156.64

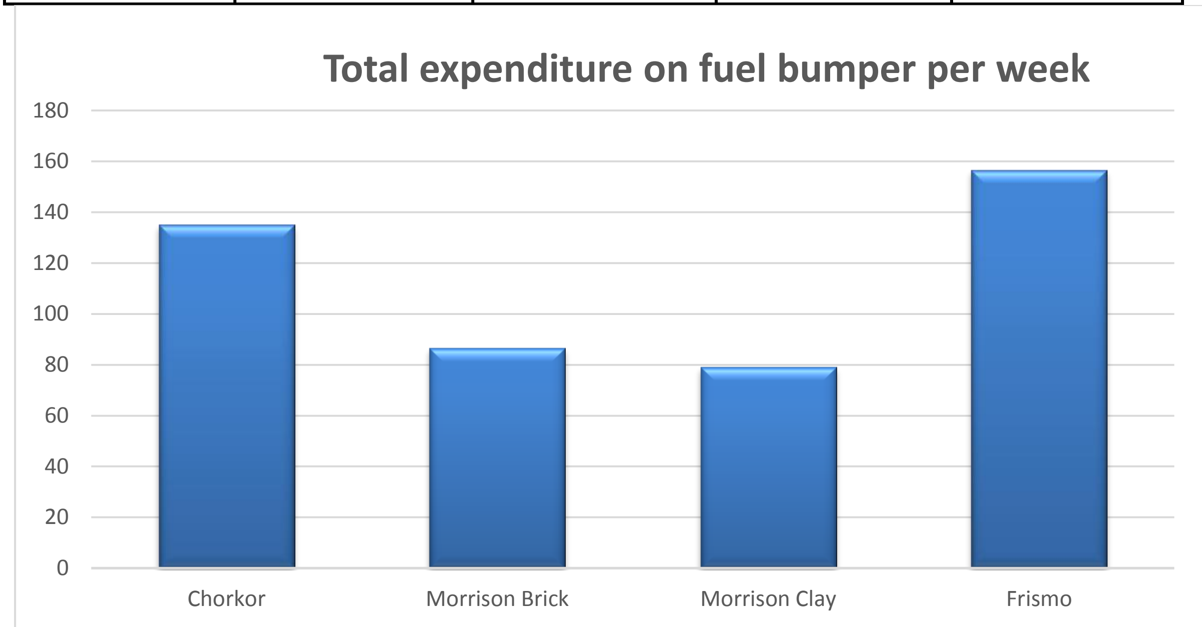

Figure 13 Expenditure on fuelwood per week

Every fish processor makes an effort to maximize the full potential of the bumper season by preserving as much fish as they can. On the average, six working days are used for fish processing leaving out Tuesday which is usually seen as a taboo day for fishing. On each day, six different batches of fish are processed and stored for market. In some few cases, fish traders come to the community and buy directly from the fish processor but in most cases, fish processors themselves take the fish to the market to sell. Figure 14 shows the energy budget for each smoking technology for the entire bumper season.

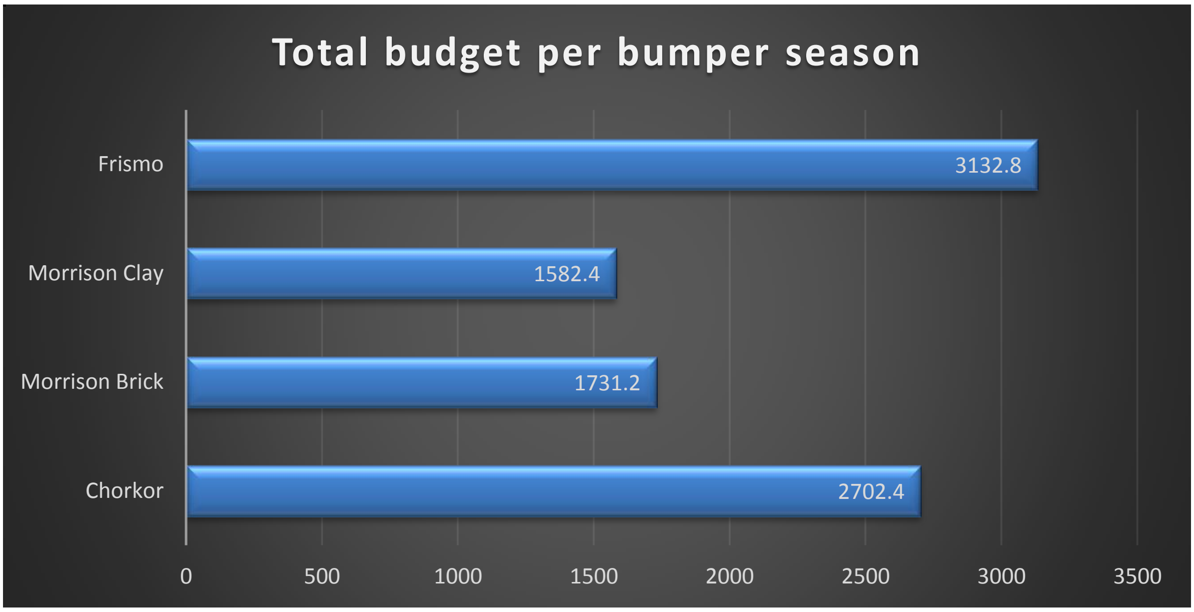

Figure 14 Energy budget for bumper season

Energy Budget for the Lean Season

In the lean season, expenditure on fuelwood is far less as compared to the expenditure in the bumper season. A processor spends one-third the amount spent on fuelwood in the bumper season. Using the Chorkor stove, a processor spends an average of GHc 36.25 per week on fuelwood. Table 8 below provides details on energy expenditure by various smoking technologies in the lean season. Figure 15 compares total expenditure on fuelwood in the lean season by stoves.

Table 8 Cost breakdown on fuelwood for lean season

Stove type	Cost of fuelwood	Cost of processing wood	Cost of smoking material	Total expenditure on fuel
Chorkor	36.25	6.49	1.00	43.74
Morrison Brick	20.63	6.49	1.00	28.11
Morrison Clay	18.23	6.49	1.00	25.72
Frismo	43.17	6.49	1.00	50.66

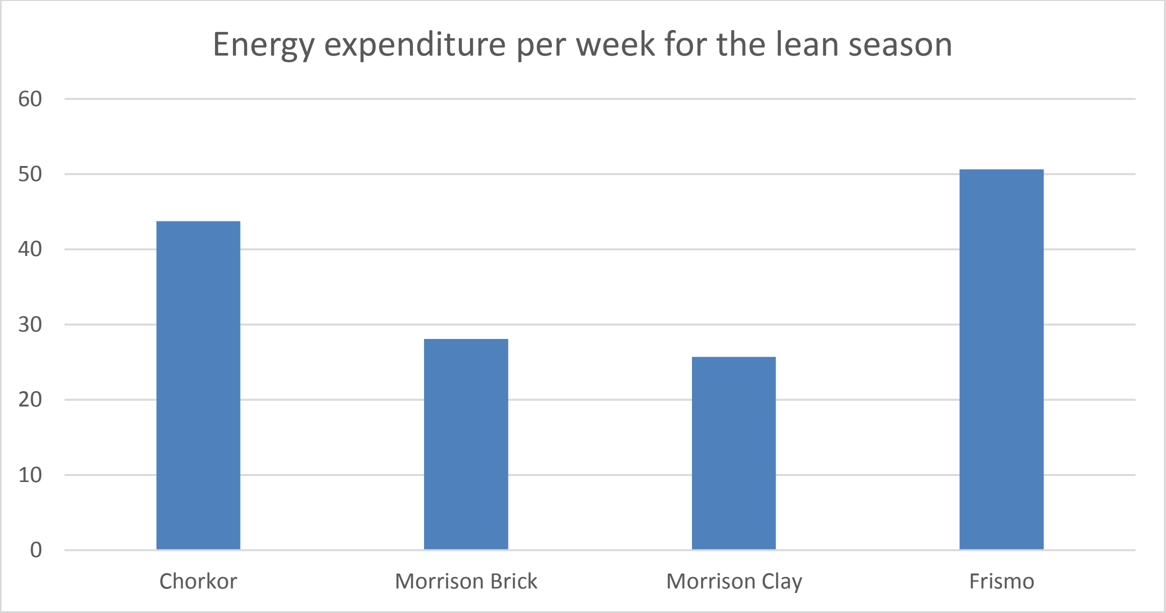

Figure 15 Energy budget per week for lean season

The lean season last for five months from December to April. During the lean season, the number of processing or working days is determined by the frequency in fish catch. On the average, the processor works on 3 days per week with 2 smoking batches per working day. Figure 16 illustrate the total energy budget for the lean season

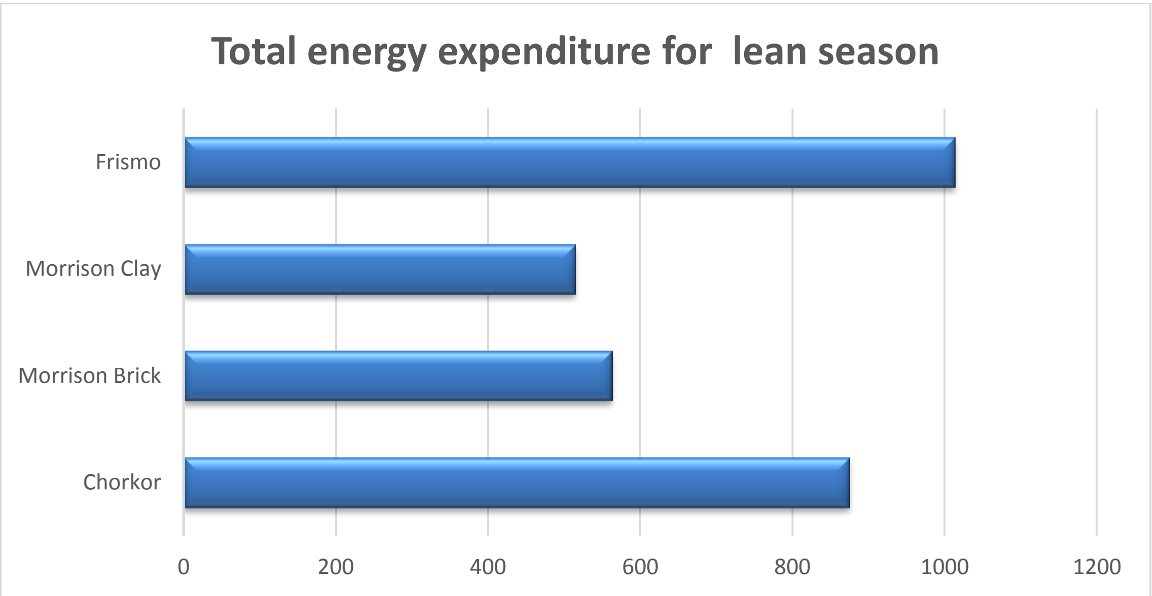

Figure 16 Energy budget for lean season

Annual Energy Budget

From the analysis, a fish processor who uses the Morrison clay stove requires an annual budget of GHc 2096.80 for fuelwood. Adopting the Morrison brick stove, one will require an energy budget of GHc 2293.40 for year (Table 9). Using the Chorkor stove, fish processor on the average spends GHc 3577.20 on fuelwood and using Frismo will cost a processor GHc 4146.00 which is almost twice the cost of using the Morrison Clay stove. Figure 17 shows the annual energy budget per smoking technology.

Table 9 Annual energy budget per stove

Stove	Chorkor	Frismo	Morrison Clay	Morrison Brick
Annual Energy Budget (GHc)	3577.00	4146.00	2096.80	2293.40

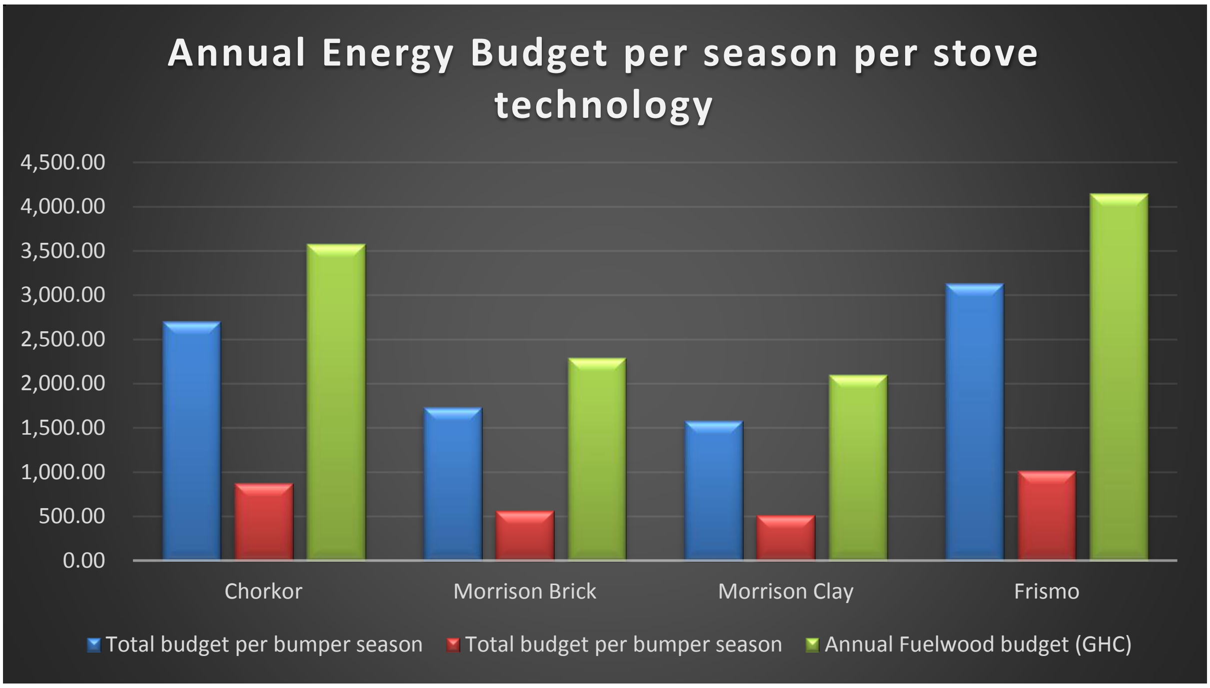

Figure 17 Annual energy expenditure

Energy Budget in Tons

In tons of fuelwood, the Morrison Clay stove uses 11.82 tons of wood per annum whereas the Morrison Brick stove consumes 12.93 tons per annum. The Chorkor stove on the other side consumes GHc 20.17 tons of wood per annum with the Frismo stove consuming 23.37 tons of wood per annum. The current total energy consumption per annum for the entire Anlo beach community is estimated to be 4,034 tons. Figure 18 shows the stove technology and its estimated energy budget in tons of fuelwood.

Table 10 Energy budget in tons

Stove type	Annual energy budget per fish processor (tons)	Annual Energy budget for Anlo beach Community (tons)
Chorkor	20.17	4034
Morrison Brick	12.93	2586
Morrison Clay	11.82	2364
Frismo	23.37	4674

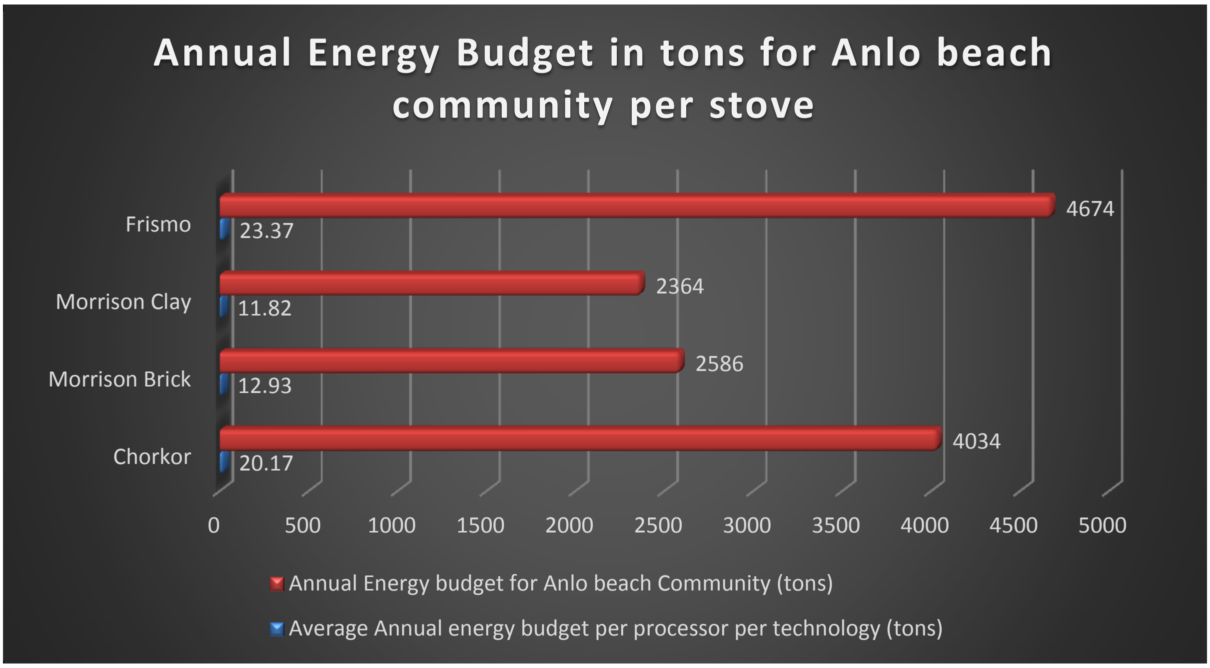

Figure 18 Annual energy budget in tons

INVESTMENT RETURNS (PAYBACK PERIOD, IRR)

Investment Cost

The investment cost for a 2 unit Chorkor stove with eight double trays is GHC 560. This cost includes materials and labor. The current Morrison clay and brick stoves comes at a full cost of GHc 1,500 and GHc 2,000 respectively. The Frismo stove on the other hand costs GHc 7,000. The economic lifespan of the Chorkor and Morrison clay stoves is 3 years and that of the Morrison brick stove is 5 years. The Frismo stove has an economic lifespan of 10 year. The Frismo stove has 8 smoking trays with capacity of about 100kg per smoking batch. The Chorkor and Morrison stove have capacity of 90kg each (Table 11). Capacity in this context is defined as kg weight of fresh fish (herrings) a stove can carry per batch.

Table 11 Specifications of stoves

Type of stove	Investment Cost (GHc)	Economic lifespan (Years)	No. of trays	Capacity (kg)
Chorkor	560	3	8	104
Morrison Clay	1500	3	8	90
Morrison Brick	2000	5	8	90
Frismo	7000	10	8	90

Payback Period

Payback period is defined as the expected number of years required to recover the original investment. If all factors being held constant, project with shorter payback period is considered as a better project because investor can recover the capital invested in a shorter period of time (Brigham & Ehrhardt, 2005). Besides, shorter payback period means greater project’s liquidity. Since cash flows expected in the distant future are generally riskier than near-term cash flows, the payback is often used as an indicator of a project’s riskiness.

From the research, it can be ascertained that, the savings on fuelwood from the Morrison clay stove over the Chorkor stove pays back the total cost of the investment in 10.9 months if the investment is done at the start of the bumper of season. This is because high fuelwood savings is recorded in the bumper season (Table 12).

In the case of the Morrison brick, the period for the fuel savings to pay back the cost of the total investment is 13.3 months. Fuel savings cannot be said of the Frismo stove since the Chorkor stove is currently fuel efficient than the Frismo stove. Comparatively, it can be concluded that, it is less risky to invest in the Morrison clay stove that the others since the payback period is shorter.

Internal Rate of Return (IRR)

IRR is essentially a break-even discount rate in the sense that the present value of benefit equals the present value of costs. In other words, IRR shows the annual percentage return on capital. The IRR equals the discount rate which would make the NPV of a project equal to zero. If the IRR of a project is greater than the discount rate, the project must have a positive NPV and is economically worthwhile (Zaizhi and Loane, 2003). It shows the decision maker what society can expect to receive back in consumption benefits for a given investment of its scarce resources.

The FIRR of investing in an improved stove is analyzed in two different hypothetical cases;

Case 1: Replacing the Chorkor stove with an improved stove at full cost

Case 2: The processor has the total cost for Chorkor stove (GHc 560) and borrow additional money to invest in an improved stove.

The above 2 cases is used to assess the financial viability of switching from the Chorkor stove to an improved. Results from the energy assessment indicates that, the savings per month of using an improved stove within a time period. The analysis took into consideration the months the stove will be in active use and seasonality effects on savings.

The analysis is based on only the returns on fuelwood savings from the various smoking technologies. Other factors like time, capacity, and smoked fish quality are significantly the same for all stoves.

Switching from Chorkor to Morrison Clay stove

Case 1:

Replacing the Chorkor stove with an improved stove at full cost of GHc 1,500.

Assumptions

- Bumper and lean season last for 5 months every year and it is consistent
- A month is made of 4 weeks
- Inflation is constant throughout the investment period
- Profit is equall to fuelwood savings
- No maintainance cost is zero

The Financial Internal Rate of Return of 3% indicates that, if a processor takes a loan of GHc1,500 with repayment period of 2 years to invest in a Morrison Clay stove, the maximum interest rate should not exceed 3% per month or 36% per annum.

However, if the repayment period is 12 months, at an interest rate of 4% per month, the fuelwood savings can pay 57% of the total cost of GHc1,500. In the realistic situation where repayment period is 6 months, fuelwood savings can pay up to 41% of the loan at an interest rate of 4% per month. The processor may have to provide or borrow additional 59% to invest.

With an economic lifespan of 3 years, the Financial Internal Rate of Return (FIRR) of investing in Morrison clay stove is 9% per month or 108% per year. This implies that, switching from the Chorkor stove to the Morrison stove makes financial sense if a processor can access a loan with repayment period of 3 years at 9% interest per month or 108% interest per annum.

Table 12 IRR and Pay back period analysis of Morrison clay stove investment at a cost of GHc 1,500

Cost				Month	Savings	Fuel Savings	Cumulative
Chorkor Smoker			Year 1	0		(1,500.00)	(1,500.00)
Bumber			Bumper Season	1	224	224.00	(1,276.00)
Cost of Chorkor stove	560			2	224	224.00	(1,052.00)
Expenditure per week	135.12			3	224	224.00	(828.00)
Number of weeks in a month	4			4	224	224.00	(604.00)
Total Expenditure per month	540.48			5	224	224.00	(380.00)
Lean			Lean Season	6	72.08	72.08	(307.92)
Expenditure per week	43.74			7	72.08	72.08	(235.84)
Number of weeks in a month	4			8	72.08	72.08	(163.76)
Total Expenditure per month	174.96			9	72.08	72.08	(91.68)
				10	72.08	72.08	(19.60)
Morrison Clay Stove				11	224	224.00	204.40
Bumper			YEAR 2	12	224	224.00	428.40
Cost of Morrison Stove	1500		Bumper Season	13	224	224.00	652.40
Expenditure per week	79.12			14	224	224.00	876.40
Number of weeks in a month	4			15	224	224.00	1,100.40
Total Expenditure per month	316.48			16	72.08	72.08	1,172.48
Lean				17	72.08	72.08	1,244.56
Expenditure per week	25.72		Lean Season	18	72.08	72.08	1,316.64
Number of weeks in a month	4			19	72.08	72.08	1,388.72
Total Expenditure per month	102.88			20	72.08	72.08	1,460.80
				21	224	224.00	1,684.80
Savings on fuelwood per week (GHC)	56			22	224	224.00	1,908.80

Cost			Month	Savings	Fuel Savings	Cumulative
Savings per month	224		23	224	224.00	2,132.80
		Year 3	24	224	224.00	2,356.80
Savings in fuelwood for smoking per week (GHC)	18.02	Bumper Season	25	224	224.00	2,580.80
Savings per month	72.08		26	72.08	72.08	2,652.88
			27	72.08	72.08	2,724.96
			28	72.08	72.08	2,797.04
			29	72.08	72.08	2,869.12
		Lean Season	30	72.08	72.08	2,941.20
		IRR		**3%**	**24 months**	
		Payback Period		**10.9**	**months**	

Case 2:

The processor has the total cost for Chorkor stove (GHc 560) and borrow additional money to invest in an improved stove.

In the above scenario, a processor will incur additional cost of GHc 940 to purchase the Morrison clay stove. The FIRR for this investment within the economic lifespan of 3years is 19% per month. The savings on the fuelwood pays back the cost of the stove in 4.8 months. (Table 13).

Assumptions

- Bumper and lean season last for 5 months every year and it is consistent
- A month is made of 4 weeks
- Inflation is constant throughout the investment period
- Profit is equal to fuelwood savings
- No maintenance cost is zero

Table 13 IRR and PB period analysis of a stove at investment cost of GHc 940

Cost				Month	Savings	Fuel Savings	Cumulative
Chorkor Smoker			YEAR 1	0		(940.00)	(940.00)
Bumber			Bumper Season	1	224	224.00	(716.00)
Cost of Chorkor stove (GHC)	560			2	224	224.00	(492.00)
Expenditure per week (GHC)	135.12			3	224	224.00	(268.00)
Number of weeks in a month	4			4	224	224.00	(44.00)
Total Expenditure per month (GHC)	540.48			5	224	224.00	180.00
Lean			Lean Season	6	72.08	72.08	252.08
Expenditure per week (GHC)	43.74			7	72.08	72.08	324.16
Number of weeks in a month	4			8	72.08	72.08	396.24
Total Expenditure per month (GHC)	174.96			9	72.08	72.08	468.32
				10	72.08	72.08	540.40
Morrison Clay Stove			YEAR 2 Bumper Season	11	224	224.00	764.40
Bumper				12	224	224.00	988.40
Cost of Morrison Stove	1500			13	224	224.00	1,212.40
Expenditure per week	79.12			14	224	224.00	1,436.40
Number of weeks in a month	4			15	224	224.00	1,660.40
Total Expenditure per month	316.48		Lean Season	16	72.08	72.08	1,732.48
Lean				17	72.08	72.08	1,804.56
Expenditure per week	25.72			18	72.08	72.08	1,876.64
Number of weeks in a month	4			19	72.08	72.08	1,948.72
Total Expenditure per month	102.88			20	72.08	72.08	2,020.80
Savings on fuelwood per week-bumper season (GHC)	56						
Savings on fuelwood per month-bumper season (GHC)	224			**IRR**	**6%**	14 months	
				Payback Period	**4.80**	months	
Savings on fuelwood per week-lean season (GHC)	18.02						
Savings on fuelwood per month-lean season (GHC)	72.08						

If a fish processor takes a loan with repayment period of 6 months at an interest rate of 4% per month which is the more realistic case, the fuelwood savings can pay up to 66% of the loan (GHc 940). The processor may have to rely on external funds to pay the difference of 34%.

Switching from Chorkor to Morrison Brick stove

Case 1:

Replacing the Chorkor stove with an improved stove at full cost of GHc 2,000.

The Morrison Brick stove has an economic lifespan of 5 years. The FIRR of investing in this stove based on the fuelwood savings over the investment life 6% per month. This can be explain as, if a processor can access a loan facility with a repayment period up to 5 years to purchase the Morrison Brick stove at full cost, then the savings can pay back the cost of investment and a cost of capital to maximum of 6% per month.

The investment is not feasible if a processor acquires a loan with repayment period of 2 years to purchase the stove at full cost with total reliance on the fuelwood savings to pay back the loan.

Since most fish processors falls into the category of microfinancing where loan repayment barely go beyond a year, realistically 6 months, then, the savings on fuelwood can only pay up to 27% of the loan amount of GHc 2,000 at an interest rate of 4% per month. A processor may need an additional 73% funds to support the repayment.

Case 2:

The processor has the total cost for Chorkor stove (GHc 560) and borrow additional money to invest in an improved stove.

In the above scenario, the processor will require an additional amount of GHc 1440 to purchase the Morrison Brick stove. The payback period for this investment is 9.6 months. The FIRR over the lifespan of the investment is 10% per month. This can be explain as, the fuelwood savings on the investment can payback a loan with repayment period of 5 years at an interest rate of 10% per month. This kind of loan is not common because, the repayment period of 5 years with the loan amount in question will not be attractive to most banks.

In a more realistic case where loans with repayment period of 6 months at an interest rate of 4% (common with most MFIs) per month, the fuelwood savings from using the Morrison Brick stove is capable of paying 37% of the loan.

Switching from Chorkor to Frismo stove

The cost of purchasing the Frismo stove is GHc 7,000. The research indicated the Frismo stove technology consumes more fuelwood than the Chorkor stove therefore in terms of fuelwood savings the Frismo stove is poor. There is therefore a negative average savings of GHc 1138 per annum. Investing in this stove will require total reliance on external funds.

CONCLUSION

The rate of fuelwood consumption at the coast for fish processing cannot not be overlooked. The study analyzed the various fish processing stove technologies, their consumption rate and efficiencies, capacity, and their internal rate of returns.

Anlo Beach is a small community with about 190 smoked fish processors and about 600 fish smoking stoves installed and in frequent use. Fuelwood is the main fuel for all the stoves identified. 88% of the fish processors in the community possess their own processing stoves and the remaining 12% depends on the peoples stove for their business.

56% of fuelwood consumed in the community are sourced from forest areas which comes in a form of blocks and transported in trucks. 44% of the fuelwood are source from farm offcuts and mangrove areas in nearby communities and are transport to the community in canoes by river.

Two main fishing seasons are experienced in Anlo beach; the major (bumper season) and the minor (lean season). The major harvesting season spans from July and stretches to November with its major peak in August. The minor season continues from December through to April. Seasonal fluctuations have significant influence on the fish smoking business as well as the rate of fuelwood consumption.

Four different fish smoking stove technologies are available in Anlo beach; the Chorkor, Morrison clay, Morrison brick and Frismo stove. A controlled cooking test analysis indicated that, the Morrison Brick stove and the Morrison Clay stove are 43.1% and 49.7% more efficient than the Chorkor stove respectively. The Frismo stove on the other hand is 19.1% less efficient than the Chorkor stove.

The annual fuelwood consumption by each smoking technology was assessed and the following were the findings; a fish processor who uses the Morrison clay stove needs an annual budget of GHc 2096.80 for fuelwood. Adopting the Morrison brick stove, one will require an energy budget of GHc 2293.40 for year. Using the Chorkor stove, fish processor on the average spends GHc 3577.20 on fuelwood and using Frismo will cost a processor GHc 4146.00. In tons, the Morrison Clay stove 11.82 tons of wood per annum whereas the Morrison Brick stove consumes 12.93 tons per annum. The Chorkor stove on the other side consumes GHc 20.17 tons of wood per annum with the Frismo stove consuming 23.37 tons of wood per annum. The current total energy consumption per annum for the entire Anlo beach community is estimated to be 4,034 tons.

The Morrison clay stove has a better fuelwood savings ability with its fuelwood savings paying back the full cost of the stove in 10.9 months. The fuelwood savings from the Morrison brick stove pays back the full cost (GHc 2,000) in 13.3 months. The Frismo stove on the other has no fuelwood savings over the Chorkor since the Chorkor tends to be energy efficient than the Frismo stove.

APPENDIX

Questionnaire to the Fish Processor

SNV Netherlands Development Organisation is collecting information on energy budgets and comparative economics of processing techniques at Anlo beach in the Western region of Ghana to be able to determine the current energy consumptions, expenditure, its financial implications on fish processing business and the direct impact on the environment to be able to plan for future energy use and for to help develop sustainable mitigation measures.

Questionnaire No.: .... Interviewed by...

1. Name of Respondent: ....

2. Phone number: ……………..

3. Age ……………………… 4. Gender: 0.Male [ ] 1.Female [ ]

A. Extent of energy consumption

1. How long have you been in the fish smoking business? ………………………………………….
2. What form of fish do you mostly smoke?
   1. Fresh catch from the sea type………………………………………………………………………..
   2. Frozen fish type……………………………………………………………………………… ……………….
3. How many boxes of fish do you smoke per day/week/month? ……………………………..
4. Which type of fuel do use for smoking fish: 1. Fuelwood [ ] 2. Fuelwood [ ] 3. Gas [ ] others (specify)...
5. Do you use any other type of fuel in smoking? 1. Coconut shell 2. Sugar cane 3.Both sugar cane and coconut shell 4.Other (specify) ………………………………………………………………..
   1. What is the cost of the smoking material? ……………………………………………………………….
6. What is the name of your fish smoking stove? ....
7. Do you own the fish smoking stove? 1. Yes 0. No How many? …………………………………
8. Where do you buy the fuelwood from? 1. Retailer 2. Wholesaler 3. Transporters 4. Harvester/producers 5. Other (specify)……………………………………………………….

9. How much do you spend on the fuel for fish smoking per day/week/ month?

Activity	**Major fishing season**			**Minor fishing season**			**Total/Month**
	Day	Week	Month	Day	Week	Month	
What quantity of fuelwood do you use ***(bundles/logs/ blocks/truck)***							
How much do you spend on fuelwood **(GHC)**							

11. Do you process the wood in any way before using for smoking? 1. Yes [ ] 0. No [ ]

12. If **Yes**, what processing activities do you undertake? Please list them and the associated costs?

Processing activity	**Quantity**	**Unit cost (GHC)**	**Total Cost (GHC)**
1. Splitting of blocks			
• *labour*			
• *hammer*			
• *chisel*			
2. Packing split wood			
3. Others ……………………			

F. Problems/challenges in fuelwood production

1. What are the main problems you face with your stove technology in the course of fish smoking business?

a. ....

b. ....

c. ....

2. What changes would you like to be implemented to make your fish smoking business and working environment better?

a. ....

b. ....

c. ....

QUANTITATIVE DATA COLLECTION TEMPLATE

INVESTMENT COSTS OF STOVE	**UNITS**	**NAME OF STOVE**
Oven base (standard dimension - specify)		
Materials	GHC	
Labour	GHC/hour/day	
Trays (each)		
Materials	GHC	
Labour	GHC/hour/day	
Full cost	GHC	
Additional items (chimney, cover etc)	GHC	
OPERATIONAL CHARACTERISTICS		
Operational life of stove base	years	
Operational life of trays	years	
High season		
No. of months per year	no.	
No. of batches per day	no.	
No. of days operation per week	no.	
Low season		
No. of months per year	no.	
No. of batches per day	no.	

No. of days operation per week	no.	
INPUT COSTS		
Smoker repairs and maintenance	GHC/year	
SALES		
Cost of packaging/kg final product	GHC/kg	
Cost of transport/kg final product	GHC/kg	
Agents/market fees	GHC/kg	
Selling price per kg final product	GHC/kg	

DATA OBTAINED BY MEASUREMENTS

Parameter	Unit	Value
Type of Fish		
Source of Fish		
Weight of Fuelwood		
Cost of Fuelwood	GH₵	
Cost of smoke generating material	GH₵	
Total weight of fish	Kg	
Cost of fish	GH¢	
Weight of fuelwood before	Kg	
Start time	Hr : min	
Finish time	Hr : min	
Total weight of smoked fish	Kg	
Weight of Fuelwood after	Kg	

REFERENCES

Amuah, N.E.E.H, (2011). The potential of agroforestry in fuelwood production for domestic and income generation activities – A case study of three communities in the Sunyani District of the Brong Ahafo Region Ghana. MSc. Thesis, Department of Agorforestry, KNUST.

Brigham, E. F. in M. C. Ehrhardt. (2005). Financial Management: Theory and Practice. Masson, OH (ZDA): South-Western.

Brownell, B., (1983). A practical guide to improved fish smoking in West Africa. UNICEF, New York.

FAO. (2010). Global Forest Resources Assessment Report.

FAO. (2015). Global Forest Resources Assessment 2015, Desk reference.

Forestry Commission Of Ghana. (2010). Ghana R-PP (Annexes), June, 2012. http://theredddesk.org/countries/ghana [Accessed April 2016].

Kwarteng, E. (2014). SNV Improved Fish Smoking Project (IFS), Fish smoking stoves available locally and internationally, SNV Netherlands Development Organization.

Mason, J. J. (2008). Building a Sustainable Model based on Management and Payments for Ecosystem Services, NCRC.

Obiri and Nunoo. (2014). An analysis of the wood fuel value chain in the Kintampo North District, Brong Ahafo Region Ghana. Research Report, ITTO, Japan.

Obiri, B., Owusu-Afriyie, K., Kwarteng, E., Nutakor, Eric. (2015). Fuelwood value chain for the Ghanaian fish smoking industry. The USAID/Ghana Sustainable Fisheries Management Project (SFMP). Narragansett, RI: Coastal Resources Center, Graduate School of Oceanography, University of Rhode Island.

Ocansey. (1985). The major significance of minor forest products. FAO, Corporate documentary repository, Paris.

Tze, S. O., Chun, H. T. (2013). Net Present Value and Payback Period for Building Integrated Photovoltaic Projects in Malaysia, International Journal of Academic Research in Business and Social Sciences February 2013, Vol. 3, No. 2 ISSN: 2222-6990.

Zaizhi, Z. and Loane, W., 2003. "Benefit-Cost Analysis of Eucalyptus Management for Sustainability in Southern China", ACIAR Proceedings No.111.