

## A COMPARISON OF INCENTIVE SYSTEMS FOR THE ADOPTION OF AN IMPROVED FISH PROCESSING TECHNOLOGY

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### ABSTRACT

Developmental aid organisations widely use micro-credit schemes to sustainably improve the livelihoods of coastal communities in developing countries. *The Sustainable Use and Conservation of the Oceans, Seas, and Marine Resources for Sustainable Development in Sierra Leone* project aims to improve these livelihoods by providing a micro-credit scheme for post-harvest processing equipment. This study compares incentive systems for adopting improved fish-smoking technologies. A literature review, including developmental aid reports, and qualitative questionnaires, indicate that processors in Sierra Leone's Tombo community are willing to transition from traditional smoking methods to cabin style (Matís) ovens. Survey responses indicate that processors are open to working with smoke oven technicians to access loans, making the Market-Based Approach viable. Additionally, interest in training on business, financial, and social themes suggests that the Smiley Coin incentive system could be effective for post-project interventions. Successful implementation will contribute to the socioeconomic empowerment of Tombo's women by providing a critical asset for securing their livelihoods.

**Keywords:** fish processing technology, micro-credit schemes, incentive systems, market-based approach, Matís smoking ovens, socioeconomic empowerment, Sierra Leone.

## TABLE OF CONTENTS

1. INTRODUCTION.....	1
<b>1.1. Literature Review</b> .....	1
<b>1.2. Micro-finance Schemes for Developmental Aid</b> .....	4
<b>1.3. Tutor web</b> .....	5
<b>1.4. The Icelandic Project - pilot study results</b> .....	6
<b>1.5. Goals and Objectives</b> .....	7
2. METHODOLOGY .....	7
<b>2.1. Questionnaires</b> .....	8
<b>2.2. Site and Participants Selection</b> .....	8
3. RESULTS.....	9
<b>3.1. Fish Processor Surveys</b> .....	9
<b>3.2. Smoke Oven Technician Surveys</b> .....	16
4. DISCUSSION .....	17
<b>4.1. Conclusions and Recommendations</b> .....	22
REFERENCES.....	23
APPENDIX .....	27
<b>Appendix 1: Questionnaire for Fish Processors in Tombo Community</b> .....	27
<b>Appendix 2: Questionnaire for Oven Technicians in Tombo Community</b> .....	35

## LIST OF TABLES

Table 1. Perceived merits of the Matis oven from fish processor survey respondents.	13
Table 2. Training themes suggested through fish processor questionnaires.	15

## LIST OF FIGURES

Figure 1. The cabin smoking kiln aka Matis oven (Gissurarson, 2019).	3
Figure 2. Traditional smoking banda with fish	4
Figure 3. Cabin smoking kiln constructed in Sierra Leone (Gbla, 2020)	7
Figure 4. Sources of additional capital sought by fish processors in the Tombo Community.	10
Figure 5. Type and ownership of smoking ovens used in the Tombo Community.	11
Figure 6. Use and rental payment method by smoking oven type in the Tombo Community.	12
Figure 7. Interest of surveyed fish processors in loan acceptance to acquire an improved smoking oven.	13
Figure 8. Percentage loan contribution that would be acceptable to fish processors in the Tombo Community for purchasing a new Matis smoking oven.	14
Figure 9. Decision making in loan taking as reported by an 85% female group of survey respondents.	16
Figure 10. Reported availability of construction materials within the Tombo Community needed for building traditional smoking ovens.	17

## 1 INTRODUCTION

Despite the global increase in the desirability of fish, post-harvest loss due to fish handling and processing remains a challenge. The quality of fish is altered before reaching the consumer by handling and processing activities. Mishandling can result in mechanical damage and stress and can lead to post-harvest fish spoilage (Rotimi, 2009). Acquiring fishing equipment and gears needed to minimise post-harvest loss often requires small-scale fishers to use loans or personal savings. Micro-credit loans are a type of development aid that can be granted by banks or other institutions and are aimed at helping disenfranchised or vulnerable people (FAO, 2006). They have been used in fishing communities to enable fishers to invest in the tools needed to minimise post-harvest loss and support fishery management goals (Ataguba & Olowosegun, 2012).

Small-scale fisheries in developing countries contribute to job creation, food security, and economic growth in these nations. This sector employs over 5.2 million fishers and over 4.9 million post-harvest processors (Isaacs et al., 2019). Like other developing nations, Sierra Leone's artisanal post-harvest sector is dominated by women, and post-harvest loss is a key challenge in this sector. One of the largest coastal fishing communities in Sierra Leone is the Tombo community, which uses fish smoking as its primary form of preservation and value addition. Despite the importance of fish smoking in this community, processors are constrained by the electricity supply, outdated fish processing technologies, and access to financial services. The combined effects of these challenges have significantly influenced the overall economic status of the women in this community (Olapade & Sesay, 2019). To improve livelihood conditions by tackling post-harvest loss, the cabin-style fish smoking oven (Matis Oven) was introduced in Tombo, Sierra Leone. This technology has the potential to be more productive and fuel-efficient, while producing a better quality of smoked fish compared to traditional ovens. This study seeks to validate the potential of using a micro-credit scheme to encourage the adoption of the Matis Oven technology in the Tombo Community in Sierra Leone.

### 1.1. Literature Review

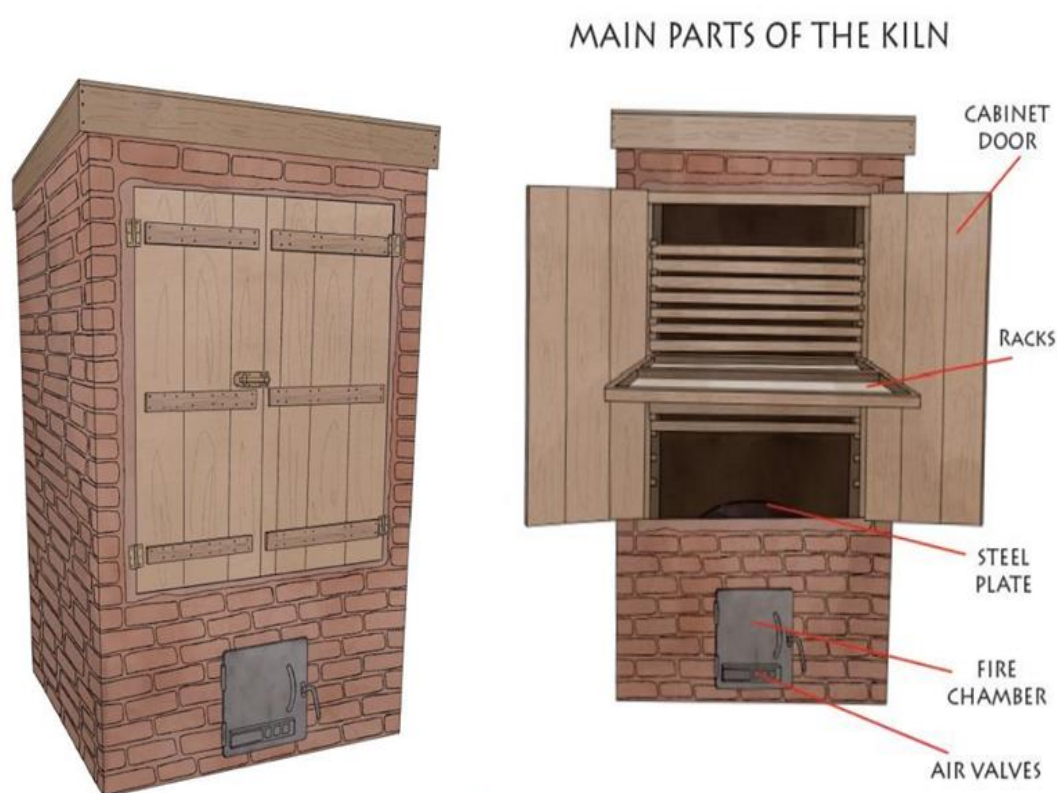
Studies have shown that fish processors can maximise economic benefits, maintain fish quality, and reduce post-harvest loss through the use of improved fish processing technologies (Rotimi, 2009). These improved technologies are enhanced by the ability to monitor the quality of fishery products, minimise production costs, meet hygiene criteria, and increase economic

returns. Modern technologies involve the use of robots and automated systems that collect, wash, sort, cut, salt, dry, smoke, freeze, package, and store finished products. They are geared towards increasing the speed of processing while preserving the quality of the product and meeting standards, thereby reducing post-harvest losses (Komlatsky et al., 2019).

Coastal developing countries are constrained by unreliable electricity supply to power-mechanised equipment, as well as limited government interventions to boost fish processing technologies (Alonge et al., 2020; Rotimi, 2009). Therefore, the introduction or use of improved technologies in these nations should be flexible enough to align with their cultural, social, and technological dynamics (Ahmed, 2008). Among the improved technologies introduced in West Africa is the Smoking Cabin kiln, developed by Matís Ltd. of Iceland, which is made of bricks, metal, and wood. The structure of the smoking kiln is built from bricks with a front fire chamber that has a metal door for loading fuelwood with valves to allow the flow of air. The smoking room has a series of racks and a bent steel plate that divides the smoking room and fire chamber. It also has doors and a chimney for smoke escape (Gissurarson, 2019; Figure 1). Studies conducted in Ghana have shown that fish products from the Matis oven have very low levels of polycyclic aromatic hydrocarbons (PAHs) and are of better quality than those from traditional smoking methods. This technology also uses less fuelwood and reduces the exposure of the product to heat. Doors and chimneys prevent the inhalation of smoke by processors, thereby reducing health issues (Odoi, 2014). The efficient use of fuelwood by the Matis oven and the availability of construction materials make this oven a valuable new smoking technology for developing countries such as Sierra Leone. Furthermore, the ability to lock the fire chamber during smoking caters to fish processors, who are primarily women with two or more children and who engage in two or more livelihoods (Agbemabiese, 2020). These women occupy the informal sector which has attracted government and non-government intervention for the past 20 years in developing nations (Munafa, 2021).

A growing intervention strategy in the informal sector in Sierra Leone is the provision of microcredit loans. These schemes are gradually moving from providing start-up capital to providing training to enhance women's holistic empowerment and sustainable development (Munafa, 2021). Despite government restrictions on taking a direct role in the implementation of micro-credit schemes, it has adopted a Micro Finance Policy that creates a conducive environment for such schemes to thrive (Kooi & Tucker, 2003). There are approximately 60 microfinance programs targeting marginalised communities in the country. However, research has shown that 83% of the country's population does not have access to financial services

(Agbemabiese, 2020). Fish processors and traders are included in this figure. Fish processors who venture into taking loans from local Micro-Credit Finance Institutions (MFI) express a series of dismays. Key among them are the conditions attached to loans, payment strategies that do not align with the seasonality of products, and the high-interest rates charged. With these limitations, there is a need for accessible, affordable, timely, need-tailored, and sustainable financial lending options to boost the fish-smoking business by enabling processors to acquire fixed assets, such as new smoke ovens, to maximise profits and reduce post-harvest loss (Agbemabiese, 2020).



*Figure 1.* The cabin smoking kiln aka Matis oven (Gissurarson, 2019).

Sierra Leoneans consume 18 kg/person/year of smoked fish, the majority of which is landed by artisanal fisheries (Kallon et al., 2017). Fish smoking is prevalent in the country because of the accessibility and availability of fuelwood, lack of electricity, and higher economic value compared to fresh fish (Agbemabiese, 2020; Olapade et al., 2021). This has contributed to the deforestation of mangroves and terrestrial forests near fishing villages. Due to the limited availability of preservation technologies, women in the processing sector resort to hot smoking of their fishery products, employing traditional methods of smoking known as “Banda Smoking” (Olapade et al., 2021, Figure 2). In addition to environmental effects, this form of

smoking also has health-related issues, including headaches, nervousness, body pain, running or blocked nose, sneezing, breathing difficulties, and eye problems. Physical injuries encountered by processors include cuts, bone fractures due to slippery workspaces, and burns due to exposure to flame during smoking (Olapade et al., 2021). Therefore, it is prudent to take measures to invest in environmental and fuel-efficient processing (smoking) technology that minimises the socio-economic challenges encountered by fish processors in the artisanal sector (Ahmed, 2008). Policies targeting the reduction of post-harvest loss and increased quality of fish products through the adoption of new technologies should be incentive-based and appealing enough to encourage fishers to abandon obsolete technologies for new ones (Ahmed, 2008). One of the simple ways for low-income earners, such as fish processors in coastal fishing communities in Sierra Leone, to invest in such technology is through a micro-credit scheme.



*Figure 2.* Traditional smoking banda with fish.

## **1.2. Micro-finance Schemes for Developmental Aid**

Despite the dismay expressed by fish processors, there are microcredit schemes operating in the country that are successful and worth considering. One is the Munafa Social Microfinance in Sierra Leone scheme, which supports 93% of women from deprived communities in Sierra Leone. The beneficiaries of the scheme are grouped and trained for a certain period. After this training, they are given loans based on their financing needs and repayment abilities. The scheme does not require a guarantor or collateral; beneficiaries are only required to participate in regular training on business management and other social themes geared towards holistic empowerment. Loan repayment is set based on the seasonality of their activity and the entrepreneur's schedule. A survey conducted in 2021 indicated that beneficiaries are satisfied with the Munafa microcredit scheme and attest to improving their living conditions (Entrepreneurs-Du-Monde 2021). A trial of such a scheme with a social dimension can also be

contextualised to fit the acquisition of fixed assets, such as smoke ovens, to preserve the quality of fish post-harvest and thereby maximise profits is worth considering.

The market-based approach is another developmental intervention used in developing countries. This approach ensures that interventions are sustainable by stimulating the target population to participate in marketing or supporting the demand for the goods or services they produce (Thorpe et al., 2017). It further offers an opportunity for the private sector to be involved in development programs to aid wealth creation, thereby making it effective and sustainable. This approach has been used by various donor organisations to implement aid in developing countries. One example comes from farmers in Ghana who needed help to increase yields in the face of rising fuel prices and cost of living. A private crop nutrition company provided access to fertiliser for farmers with support from USAID in a market-based approach, thereby successfully decreasing production costs and increasing yields for farmers (USAID private sector engagement, 2022). A similar approach might be suitable in Sierra Leone to support fish processors who wish to adopt new technologies, such as smoking cabin kilns.

### **1.3. Tutor web**

Tutor-web is an online (web-based) platform created for learning and research purposes. This web-based tool has been used to help students improve their grades in diverse academic subjects (Stefansson & Jonsdottir, 2021). Recently, the tutor web has been modified for use in mobile phones and tablets and can be used without Internet access (Jonsdottir et al., 2017). The platform awards grades to evaluate student achievement and has a built-in reward system in the form of cryptocurrency known as SMLY (or Smiley Coin). SMLY has a monetary value that can be redeemed and utilised for personal needs. At the University of Iceland, students using tutor web were able to use Smiley Coins on campus to purchase coffee and other goods (Stefansson & Lentin, 2017).

This platform has the potential for use as a research tool (based on completion of surveys) and method follow-up support to supplement developmental aid schemes, using Smiley Coin as an incentive for engagement.



#### **1.4. The Icelandic Project - pilot study results**

The Sustainable Use and Conservation of the Oceans, Seas, and Marine Resources for Sustainable Development in Sierra Leone Project (aka Icelandic Project) has as one of its objectives to provide a micro-credit scheme for postharvest processing equipment (Output 2.2 of Ministry of Fisheries and Marine Resources, 2018). This project is funded by the Icelandic government with an overall objective of “a holistic and integrated approach to sustainably improve livelihoods and conditions in coastal communities and increase the institutional capacity of fisheries authorities to sustainably use marine resources, combat illegal fishing, and increase revenue from fisheries resources” (Ministry of Fisheries and Marine Resources, 2018). The pilot phase of this project constructed a 12-chamber structure of the Cabin Smoking kiln (Matis oven, Figure 3) for fish processors in the Tombo community of Sierra Leone. Women in the fisheries group established by the Ministry of Fisheries and Marine Resources (MFMR) were the targets for this phase. To ensure the sustainability and acceptance of the new processing technology, a series of consultative meetings were held with women and relevant stakeholders. The suitability and acceptance of the technology were demonstrated when women processors chose to travel to utilise the Matis oven despite the distance from their homes or usual smoking point. This highlights the need to invest in additional ovens either at their usual smoking points or in areas more easily within reach, as suggested in the Feasibility Studies Report for Integrated Microcredit Scheme (Agbemabiese, 2020).

To achieve Output 2.2 of the Icelandic Project, a micro-credit scheme can be used to assist women fish processors in acquiring Matis ovens to replace their existing traditional smoking ovens. The results from the standardisation of the Matis oven and value chain analysis for the resulting smoked fish product will help clarify the efficacy of this new technology for small-scale fish processors in Sierra Leone. This information will be vital to inform micro-financing strategies and incentive systems aimed at enabling the adoption of modern smoking technology to reduce postharvest loss and maximise profits for fish processors.



*Figure 3. Cabin smoking kilns constructed in Sierra Leone (Gbla, 2020).*

### 1.5. Goals and Objectives

The overall goal of this project is to describe and compare different systems that could be used to encourage fish smokers to invest financially in improved fish-processing technology. The project seeks to:

- i. Suggest the most efficient method by which the cabin smoking kiln can be distributed and utilised by fish processors in the Tombo fishing community through a micro-credit scheme.
- ii. Explore the possibility of creating a supply chain by involving local smoking oven technicians or interested locals.
- iii. Determine the possibility of introducing an incentive system for processors using new smoking technologies.
- iv. Illuminate the local knowledge held by women fish processors regarding the pros and cons of smoking methods.

## 2 METHODOLOGY

This project utilised a qualitative research design through a desktop review of journals, publications, reports, and government documents related to the study, as well as the administration of questionnaires, as prescribed by Ravitch (2021). The desktop review focuses on documents related to government or donor support for developing communities in the form of incentives. Furthermore, similarities concerning the target population's needs and social and cultural constructs were considered. The incentive systems discussed cater to a participatory approach that enhances project ownership and sustainability after donor withdrawal and are

widely used by donor partners to alleviate poverty in developing countries (Bangura, 2021; Thorpe et al., 2017).

## **2.1. Questionnaires**

Qualitative questionnaires were administered to assess the perception of the target population of the Tobo community in Sierra Leone regarding the suggested adoption of modern smoking technology. Through closed and open-ended questions and demographic and rating questions, the questionnaire sought to:

- i. Assess the knowledge held by processors and technicians regarding modern technology.
- ii. Determine the cost that processors and technicians are willing to adopt to abandon their traditional smoking methods.
- iii. Establish stakeholder willingness to accept a repayable soft loan to replace existing smoking ovens.
- iv. Establish local technicians' availability and acceptance of training in the construction of new ovens and their willingness to be supervised during the project lifecycle.
- v. Establish the willingness of stakeholders to stop constructing "banda" smoking ovens.
- vi. Determine the total cost involved in constructing a traditional smoking oven.
- vii. Determine the willingness of processors and technicians to work with local microfinance institutions to access loans and redeem incentive points.
- viii. Assess perceptions and plans surrounding potential loan repayments.
- ix. Determine the system that will have the greatest potential for success in Sierra Leone.

## **2.2. Site and Participant Selection.**

The goal of the questionnaire survey was to obtain context-based knowledge of traditional and modern smoking technologies held by processors and their perception of the proposed incentive systems.

The site selected for this study was based on its correlation with the research goals and technology used by processors in the community. The Tombo community is located approximately 34 km away from the capital city. Fishing and fish processing are the primary socio-economic activities in this community, and they also serve as a fish market for fishermen from the provinces, surrounding communities, and villages (Kallon et al., 2017). The prevalent smoking technology in this community is "Banda" smoking, and this community was the recipient of the prototype of the Matis Oven.

Purposeful sampling was conducted in the study area based on the fish processor's sex, reason for fish smoking (subsistence or commercial), number of years they had been smoking fish, and their age. Participant selection was based on willingness to accept a repayable soft loan geared towards the construction of an improved smoking oven, training in the use of modern technology, and reasonable start-up capital. The same sampling method was used for private sector mobilisation. Local smoking oven technicians in the community were the main targets. Their age, sex, number of years working in the value chain, and location formed a part of the selection process. A paper-based questionnaire was administered by research assistants targeting fish processors within the Tombo fishing community. Forty fish processors and 10 local technicians were surveyed.

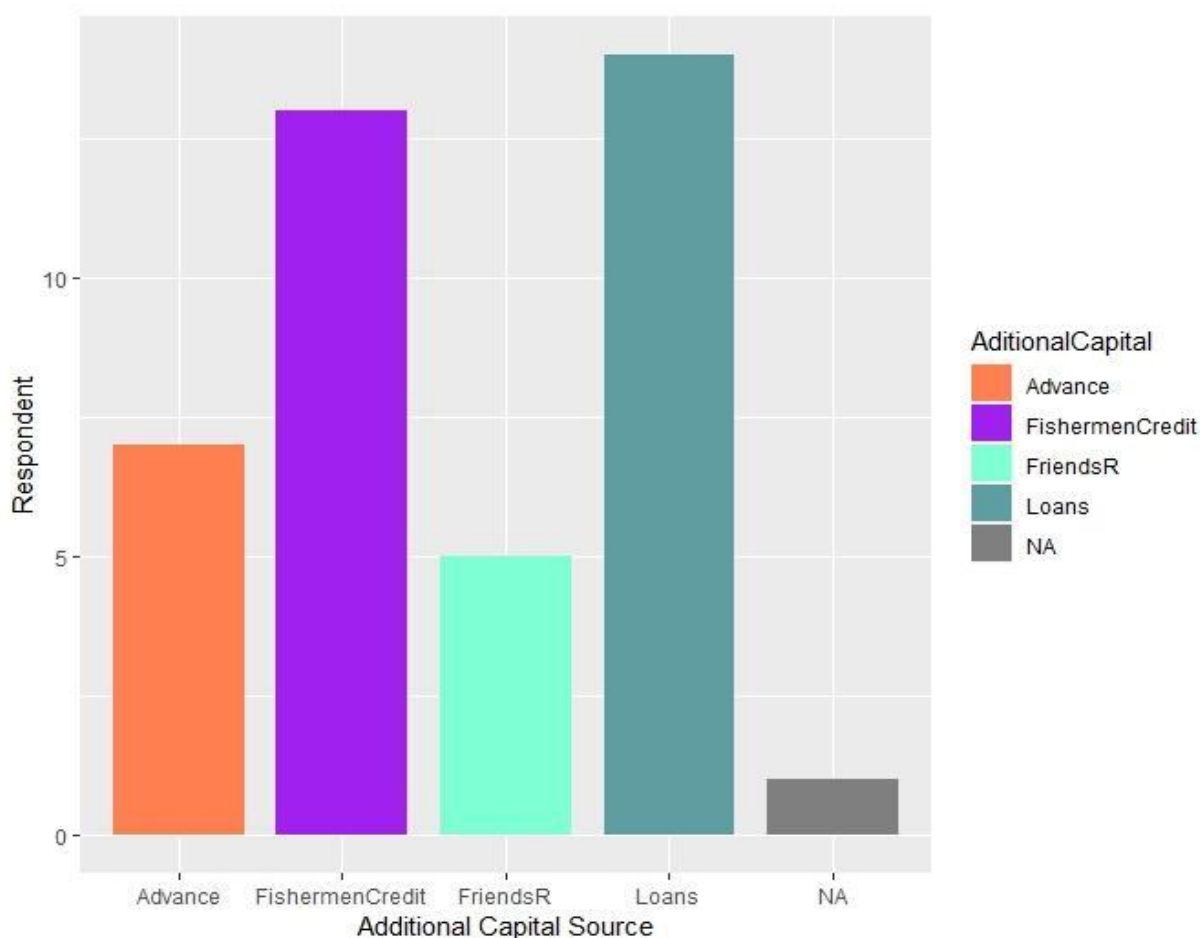
### 3 RESULTS

Questionnaires were administered to 40 fish processors and 10 smoke oven technicians. Since women dominate the post-harvest sector, they are the target group for the micro-credit scheme proposed by the Icelandic project. Therefore, emphasis was placed on the responses received from female processors.

#### **3.1. Fish Processor Surveys**

Of the fish processors, 85% were women and 15% were men. All the processors were between 25 and 61 years old, with most of them being between 25 and 30 years old, 60% of all the fish processors were married, and 56% of them had no formal education. The selling and processing of smoked fish was the major source of livelihood for all of the surveyed fish processors, and all had been processing and selling fish for more than five years.

An analysis of the survey data shows that, on average, these processors smoke a minimum of 500 dozen herring fish per month. However, they do not have enough capital to keep their businesses afloat and report using loans from banks and financial institutions, as well as in-kind credits from fishermen. In-kind credit is a system whereby fishermen give processors fresh fish to process, with the agreement that they will pay for the fish with interest after selling their product (Figure 4).



*Figure 4.* Sources of additional capital sought by fish processors in the Tombo Community.

The surveys were conducted on three major wharves (Kassi, Small Wharf, and Pepper Wharf) in the Tombo community. Most processors interviewed at these wharves used the traditional Banda smoking oven to process their fish (Figure 5). Most processors own their own smoking ovens. For those who rent oven use, payment is made based on the quantity of fish they intend to smoke (Figure 6). The banda ovens are located within the community, and there are approximately four smoke oven technicians in the community according to the processor survey responses. These traditional ovens can smoke approximately 500 dozen fish per month, and one oven can smoke up to 70 dozen in one smoking cycle depending on the size of the herring fish. The survey responses also suggest that processors are aware of the demerits of using old smoking technology, including its associated health risks. From the processor's perspective, the average cost of constructing the old smoking technology is NLe7000 (equivalent to \$324.23 USD), with a maintenance cost of NLe 2370.1 (equivalent to \$109.77 USD).

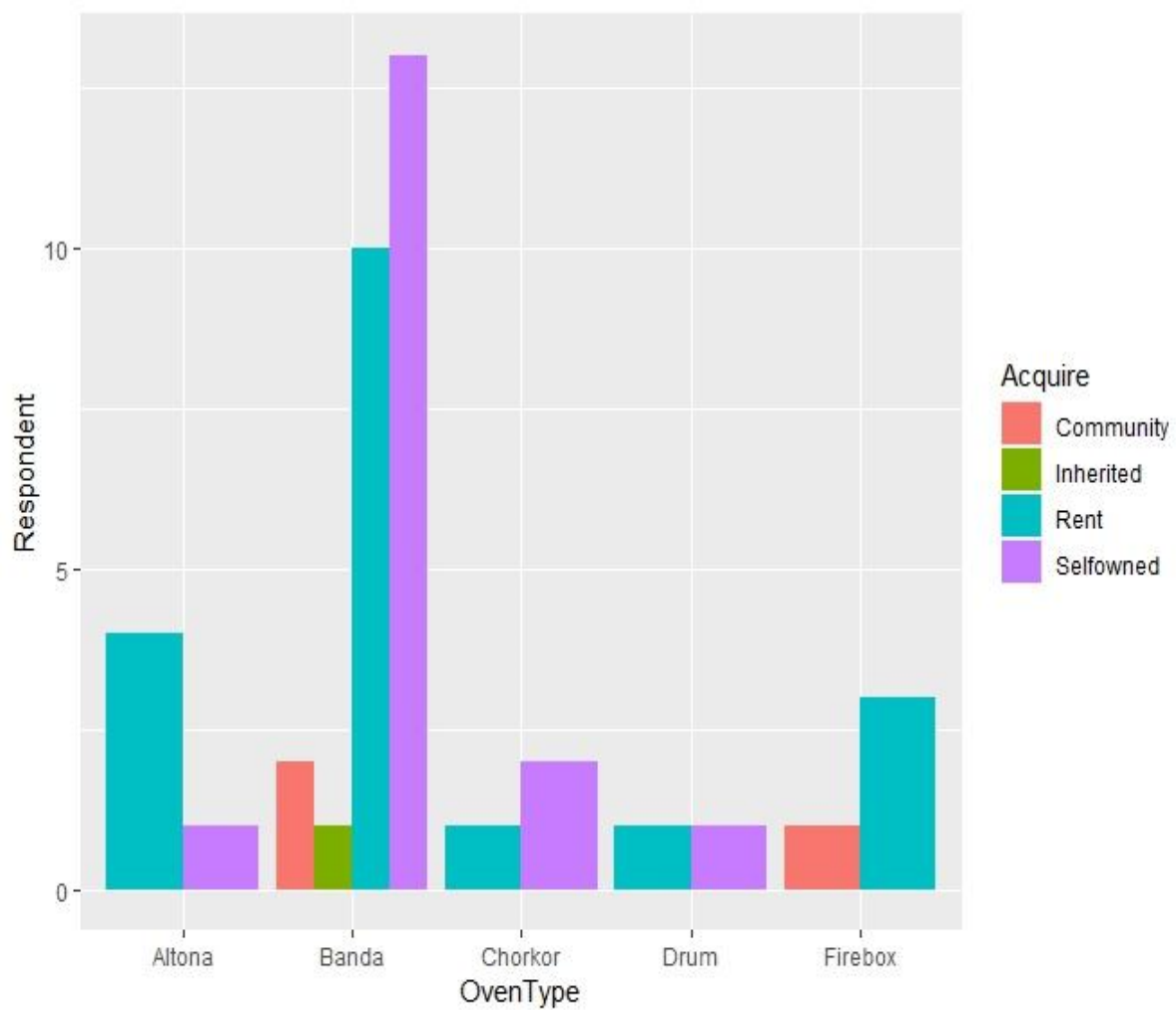


Figure 5. Type and ownership of smoking ovens in the Tombo Community.

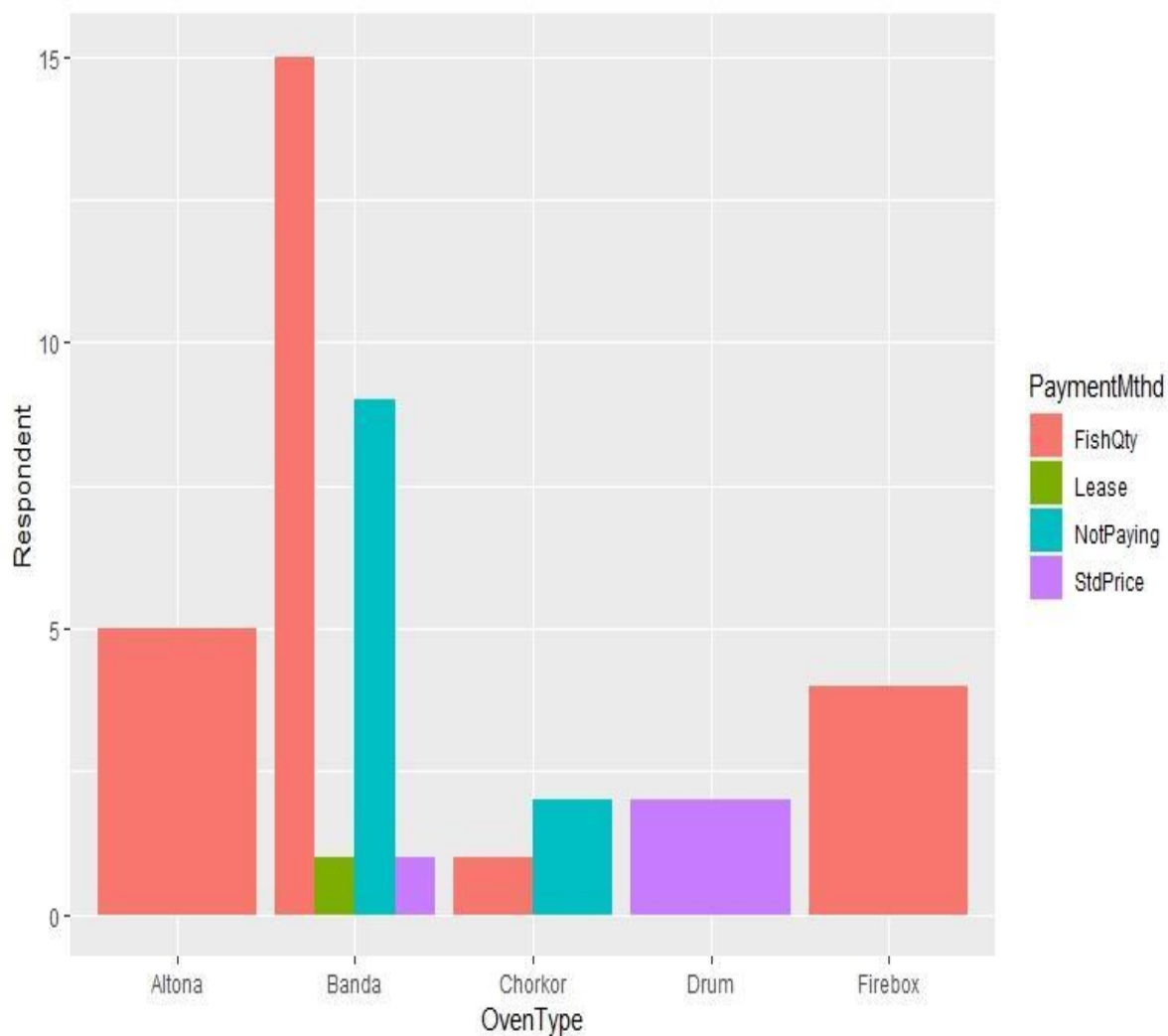


Figure 6: Use and payment method by smoking oven type in Tombo Community.

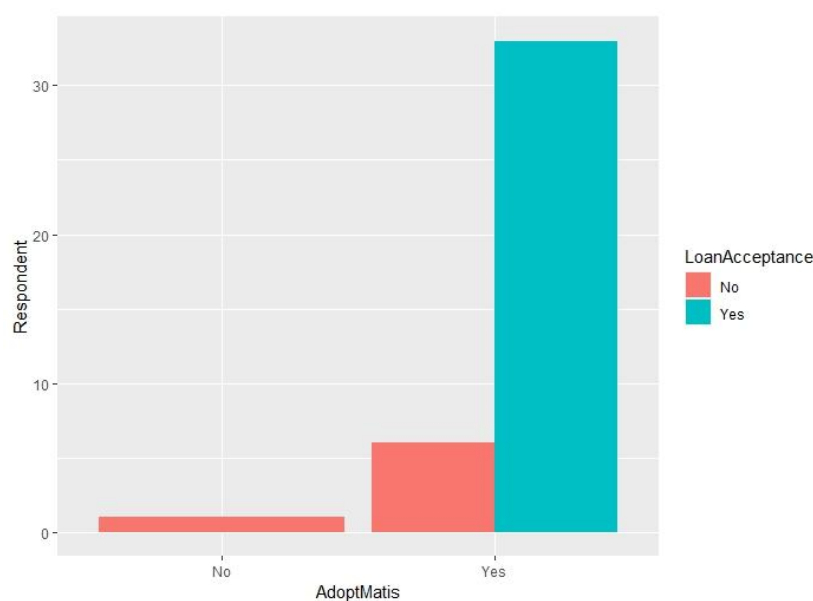
Survey responses indicated that four processors (10% of respondents) were not aware of the Matis oven in the community. Of the 36 respondents who were aware of the Matis oven, 13 did not use the oven but acknowledged some of its perceived merits; however, they maintained that smoking time was longer in the Matis oven (Table 1).

*Table 1.* Perceived merits of the Matis Oven from fish processor survey respondents.

**Table 1. Perceived Merits of the Matis Oven**

Matis.Merits	Yes	No	NA.
Uses Less Fuel	18	5	17
Products are of Better Quality	21	2	17
Processing Time is Longer	15	8	17
Demands Less Labor	19	4	17
Little or no Smoke Inhalation	19	4	17

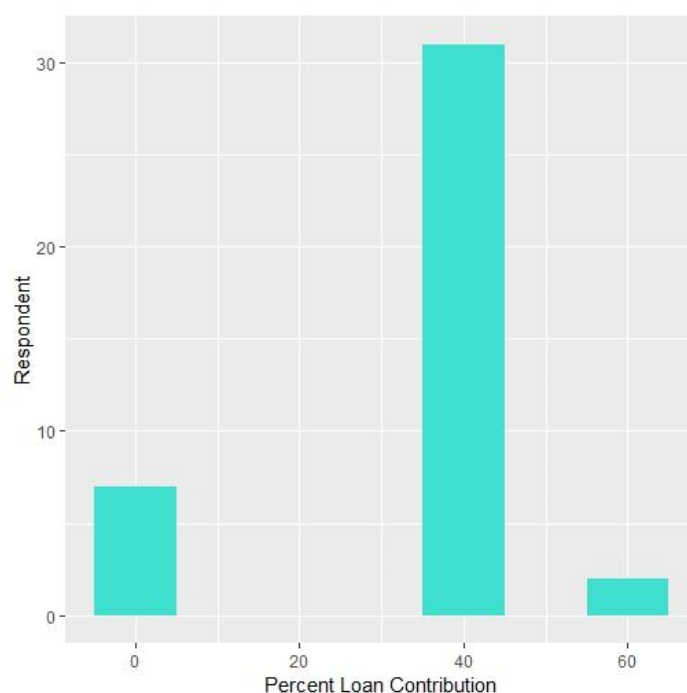
However, 33 processors (83%) indicated that they would be willing to accept a loan aimed at helping them acquire an improved oven, while 7 processors (17%) were not interested in the loan (Figure 7).



*Figure 7.* Interest of surveyed fish processors in loan acceptance to acquire an improved smoking oven.

Of those who indicated they were not interested in a loan, one responded that they did not want to adopt the new technology, while the other six would be more willing to pay for the technology outright rather than take a loan. With a total cost of NLe 21,607.72 (\$1,000 USD) for a new oven, these respondents were also willing to pay 40% (NLe 8,643.080, equivalent to \$401.28 USD) of the total construction cost and take a loan for the remaining 60% (NLe 12,964.632, equivalent to \$ 600.31 USD), (Figure 8).





*Figure 8.* Percentage loan contributions that would be acceptable to fish processors in Tombo Community for purchasing a new Matis smoking oven.

In addition to committing financially, survey respondents indicated that they were willing to work in groups of two to acquire the technology, if necessary. All 40 respondents were in support of training local smoke oven technicians in the construction of modern technology, and 36 respondents (90%) were in support of collaborating with trained technicians to obtain the technology. The survey results further indicated that the best repayment strategy would be through monthly payments for 6 months.

All 40 fish processor survey respondents supported having a training component alongside the micro-credit scheme. They also suggested a range of training themes broadly categorised into environmental, health-related, and social issues (Table 2). They indicated that they would be willing to partake in subsequent training after the acquisition of improved technology to earn credit points.

Table 2. Training themes suggested through fish processor questionnaires.

No.	Trainings
1	Business Managemnt
2	First Aid treatment on injuries sustained during fish smoking
3	The use of the new smoking technology
4	Alternative fish processing methods and marketing
5	Good practices in managing community owned properties
6	Bussiness ethics
7	Hygiene and Sanitation
8	Working with Microfiance Institutions

The credit history of the respondents indicated that most of them have borrowed cash from local fish merchants or middlemen. However, in most cases, the respondents' husbands were the ones making the decision (Figure 9). Many of the respondents did not know the percentage of the loan they were granted and reported that it took about a month for them to get a loan. Delays in the repayment of these loans were mostly because the cash that was borrowed was mostly used for unintended purposes such as paying fees and medical or other emergencies, rather than building capital.

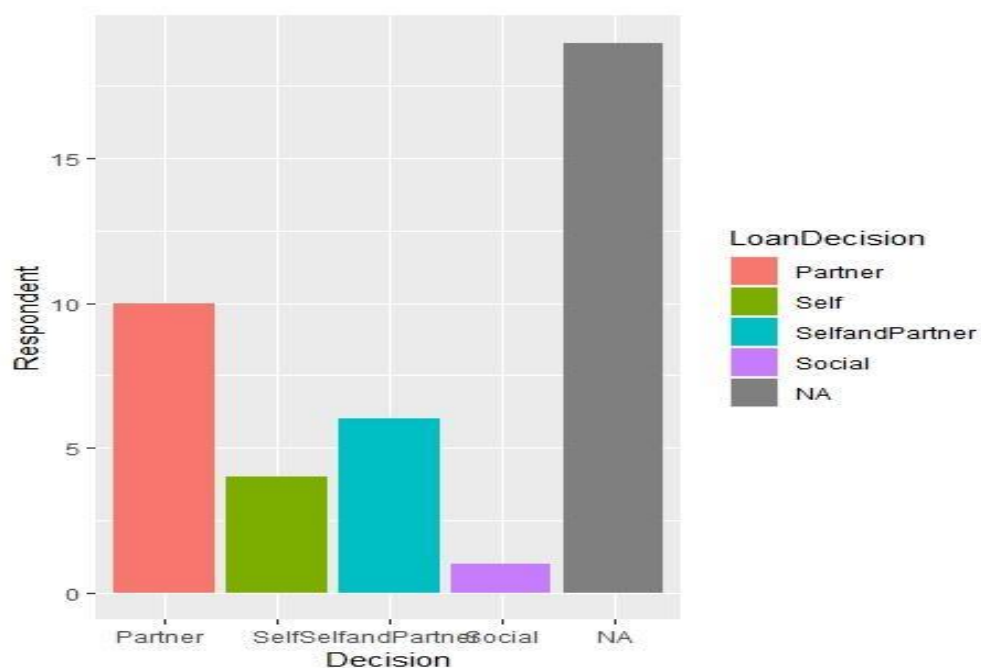
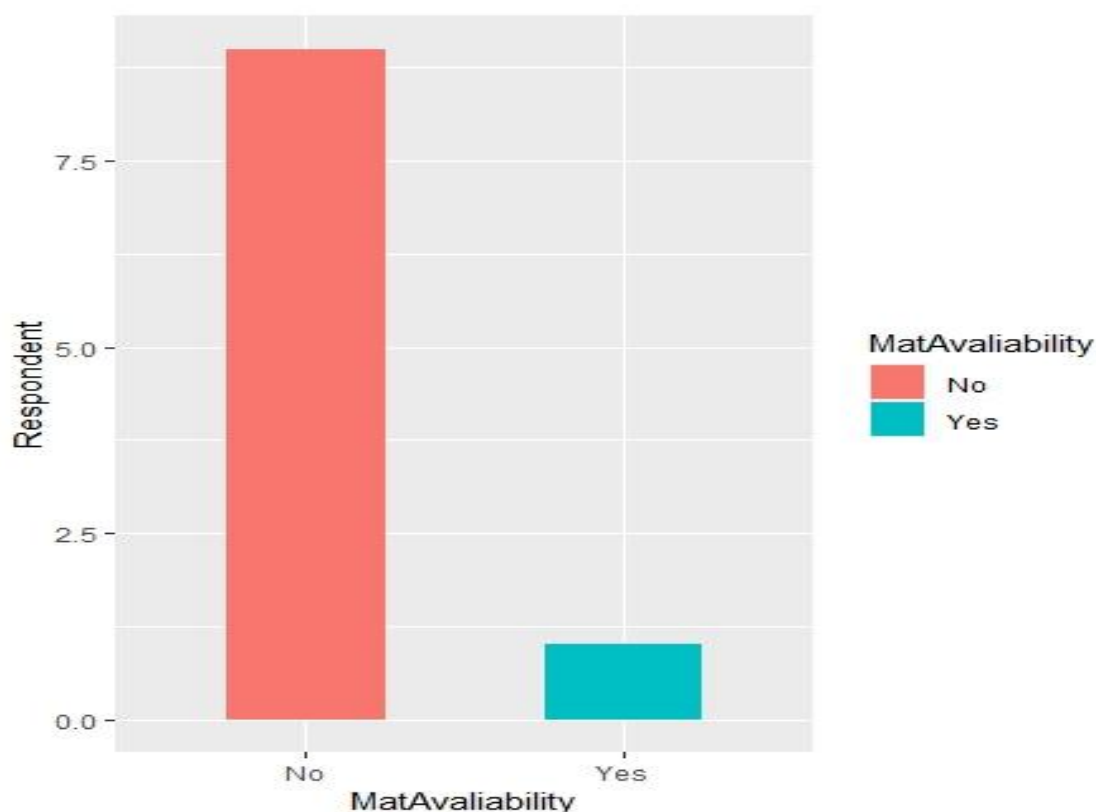


Figure 9. Decision making in loan taking as reported by an 85% female group of survey respondents.

### 3.2. Smoke Oven Technician Surveys

The smoke oven technicians in the Tombo fishing community were all male and between the ages of 41 and 50. According to the technicians interviewed, approximately 20 technicians in the community had no formal education. All but one respondent indicated that their main profession was as a local contractor and that they worked on smoke ovens as a side job. The technician respondents had more than five years of experience in constructing Banda and Altona smoke ovens. Their clients were mainly fish processors and traders within the community, with an average construction cost of NLE 5,500 (\$265 USD) and periodic maintenance for an average cost of NLE 2550 (\$123 USD). Payment for the construction of the ovens is typically done in part with an agreed amount paid before the job and full payment due when the job is done. Construction materials are mostly not found within the community, but the client provides the materials for construction (Figure 10), and the entire process takes approximately a week to complete.



*Figure 10.* Reported availability of construction material within the Tombo Community needed for building traditional smoking ovens.

Most technicians had not seen products from the Matis oven; however, they responded that they were willing to attend a training course geared towards learning techniques for constructing new ovens. More than half of the surveyed technicians did not attend any training on oven construction techniques and reported that there was no requirement to attend the training program. Technicians preferred a training course of 2 weeks to gain expertise in Matis oven construction and indicated a willingness to collaborate with fish processors in the community to obtain loans for oven construction.

#### 4 DISCUSSION

A key principle of the Sustainable Livelihoods Approach is working in partnership with fishers and stakeholders to achieve an effective, flexible approach to management (Allison & Horemans, 2006). Therefore, the willingness of fish processors to contribute 40% of the total cost involved in acquiring the oven and to work in groups, as well as with technicians, demonstrates their commitment to partnership with the project. Such partnerships are necessary for a Market-Based approach incentive system. A similar partnership was formed in

Bangladesh, where a social mobilisation campaign for sanitation created a market for latrine construction. The partnership opened a profitable supply chain for private workshops to produce latrines after massive campaigns on the need for proper sanitation (Heierli, 2008).

This project can build on existing chains of interaction between fish processors and oven owners. Processors currently pay oven owners based on the quantity of fish they smoke. This concept can be transferred into payments to Micro Finance Institutions (MFI) as a loan repayment strategy. Another existing relationship that can be incorporated is the client-contractor relationship between fish processors and oven technicians. The client demonstrates trust in the contractor by providing the raw construction materials and partial payment prior to construction, with full payment due on project completion. In most cases, case studies of developmental aid schemes indicate that reinventing the wheel by introducing new concepts faces resistance and slows adoption. However, modifying and building on existing structures and community strengths and relationships catalyzes adoption and helps ensure the sustainability of the project (Allison & Horemans, 2006).

Aside from the need to facilitate access to improved smoking technology, the desire for capacity building through training on diverse themes stood out in this research. The incentive systems proposed rely on training the target population to enhance overall socioeconomic growth in the community. Although the goal is the same, each incentive system employs a different training strategy. The market-based approach seeks to stimulate demand for the use of the improved Matis oven in the smoking of fish, which would create a market and, thus, a demand for technicians to construct Matis ovens. The microcredit approach seeks to train processors on the use of Matis oven and other social themes, thereby tracking their overall growth throughout the project cycle. Previous studies have shown that training on gender-related issues and marketing has proven successful. However, training in fish processing and handling is among the least successful training modules, because women do not have access to the equipment or facilities on which they are trained (Smith, 2022). This underscores the need for training and continued access to appropriate fish-processing facilities.

Fish processors' willingness to participate in training courses to earn extra credit can be used to introduce the Smiley Coin system (Stefansson & Lentin, 2017) to cover maintenance costs. One of the challenges encountered by Kenya's Educational Suitcase Program was Internet access. Hence, they relied on cooperative libraries for the redemption of Smiley Coins (Stefansson & Jonsdottir, 2021). A similar approach can be adopted for a project in Sierra Leone. As part of their training package, participants could be trained on the use of the offline

version of the tutor web for participation in post-project intervention activities, such as data collection, data entry, and post-project surveys. Participating in these activities could earn them smiley coins or credits that could be redeemed at the participating institution (project office or Ministry). The level of participation determines the amount of coins or credit earned through the reward system. These rewards can be used to replace damaged parts in the oven, cover maintenance costs, obtain cleaning equipment, etc.

Responses from the surveyed processors regarding their loan history and access to microcredit lending indicate that they have limited knowledge of how these financial institutions work. This confirms previous studies suggesting that women in fishing communities have limited access to financial services (Agbemabiese, 2020). Those whose loan requests were granted had limited knowledge of the processes involved and the loan decision was primarily taken by the husbands. The proposed intervention by the project is a new form of micro-credit scheme; therefore, these gaps in understanding and loan decision-making necessitate stakeholder sensitisation to expose women fish processors to the operations of financial institutions. Processors are willing to pay monthly, with a loan cycle of approximately one year based on construction costs, depending on the total cost involved. Inhabitants in developing communities, such as Tombo, are typically unable to make upfront payments for large sums of money. Therefore, innovative repayment strategies, such as leases, renting, and payment plans, can cushion loan repayment stress. Those who have received loans stated that one of the problems they encounter in repayment is the need to spend money due to home emergencies or using cash to settle unforeseen circumstances. Implementing a product loan option to obtain an improved oven could help avoid payback issues.

In the Tombo community of Sierra Leone, as in other developing communities, women dominate the onshore post-harvest processing chain (FAO, 2016; Odulate et al., 2012) The sale of smoked fish is not only limited to dedicated smoke fish processors. The survey responses in this study indicate that women selling fresh fish also smoke their day's leftovers, which can then be sold the following day. All surveyed fish processors stated that fish processing and trade were their primary sources of income. Therefore, there is strong motivation to secure the supply of fish and maximise their earning potential. While this project seeks to increase the earning potential from smoked fish products through the introduction of the Matis oven, it might be worth considering setting aside some funds as start-up funds to secure their livelihood. Staying afloat year-round is a challenge for these women, which is one reason they explore the possibility of obtaining loans from banks or in-kind credit from fish merchants. Female fish

processors in Sierra Leone often bear the greater financial burden of providing for their households, which can be a burden for a household that can have seven or more dependents (Agbemabiese, 2020). The quest to meet daily family needs might lead processors to make risky agreements with fishers to gain access to their source of livelihood. Studies have also shown that most of these women engage in general petty trading as a substitute during periods of low fish supply. This shows the degree of entrepreneurial skill and versatility in the informal sector. They can swap with other traders if they have enough capital during periods of fish scarcity, thereby keeping their capital rotating (Agbemabiese, 2020). This study and previous studies conducted in and out of Sierra Leone have reinforced the need to secure the livelihoods of these women. Regardless of the incentive selected by the project to meet this objective, the empowerment of women in fishing communities lies in securing their livelihoods.

Women engaged in selling fresh fish increases competition for existing traditional smoke ovens, which underscores the need for additional smoke ovens in the community. Owning the essential assets for their source of livelihood through the project is a major step in securing the livelihood of women in the sector. Based on the standard of construction materials, the lifespan of a traditional smoke oven is between 10 and 15 years with regular maintenance (Agbemabiese, 2020). Therefore, in replacing this technology, the substitute (the Matis oven) should have a similar lifespan or last longer. From the survey conducted, a standard traditional oven can take between 500 dozen to 700 dozen fish based on fish size (Agbemabiese, 2020) and mainly smoke *Sardinella*, *Etmalosa*, and other small pelagics (Agbemabiese, 2020). Research on the efficiency of the Matis oven using *Sardinella* fish suggested that the oven can hold over 120 kg (12 racks). This is equivalent to 912 dozen fish (subject to change based on fish size). This study further confirms that the improved technology uses less fuel wood than the old technology. The vertical structural design of the Matis oven compared to the horizontal Banda design favours improved technology's holding capacity per smoking session (Kabba, 2023). The correlation of the cost of constructing one traditional smoke oven between the processors and the technicians suggests that the cost of constructing one Banda ranges between NLE 6,000 and NLE 7,500 (\$285 to \$354), with a maintenance cost around NLE 200,000 (\$94 to \$123). The construction cost for a single unit of the Matis oven with reinforced metal was approximately \$1,600. Affordability issues and awareness raising are key to delivering public goods (Matis ovens) to enhance effective aid or intervention (Heierli, 2008). Hence, the provision of a micro-credit scheme directed at helping fish processors own a matis oven, as proposed, will help in the adoption of improved technology. The results obtained from this

study indicate that most of these processors own ovens and thus manage and control the much-needed assets for their livelihood. However, the overall status of these traditional ovens shows that most are in a deplorable status because of the 2006 flooding experienced by the community (Agbemabiese, 2020). This may be the reason for the high number of processors renting ovens to smoke their products. The study further states that there are no lending product schemes or insurance to compensate for the losses suffered by processors (Agbemabiese, 2020). By using any of the suggested incentives, the project can demolish the deplorable ovens and construct a new technology at the same time, which could ease the transition from the old to the new technology. This could also address complaints about post-harvest losses incurred during processing because of rain, pest infestation, health-related risks, or the rise in price for the cost of fuelwood (Smith, 2022).

Survey responses suggest that there is a need for greater awareness of the existence of improved technology in the community. Women who have utilised improved technology are confident about the merits associated with it. Their major concern, however, was the smoking time, which they thought was much longer than that of the traditional oven. However, some of these women believe that this is temporary, and that with continuous use, the kiln will be able to smoke their products in a shorter time. This theory is supported by the USAID Ghana report, which notes that clay-enclosed smoke chambers can retain and maintain heat, influencing smoking time and quality of the overall fish (USAID, Ghana, 2016). Furthermore, Kabba (2023) noted that because the Matis oven holds more fish, it takes longer to smoke. The value analysis of the *Sardinella* species using the Matis oven corresponds with the processor's observation that the product from the improved oven is of better quality than the traditional oven (Kabba, 2023). The proof of the better quality of the product is also supported by Odoi (2014), who states that the product quality is good compared to the traditional smoke oven in Ghana. Furthermore, the overall profit from smoked products from the Matis oven is higher than that from the traditional oven (Labour-Sesay, 2023) during *Sardinella* value chain analysis. Regardless of the limited knowledge held by processors of the new technology, they are willing to adopt the technology and abandon their traditional methods of smoking. The project could leverage their willingness to adopt the oven by finding a way to expand access to the prototype oven. A first-hand experience using the oven will give processors a clear perspective as to which incentive systems will work best for them.

Smoke oven construction is a side job for many of the technicians in the community; however, with the right incentives, they are willing to avail themselves of proper training on the



construction of the Matis oven and collaborate with women to access microcredit loans. This willingness is needed for the successful implementation of the suggested Market Based Approach incentive systems. Despite their vital role in implementing this approach, some processors are unwilling to collaborate with them. Further probing should be conducted to understand why they are not willing to collaborate with technicians.

The demographics section of the questionnaire showed that the processors in the community were within the energetic age bracket. Therefore, there is a high likelihood that any intervention made will be impactful in tackling issues such as food security and economic and social empowerment, given the right platform. The decrease in the number of processors from age 40 concurs with the theory that fishery-related activities are energy-draining; thus, fishermen leave the profession as they get older (Olapade & Sesay, 2019). The technicians in the community were mostly between the ages of 41 and 50, implying that they were less active and energetic. Both technicians and processors have little to no formal education. However, based on their responses, it is evident that they have extensive professional experience; therefore, their local knowledge should not be ignored. Training should be participatory and tailored to merge local and scientific knowledge for the proper use and full harnessing of the technology's productivity.

## 5 CONCLUSIONS AND RECOMMENDATIONS

Fish smoking and trade are major sources of livelihood for women in the Tombo community. After analysing the survey responses from the target population, all proposed incentive systems have the potential to produce the desired outcome. The market-based approach, loans with a social dimension, and smiley coin incentives can nudge processors towards owning and utilising the Matis oven which is critical to securing their livelihood.

Unfamiliarity with the proposed loan trajectory calls for a tailored capacity-building component that fits the educational level of the target population and project goals. As a motivation for technicians, they could be given a certificate that authenticates their participation in training. The results of this study suggest that all incentives have the potential to yield desired results. If possible, technicians' training should include interested people of a younger age, considering the current age of the interviewed technicians. Considering the effect of inflation and standard of living, further dialogues should be held with processors with regard to their percentage contribution in securing the technology. To cushion the inflation effect, including a start-up loan in addition to the product option loan (Matis Oven loan) is worth considering. While

waiting for the second phase of the project to start, the prototype Matis oven can be made accessible to all processors in the community.

The successful implementation of component 2 of the Sustainable Use and Conservation of the Oceans, Seas, and Marine Resources for Sustainable Development in the Sierra Leone Project will contribute to the achievement of one of the project's goals, which is to improve the lives of coastal communities. At the national level, this will aid the government's strides in achieving Cluster 2.2 target 2 and Cluster 5 target 2 (*Sierra Leone's Medium-Term National Development Plan 2019-2023*, 2019). Cluster 2 of the Medium-Term National Development 2 target 2 seeks to enable the fisheries sector to generate at least US\$15–20 million in government revenue and contribute at least 16 percent to the country's GDP by the end of 2023. Cluster 5 target 2 seeks to ensure that more women are supported to engage in entrepreneurial activities by the end of 2023 compared to 2018. At the global level, the success of this project will add to the strides taken to achieve Sustainable Development Goals 1, 2, 5, 13, and 14 (United Nations, 2022).

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## APPENDICES

### Appendix 1: Questionnaire for Fish Processors in Tombo Community

#### The Objective

This survey is part of a study that seeks to explore the possibility of setting an incentive system for the adoption of an improved smoke oven technology locally known as the Matis Oven. The study is sponsored by the GRO-Fisheries Training Program with the objective of obtaining the fish processor's perception of which incentive system works best for the adoption of the new fish processing technology within the Tombo Fishing community.

The survey consists of six sections, the 1<sup>st</sup> section answers questions on the demographic characteristics of the respondent, the 2<sup>nd</sup> section is on the key source of livelihood, and the 3<sup>rd</sup> and 4<sup>th</sup> section seeks to know knowledge held by the respondent on the old and new technology. The 5<sup>th</sup> and 6<sup>th</sup> section of the questionnaire assess the respondents' perceptions of the proposed incentive systems, their experience working with Microfinance Institutions (MFIs), and their general knowledge of taking a loan.

#### The Interview Procedure

The interviewer is required to introduce him/herself to the respondent. The questions should be read out exactly, as given in the questionnaire. The interviewer should not modify the question as per his/her understanding in case the respondent is not clear about the same. If the respondent is not clear about the question, the interviewer should repeat the question word by word.

To mark the answers, the interviewer is required to tick the ANSWERS provided in the grid, given below every question. Attention should be paid to the questions that require multiple answers.

#### A. Demographic

1. What is the respondent's gender?

- |         |           |
|---------|-----------|
| a. Male | b. Female |
|---------|-----------|

2. Age of respondent

- |                       |                |
|-----------------------|----------------|
| a. Below 25 years     | b. 26-40 years |
| c. 41-50 years        | d. 51-60 years |
| e. More than 61 years |                |

3. What is the educational level of the respondent?

- |   |                                  |
|---|----------------------------------|
| a. none   | b. Primary Education (Class 1-6) |
| c. Junior Secondary (JSS1-3)  |                                  |
| d. Senior Secondary Education or Technical Vocational Education (SS1-3) |                                  |
| e. University level   |                                  |

4. What is the respondent's civil or marital status?

- a. Never Married
- b. Living together.
- c. Married
- d. Separated
- e. Divorced
- f. Widowed

**B. Livelihood**

5. Are you, or any members of your household, engaged in any of the following livelihood activities? (Check all that apply 1 being the 1<sup>st</sup> preference)

- a. Fish trading and processing
- b. Fish processing only.
- c. Fish farming, trading, and processing (rubber etc)
- d. Farming plantation crops (cocoa, rubber etc)
- e. Livestock Rearing (fishing puts).
- f. General Trading (provisions, fishing puts).
- f. Other (specify).....

6. In order of preference, which livelihood activity is most important to your household?

- a. Fish trading and processing
- b. Fish processing only.
- c. Fish farming, trading, and processing
- d. Farming plantation crops
- e. Livestock Rearing General
- f. Trading (provisions, fish inputs, ice)

7. What is (are) the source(s) of your business capital?

- a. Self
- b. Friends & Relatives
- c. Partnership
- d. Loans from banks & finance institutions
- e. Trade advance from Fish mummies
- f. Credit from Fishermen
- g. Others specify).....

8. Do you have adequate capital for your business?

- a. Yes
- b. No (if YES skip Q. 14)

9. In what ways do you intend to acquire additional capital for your business?

- a. Friends & Relatives
- b. Loans from banks & finance institutions
- c. Trade advance from Fish mummies
- d. In-kind Credit from Fishermen

10. When did you start your fish-handling business?

- a. Less than 2 years                      b. 2-5 years                      c. More than 5 years

11. What is the main product you have been dealing in

- a. Fresh                      b. Smoked                      c. Sundried                      d. Fried

12. How long have you been operating at the current scale in fish processing and or trading?

- a. Less than 2 years                      b. 2-5 years                      c. More than 5 years

### C. Status/knowledge of the old form of processing equipment

13. Indicate the type and quantity of equipment you are using for processing

- a. Drum oven                       b. Firebox (Clay/sun-dried clay blocks)                       c. Altona oven   
 d. Charcoal oven                       e. Open/closed side dug oven/Banda ovens.   
 f. Chorkor kiln/Rectangular oven                       h. Cold room                       k. Deep freezer

14. How did you acquire the equipment/s you are using for processing operations?

- a. Self-owned                      b. rented                      c. Given/Inherited  
 d. Community-owned                      e. others (specify).....

15. Based on the selection of community owned or rented/leased what is the payment method?

- a. a standard fee regardless of the quantity of fish  
 b. pay based on the amount of fish smoked.  
 c. a standard fee paid on a weekly basis  
 d. in kind.

16. Where is your processing business located?

- a. Within locality                      b. Within business premises  
 c. Outside of the community                      d. other parts of the country  
 e. my home/backyard

17. Capacity of each Equipment (dozen)

- a. Less than 500 dozen per month                      b. 501-700 dozen per month  
 c. 701-900 dozen per month                      d. More than 901 dozen per month



18. Are you aware of the demerits of this form of smoking?

a. YES b. NO (If YES kindly list them)

.....  
 .....  
 .....  
 .....

19. Are there local technicians in the community that construct the old technology?

a. YES b. NO

20. How many and what is the total cost of constructing one old technology

Number of technicians	Cost of construction

21. What is the cost of maintenance and how regularly do your maintenance on your oven?

Maintenance Cost	Regularity

**D. Knowledge of The New Technology**

21. Are you aware of the new smoking technology (Matis) oven

a. YES b. NO ( if NO skip to Q25.)

22. Have you processed your fish product using the Matis oven?

a. YES b. NO ( if NO skip to Q26.)

23. On a scale of 1 to 5 how efficient and effective is the new technology compared to the old technology ( 1 being poor and 5 excellent )

1	2	3	4	5
---	---	---	---	---

24. From your experience what are the merits and demerits of modern technology? (Mark YES or NO against the selected option)

- a. product from this technology uses less fuel compared to the old technology.
- b. products are of better quality.
- c. processing time is longer.
- d. demands less labor.
- e. little or no smoke inhalation

25. Are you willing to adopt modern technology and abandon old technology?

- a. YES
- b. NO

26. Are you willing to use the oven despite you haven't used it yet?

- a. YES
- b. NO (if NO end of interview)

**E. The Incentives Systems**

27. Are you willing to accept a loan geared towards replacing your old smoking technology?

- a. YES
- b. NO

28. At a cost of NLe 19,457(\$1000) for the construction of one Matis oven, what percentage are you willing to contribute to constructing modern technology?

- a. 0%
- b. 40%
- c. 60%
- d. 80%
- e. 100%

29. Are you willing to collaborate with other processors if the need arises to get this technology?

- a. No.
- b. Yes in groups of 2
- c. Yes, in groups of 4
- d. Yes, in groups of 6.

30. Are you willing to attend a one-off training on the use of the Matis oven as part of the eligibility criteria to access the loan?

- a. Yes
- b. No (If NO skip to Q.31)

31. On a scale of 1 to 5, will you choose a one-off training on the technology use or training on various social themes including the use of the oven (mental health issues, gender-based violence, business management etc.), 1 been the most preferred and 5 the least

1	2	3	4	5
---	---	---	---	---

32. Can you suggest training that you think women in the community need more insight on?

.....

.....

.....

33. Would it increase your willingness to participate in training courses if you were to be given credit to participate in these training courses?

- a. Yes
- b. NO

34. Do you think it is important to have trained and specialized technicians in the construction of modern technology in the community?

- a. YES
- b.NO



43. What type of loan/borrowing?

- a. Cash b. In-kind c. Cash and in kind

44. Purpose of Loan

- a. Business/Working Capital Loan b. Emergency Loan  
d. education c. Housing

45. Who made the decision to borrow from this source?

- a. Self b. partner c. Self and Partner  
d. other household member(s) e. Self and other household member (s)  
f. Partner/Spouse and another household member (s)  
g. Social/Occupational Group/SHG

47. What percentage of the loan applied was granted?

- a. 100% b. 75-99% c. 50-74% d. Less than 50%

48. How long does it take to access the credit from your Lender?

- a. Less than a week b. 1-2 weeks  
c. 2-3 weeks d. 3-4 weeks  
e. Above 4 weeks

49. Does your Lender require collateral securities before the loan is granted

- a. Yes b. No (IF NO Go to Q52)

50. What form of security was required?

- a. Land b. House  
c. Car d. Business assets  
e. Jewel f. Individual Guarantee Group Guarantee  
g. others (specify):.....

51. Have you ever faced any problems with paying back the credit as well as the interest?

- a. Yes b. No (IF NO END OF SURVEY)

52. What were the problems

Select up to 4 reasons only for your inability to repay the loan below

- 1 “Force majeure” due to a natural disaster (Outbreak of Ebola) and or, War etc.
- 2 Poor cash or delayed harvest
- 3 Lack of subsistence funds
- d. The loan repayment period was very short.
- e. Use of loan for household consumption or unintended purposes
- f. Medical/other setbacks and emergencies

## **Appendix 2: Questionnaire for Oven Technicians in Tombo Community**

### **The Objective**

This survey is part of a study that seeks to explore the possibility of setting an incentive system for the adoption of an improved smoke oven technology locally known as the Matis Oven. The study is sponsored by the GRO-Fisheries Training Program, with the objective to know the perception of the target population on the possibility of creating a private sector; that will be responsible for the construction of the new smoking technology for fish processors and interested parties within the Tombo Fishing community.

The survey consists of 4 sections, the 1<sup>st</sup> section answers questions on the demographic characteristics of the respondent, and the 2<sup>nd</sup> section is on the key source of livelihood and knowledge held by the respondent on the old technology. The 3<sup>rd</sup> and final sections seek to know the knowledge held by the respondent about the new technology and the final section is about their willingness to be part of a training plan on how to construct the new technology.

### **The Interview Procedure**

The interviewer is required to introduce him/herself to the respondent. The questions should be read out exactly, as given in the questionnaire. The interviewer should not modify the question as per his/her understanding in case the respondent is not clear about the same. If the respondent is not clear about the question, the interviewer should repeat the question word by word.

To mark the answers, the interviewer is required to tick the ANSWERS provided in the grid, given below every question. Attention should be paid to the questions that require multiple answers.

### **A. Demographics**

1. What is the respondent's gender?

a. Male

b. Female

2. Age of respondent

a. Below 25 years

b. 26-40 years

c. 41-50 years

d. 51-60 years

e. More than 61 years

3. What is the educational level of the respondent?

a. none

b. Primary Education (Class 1-6)

c. Junior Secondary (JSS1-3)

d. Senior Secondary Education or Technical Vocational Education (SS1-3)

e. University level

**B. Livelihood**

4. Are you, or any members of your household, engaged in any of the following livelihood activities? (Check all that apply)

- a. Smoke oven construction
- b. Fishing, fish sales, and construction of ovens
- c. Local Contractor (general construction) contractor.
- d. Livestock Rearing and general contractor.
- e. General Trading and contractor.
- f. Other (specify).....

5. In order of preference, which livelihood activity is most important to your household? (1 being the top preference)

- a. Fish smoke oven construction
- b. Fishing, fish sales, and construction of ovens
- c. Local Contractor (general construction)
- d. livestock Rearing and general contractor
- e. General Trading and contractor
- f. Other (specify).....

6. What sort of smoke oven construction do you have expertise in?

- a. Drum oven
- b. Altona oven
- c. Charcoal oven
- d. Open/closed side dug oven/Banda ovens.
- e. Chorkor kiln/Rectangular oven

7. As a smoke oven technician what is (are) the source(s) of your clients?

- a. fish Processors and traders within the community
- b. fish Processors within the community only
- c. contracts from the community
- d. contracts from government institutions and other NGOs
- e. Contracts from interested people outside the community.

8. How regular or at what rate do you have contracts to construct or do maintenance of smoke ovens? (Tick all that apply)

Construction	Maintenance
One-off	One-off
After a year	After a year
After 2 years	After 2 years
After 3 years	After 3 years

9. How much does it cost to construct or maintain one smoke oven?

Construction	Maintenance
Le	Le

10. How is the construction process done?

- a. the technician provides the materials, and the cost is embedded in the total workmanship cost
- b. the client provides the materials and deducted from the total workmanship cost
- c. Materials are contributed on percentages bases aside from the workmanship cost
- d. other (.....)

11. How is the payment for the construction done?

- a. upfront payment of total cost
- b. part payment before construction and full after construction
- c. a payment plan is made within a certain time frame
- d. in kind
- e. other .....

12. Are the main construction materials readily available within the community?

- a. YES
- b. NO

13. How long does it take to construct one oven?

- a. a day
- b. a week
- c. 2 weeks
- d. 3 weeks
- e. a month

14. How long have you been a smoke oven technician?

- a. Less than 2 years
- b. 2-5 years
- c. More than 5 years

15. What is the total number of smoke oven technicians in Tombo community?

#### **D. Knowledge of The New Technology**

16. Are you aware of the new smoking technology (Matis) oven

- a. YES
- b. NO (if NO skip to Q20.)

17. Have you ever witnessed the use of the Matis oven

- a. YES
- b. NO (if NO skip to Q20)



