STUDY ON THE PROFITABILITY OF FISH SMOKING WITH FTT-THIAROYE KILNS IN CÔTE D'IVOIRE

Koane Mindjimba
FAO Consultant
Douala, Cameroun

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
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ABSTRACT

The FAO-Thiaroye fish processing technique (FTT) was developed in 2008–2009 by the Food and Agriculture Organization (FAO) of the United Nations in collaboration with the Centre National de Formation des Techniciens des Pêches et de l'Aquaculture in Senegal. The goal in developing this technique was to solve many issues inherent to traditional fish smoking methods in terms of health, safety and the environment. After the FTT was developed in Senegal, many other countries in sub-Saharan Africa have adopted this new method, while others are considering doing so. Using Côte d'Ivoire as the benchmark country for introducing the FTT in small-scale fisheries, this study was based on the assumption that it would be risky to increase the number of these kilns without first establishing their profitability. To do this, the field study combined qualitative and quantitative methods with institutional partners in Abidjan and with fish processors at three of the four pilot FTT processing facilities (Abobo-Doumé, Braffedon and Guessabo). The FTT kilns' financial and economic profitability has been determined using the net present value method, which was combined with sensitivity and break-even analyses. The FTT adoption determinants were ranked according to the so-called ranking model. The results not only confirm the technical superiority of the FTT over traditional smoking systems, but also demonstrate its financial and economic profitability. In light of these findings and lessons learned from the pilot processing facilities, priority actions have been identified at the various levels – facilities, local, regional and national – for the adoption of the FTT by more operators, and its wide dissemination. These actions aim to promote the FTT's sustainability and replicability, and suggest, in particular, that it is possible to increase the number of processing facilities with the same capacity (3 tonnes per day) from 4 units to 25 in Côte d'Ivoire. The total processing capacity would increase from the current 2 640 tonnes of fish to 16 500 tonnes on the basis of 220 days of operation per year considering rest days and maintenance of the kilns, as well as the seasonality of fish supplies.

Keywords: *FTT-Thiaroye, smoking, fish, profitability, determinants, adoption, Côte d'Ivoire.*

PREFACE

Despite the socioeconomic and nutritional importance of fish, fish smoking systems in Côte d'Ivoire are generally rudimentary, just as they are in other developing countries. In particular, these systems are non-compliant with the principles and recommendations of the Codex Alimentarius' Code of Practice CAC RCP-68-2009, which deals specifically with polycyclic aromatic hydrocarbons (PAHs). The FAO-Thiaroye fish processing technique (FTT) was purposefully developed as a solution to the many problems posed by traditional fish smoking systems (Anoh, Outtara and Ossey, 2016). These problems include: food safety (abnormally high PAH levels in products); health (prolonged exposure of fish processors to heat, smoke and toxic gases); food security and economic repercussions (relatively high post-harvest losses); and the environment (over use of fuelwood, and thus accelerated degradation of forest ecosystems, and air pollution due to harmful gas emissions).

After the FTT's development in Senegal, other African countries adopted this fish smoking innovation, with Côte d'Ivoire as one of the pioneers. In 2009, the first FTT prototype was built for semi-industrial fish processing, following Côte d'Ivoire's self-export suspension of smoked products to the European Union. FAO set up, for the first time in its history, another FTT prototype for artisanal fisheries in Abobo-Doumé (a suburb of Abidjan) in May 2013 in the aftermath of a regional workshop. This experience formed the basis of the Technical Cooperation Project "Support for Capacity Building and Regulatory Framework for the Prevention and Reduction of Post-harvest Losses in Côte d'Ivoire". This project was implemented from April 2014 to March 2016.

Three other prototypes were built, one each in Braffedon (near Grand-Lahou in the Grands Ponts Region), Guessabo (Haut-Sassandra Region) and Marcory-Anoumabo (Abidjan District). The main objective of these prototypes was to strengthen the food safety of artisanal fishery products in the country, particularly those that are processed. The prototype kilns were officially handed over to women fishmonger associations in Abobo-Doumé on 10 May 2013, Marcory-Anoumabo on 10 March 2016, Guessabo on 14 March 2016, and Braffedon on 18 March 2016.

Previous studies in both Côte d'Ivoire and other sub-Saharan African countries (Ghana, Democratic Republic of the Congo, United Republic of Tanzania and Togo), have clearly demonstrated the technical superiority of the FTT for fish smoking over other processes (improved or traditional).

Despite all of these undeniable comparative advantages, it must be recognized that these alone are not enough to motivate the decision to invest in this system. No study to date has, to our knowledge, compared the different systems' economic performance in terms of profitability. The kiln prototypes used in Côte d'Ivoire have been classified on the basis of health, safety and economics, which are essential criteria to this classification. This is why the knowledge of these aspects underlies the FTT adoption by processors and its dissemination on a larger scale. This comparison is of prime importance in relation to FAO's Strategic Objective 4, given the plan to extend the FTT system to fisheries and aquaculture sectors in other continents, Asia in particular, starting in 2017.

This report's overall objective is to determine the profitability of fish smoking using the FTT system on the basis of clearly established criteria. The study had three specific objectives: (i) compare the economic, social and environmental benefits, as well as the technical performance of the FTT versus traditional systems; (ii) establish an income statement of a standard processing unit and marketing of products made with it; and (iii) highlight the priorities for an enabling environment, including policy and institutional framework, fostering its adoption by processors and its large-scale expansion, as well as updating national PAH regulations.

This report is intended for competent authorities and the private sector in member countries, as well as international development agencies involved in fisheries and aquaculture in these countries. Individuals involved in these sectors thus have a guide containing relevant information on the FTT kilns' financial and economic profitability. This information also determines not only the factors that influence the adoption of these kilns and their widespread dissemination in Côte d'Ivoire, but also their introduction into other countries.

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Several institutional partners, each in their own capacity, provided the data and information. These are INFOPÊCHE, Laboratoire National d'Appui au Développement Agricole (LANADA), Institut de Géographie Tropicale (IGT) within Université Félix Houphouët-Boigny (UFHB), and Centre Hospitalier Universitaire under the UFHB.

Last but not least, to the women fish smokers, from both the FTT processing facilities and users of traditional kilns, who provided their inputs during the semi-structured interviews.

EXECUTIVE SUMMARY

Purpose and objectives of the study

Purpose

The purpose of this study is to ensure a progressive and viable shift of both small- and medium-holder fish processors from traditional fish smoking systems to the FAO-Thiaroye fish processing technique (FTT). The findings of this study should help policymakers and interested private investors make informed investment decisions about this new fish smoking system.

Overall objective

The overall objective of the study is to determine the profitability of smoking fish using this new system on the basis of clearly established criteria.

Specific objectives

The study's three specific objectives are to: (i) compare the economic, social and environmental benefits, as well as the technical performance of the FTT versus traditional systems; (ii) compile an income statement of a typical processing and marketing unit of products obtained with the FTT; and (iii) highlight the priorities for an enabling environment (including policy and institutional) fostering its adoption by processors and its widespread dissemination, as well as updating national polycyclic aromatic hydrocarbons (PAH) regulations.

Methodological approach

To achieve these objectives, the study combined qualitative and quantitative methods, and conducted a literature review of previous studies on the health and environmental impact of different fish smoking systems, which included a review of their respective strengths, weaknesses, opportunities and threats. Data and information in the field were collected through focus group discussions with institutional partners in Abidjan and women fish processors at three of the four pilot FTT processing facilities (Abobo-Doumé, Braffedon and Guessabo).

Main conclusions

Comparing the technical performance of different fish smoking systems

This study's results confirm those of previous studies conducted in both Côte d'Ivoire and other countries, which clearly demonstrate that the FTT is technically superior to other fish smoking processes and kilns, whether they are improved (such as the Chorkor kiln) or traditional (metal drum[1], earth or clay). In fact, in terms of food safety, FTT-smoked products are not only safer – owing to significantly lower PAH levels – but are also of higher quality. Results from tests involving 111 fish smokers in Abobo-Doumé, Braffedon and Guessabo in 2015 (Traoré, undated) showed that fish smoked with the FTT contain PAH levels that are 40 to 60 times less – depending on the fish species used (tuna-like or catfish) – than fish of the same species smoked with traditional systems. Results confirming these differences were obtained in neighbouring Ghana (Bomfeh, 2016), where it was found that fish smoked with the FTT system contained lower PAH levels than fish smoked with another method, where the PAH levels were found to be 35 times higher than the acceptable limits of the European Union.

Women using the new FTT system are less exposed to heat, smoke and toxic gases, and are less prone to ocular, respiratory and skin diseases than women using other fish smoking methods. Thus, their working conditions are significantly improved in terms of comfort, hygiene and health. According to the results of clinical and para-clinical examinations carried out on a sample of 52 women fish smokers at the Grand-Lahou and Braffedon artisanal processing sites in 2016 (Anoh, Outtara and Ossey, 2016),

[1] Also called drum kilns (GRET, 1993).

more than half of them had developed ailments related to their occupation. The most recurrent health problems were respiratory and ophthalmic diseases, and ear, nose and throat ailments. Cases of skin infections and typhoid fever were also recorded, and are due to a lack of hygiene and an unsanitary work environment.

From an environmental viewpoint, traditional fish smoking processes require the burning of large quantities of fuelwood, and thus produce a large volume of carbon dioxide (CO_2), which is responsible for significantly increasing greenhouse gas emissions, and higher carbon monoxide (CO) levels than the regulatory standards in this area allow.[2] With the FTT system, however, the consumption of fuelwood and other fuel types is much lower, resulting in less pressure on forest resources and a reduction of toxic gases and harmful pollutants into the atmosphere. For example, the FTT uses 0.8 kg of wood to smoke 1 kg of fish as opposed to 3–5 kg of wood used in traditional smoking systems (Ndiaye, Sodoke Komivi and Diei-Ouadi, 2015; Ziehi, 2016). Therefore, fewer toxic gases are released into the atmosphere (Anoh, Outtara and Ossey, 2016), which also helps to better protect fish smokers' health.

Financial and economic profitability analysis

The results prove that FTT kilns are, moreover, financially and economically profitable. They require an investment of XOF 857 600 or 2 845 200[3], depending on whether a single prototype kiln (FTT Banda) is purchased or whether all of the kilns installed on a typical pilot unit (comprising two FTT Banda kilns and one FTT Altona kiln on the Abobo-Doumé and Guessabo facilities). Indeed, their net present value (NPV) amounts to more than XOF 10.3 million (USD 17 133) and more than 7.6 million (USD 12 636), respectively, corresponding to an internal rate of return (IRR) of 34.9 percent and 31.7 percent on the basis of a discounting rate of 10 percent per annum over 10 years.

Sensitivity analysis

According to analysis, all items (whether expenditures or revenues) do not have the same effect on the FTT kilns' financial capacity (NPV and IRR). In descending order, those with the most effect are fish smoking and marketing (in either direction); fresh fish purchasing; revenue from ancillary income-generating activities (IGAs); and miscellaneous expenditure. In contrast, this capacity is less affected by items such as personnel costs and the discount rate (this rate's decrease, however, has a significantly greater effect than its increase). IGAs (i.e. sale of food packaging, basins, internal savings and loan system) thus contribute to increasing processors' revenues. Diversifying and adding value to fishery products (e.g. sausages, croquettes, fish "samosas", use of fish fat) also achieve the same objective. It is planned that that these kilns will be used in other fishing communities across the country.

Break-even point analysis

The break-even point analysis of the key parameters shows that the two kiln prototypes selected for this purpose are only profitable if they generate an annual turnover of nearly XOF 11.5 and 12.1 million (USD 19 032 and 20 014) for the sale of 3.9 tonnes and just over 4.1 tonnes of smoked fish, respectively. This corresponds to a processing capacity of more than 8.9 tonnes and nearly 9.4 tonnes of fresh fish a year when fish smoking entirely substitutes IGAs. The break-even point is less than 5.3 and 5.7 tonnes of fresh fish when processors undertake other activities, resulting in more than 1.6 and 1.7 times less. This reflects the wide dissemination margin for FTT kilns across Côte d'Ivoire in terms of nominal processing capacity (i.e. 3 tonnes of fresh fish per processing facility per day), fisheries potential, food availability and market needs, among other factors.

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[2] Although CO_2 levels are relatively low (between 0.2 and 0.5 percent), they can alter air quality given the need to burn large quantities of wood when using traditional fish smoking techniques (Anoh, Outtara and Ossey, 2016; Ndiaye, Sodoke Komivi and Diei-Ouadi, 2015; Ziehi, 2016). However, as it has been demonstrated (Anoh, Outtara and Ossey, 2016), the levels of CO and other toxic gases (H_2S, VOC, NO_x) are comparatively higher and vary according to the type of fuel used.

[3] Equivalent to USD 1 419 and 4 709, respectively.

Main lessons learned from the FTT and the determinants of its adoption and widespread dissemination

Several lessons can be learned from the FTT, which determine the conditions not only for its adoption by processors, but also its widespread dissemination, and hence its sustainability and replicability. In order to entrench achievements, these lessons particularly emphasize the importance of adopting a participatory approach in the planning of this system, its implementation and its monitoring, as well as carefully selecting the site's location, adapting the equipment used to local conditions and market needs. They further highlight the need to: (i) sensitize populations and target groups to entrust the kilns' use and management to well-structured and organized target groups; and (ii) strengthen their capacity, monitor and evaluate their activities so as to take corrective action in a timely manner as needed.

According to the target groups, the main determinants for adopting the FTT are: (i) sociodemographic – the number of FTT kilns available versus need, which had a mean score of 8.57 out of 10; (ii) geographical – the proximity of the kilns to processors' dwellings, which had a mean score of 6.48; and (iii) environmental and non-environmental pollution, which had a mean score of 6.00. Sanitary and safety factors (e.g. safety and quality of products, preservation of women processors' health, and improvement of their working conditions) ranked only 6th in importance (mean score of 4.13) and 10th in importance (mean score of 2.43), respectively. These results reflect the unsatisfactory business environment and consumer behaviour, which do not clearly differentiate between FTT and traditional products, particularly in terms of price and quality.

Priority actions

Priority actions have been identified at different levels (FTT processing facilities, local, regional and national) in light of the above and in view of the FTT adoption by a larger number of processors and its wide dissemination. These actions are intended to promote the sustainability and replicability of this innovation.

Main recommendations

The above conclusions highlight the need to pay particular attention to key parameters that have the greatest effect on the financial capacity of FTT kilns. These conclusions and the resulting lessons thus have implications on the decision-making process concerning priority actions to be taken to replicate these kilns across the country.

i. **Increase the number of FTT facilities from 4 to 25** (21 additional units of the same capacity); in so doing, the total processing capacity would increase from 2 640 tonnes of fish to 16 500 tonnes on the basis of 220 days of operation per year considering the number of rest days and days used to maintain the kilns, as well as the seasonality of fish supplies.
ii. **Choose the locations of the FTT facilities so that the largest number of potential users are reached out,** with the knowledge that the effects of the FTT are more noticeable among fishing communities with a high concentration of women fish smokers than among those where women tend to smoke fish on an individual basis.
iii. **Select and adapt the equipment to be used according to the specificities of each site**, and in consideration of the main fish species targeted and market needs.
iv. **Strengthen good hygienic practices in general**, and systematically treat well-water and rainwater used to wash utensils and raw fish prior to smoking according to prevailing standards.
v. **Raise awareness and educate** consumers, decision-makers and competent authorities about the FTT's comparative advantages over traditional fish smoking systems, including placing healthy and higher-quality products on the market through appropriate channels, including, in agreement with competent authorities, broadcasting videos produced by FAO on this new technology on local television channels; processors, for their part, should further be made aware of the need to protect their health and conserve the environment, and the necessity to better package and label their products.

vi. **Target more rewarding markets for FTT products** by meeting these markets' requirements in terms of quality assurance and control, traceability and regularity of supplies, and **explore the possibility of setting up model market stalls**.
vii. **Strengthen the capacity of processors and government staff responsible for providing monitoring and support** (regarding, among other things, smoking techniques, the use of improved processing facilities and FTT kilns and their maintenance, bookkeeping and functional accounting, monitoring and commercial strategies). **Also strengthen the capacity of local artisans' (metal carpenters, blacksmiths, welders and cutters)** to manufacture and assemble FTT components and ensure their maintenance in view of disseminating this new technology, after having identified and selected them according to clear criteria.
viii. **Encourage additional learning** by promoting or organizing (or both) exchanges of experiences between FTT facilities for processors and government staff responsible for providing monitoring and support.
ix. **Strengthen collaboration mechanisms among institutional partners** by revitalizing the Fisheries Advisory Committee.
x. **Update national regulations regarding PAHs**, with a view to guaranteeing fishery products' traceability and quality control; the objective is to ensure that PAH and metal trace element contents in products placed on the market do not exceed national and international standards in force, and that these standards are respected and upheld throughout the value chain.

CHAPTER 1: INTRODUCTION

1.1 Background

1.1.1 A solution to the challenges in traditional fish smoking systems

Despite the socioeconomic and nutritional importance of fish, fish smoking systems in Côte d'Ivoire are generally rudimentary, just as they are in other developing countries. In particular, these systems are, in fact, non-compliant with the Codex Alimentarius Code of Practice CAC RCP-68-2009, which deals specifically with polycyclic aromatic hydrocarbons (PAHs).[4] The Food and Agriculture Organization of the United Nations (FAO)-Thiaroye fish processing technique (FTT) was purposefully developed by FAO – in collaboration with the Centre National de Formation des Techniciens des Pêches et de l'Aquaculture in Senegal – as a solution to the many problems posed by traditional fish smoking systems (Anoh, Outtara and Ossey, 2016). These problems comprise: food safety (abnormally high PAH levels in products); health (prolonged exposure of processors to heat, smoke and toxic gases); food security and economic repercussions (relatively high post-harvest losses); and the environment (over use of fuelwood, and thus accelerated degradation of forest ecosystems, and air pollution due to harmful gas emissions).

After its development in Senegal, other African countries adopted this fish smoking innovation, with Côte d'Ivoire as one of the pioneers. In 2009, the first FTT prototype was built for semi-industrial fish processing, following Côte d'Ivoire's self-export suspension of smoked products to the European Union market.[5] FAO set up, for the first time in its history, another FTT prototype for artisanal fisheries in Abobo-Doumé (a suburb of Abidjan) in May 2013 on the occasion of a regional workshop. This experience formed the basis of the Technical Cooperation Project (TCP) "Support for capacity building and regulatory framework for the prevention and reduction of post-harvest losses in Côte d'Ivoire" (TCP/IVC/3501). This project was implemented between April 2014 and March 2016 under the auspices of the Ministry of Animal and Fisheries Resources (MIRAH) in partnership with local authorities (FAO, 2016a).

Three other prototypes were built in Marcory-Anoumabo (Abidjan District, prototype renamed FTT-Abidjan), in Guessabo (Haut-Sassandra Region) and in Braffedon (near Grand-Lahou in the Grands Ponts Region). The main objective of these prototypes was to strengthen the food safety of artisanal fishery products in the country, particularly processed fish. The kilns were slightly modified from one site to another based on observations made by the women users of the preceding models (e.g. reducing the racks' mesh size so as to smoke smaller fish, and the kilns' height). These pilot fish processing facilities were officially inaugurated and handed over to the beneficiaries by MIRAH on 10 May 2013 for Abobo-Doumé, 10 March 2016 for Marcory-Anoumabo, 14 March 2016 for Guessabo and 18 March 2016 for Braffedon).

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4 These are chemical compounds deposited on food resulting from the incomplete combustion of wood. Studies and tests carried out on both these foods and fumes (Auby *et al*., 2013; Djessouho, undated; OFSP, 2012; Traoré, undated) have highlighted the carcinogenic potential for the consumer. They originate as much from wood combustion as from the fat from the fish that drips on the fire, and are thus found in the fumes. Because of this, they are subject to national and international regulations. Thanks to the fat collector, fish smoked with the FTT contain 40 to 60 times less PAHs than those smoked with traditional systems, depending on the fish species. As various studies demonstrate (Bomfeh *et al*., 2016; Traoré, undated), the type of kiln used influences the level of contamination in the smoked fish.

5 This self-suspension, which took place between 2006 and 2011 in order to solve the problem related to PAHs and to avoid European Union embargo measures, caused significant economic losses, estimated at around XOF one billion per year (USD 1.6 million). As a result, small processors could no longer sell their products in this lucrative market (Djessouho, undated; Randrianantoandro, 2015).

1.1.2 Constraints of traditional fish smoking systems and the comparative advantages of the FTT

Previous studies in Côte d'Ivoire (Anoh, Outtara and Ossey, 2016) and neighbouring Ghana (Bomfeh, 2016; Bomfeh *et al*., 2016), and other countries such as the Democratic Republic of the Congo[6], the United Republic of Tanzania and Togo[7] (Djessouho, undated; Kissai and Mgawe, 2017; Randrianantoandro, 2015), have clearly demonstrated the technical superiority of the FTT for fish smoking to other smoking processes, be they improved (such as the Chorkor kiln) or traditional (e.g. in barrel sections, in mud or clay). In fact, in terms of food safety, FTT products are not only safer, having significantly lower PAH levels, but are also of higher quality. According to the results of tests carried out on 111 fish smokers in Abobo-Doumé, Braffedon and Guessabo in 2015 (Traoré, undated), fish smoked using FTT kilns contain 40 to 60 times less PAHs, depending on the fish species (tuna-like or catfish) than the same species smoked with traditional systems. Results confirming these differences were obtained in neighbouring Ghana (Bomfeh, 2016), which showed that PAH levels were lower using the FTT technique, and about 35 times higher using traditional processes, as measured against the European Union standards.

In terms of public health, it has been shown (Anoh, Outtara and Ossey, 2016) that women who use FTT kilns are less exposed to heat, smoke and toxic gases than women who use other smoking processes. The main toxic gases produced during smoking are carbon monoxide (CO)[8] and low levels of carbon dioxide (CO_2) from wood combustion, along with other gases such as volatile organic compounds (VOC), nitrogen monoxide (NO), hydrogen sulphide (H_2S) and sulphur dioxide (SO_2), depending on the type of fuel used.[9] Women who use FTT kilns are therefore less prone to ocular, respiratory and skin diseases, and their working conditions are significantly improved in terms of comfort, hygiene and cleanliness. According to the results of clinical and para-clinical tests carried out with 52 women involved in processing at artisanal fish smoking sites in Grand Lahou and Braffedon in 2016:

> *Fifty-two percent (52%) of these women develop pathologies related to their activity. The most common health conditions are respiratory diseases (50%); ophthalmic and ear, nose, and throat diseases (47%). [...] With traditional smoking techniques, [these women] burn large quantities of wood, which means that a huge volume of CO_2 is responsible for increasing greenhouse gas emissions. In addition, traditional smoking emits harmful pollutants to the women's respiratory system.* (p. 3)

The same source (Anoh, Outtara and Ossey, 2016) also reports cases of skin infections and typhoid fever in 8 percent of women, which are attributed to the lack of hygiene and the unsanitary environment in their workplace.

The same types of comparative examinations carried out previously on women fish processors who used traditional smoking systems in Yopougon-Abobo-Doumé showed that almost 65 percent of them developed activity-related pathologies. The most common health problems were respiratory diseases

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6 As reported in the United Nations article in Democratic Republic of the Congo titled: *"*La RD Congo adopte le four FTT-Thiaroye de transformation du poisson*"*. (available at http://cd.one.un.org/content/unct/rdc/fr/home/actualites/la-rd-congo-adopte-le-four-ftt-thiaroye-de-transformation-du-poi.html).
Farhay, X. undated. La FAO introduit une technologie innovante en fumage et séchage du poisson en RD Congo. FAO Democratic Republic of the Congo Country Office press release. (available at https://www.humanitarianresponse.info/fr/system/files/documents/files/fao-_communique_de_presse_30042015.pdf).
Bungubetshi, G. undated. Plan d'affaire PFT/FTT. Unpublished report.

7 Kpakpabia, C., personal communication, 8 June 2014. (available at http://letempstg.com/2014/06/08/fao-thiaroye-nouvelle-technique-fumage-sechage-poisson-professionnaliser-peche-au-togo/).

8 It is a very dangerous, odorless, colourless, non-irritating gas that is slightly lighter than air: it thus mixes very quickly with the latter to form carbon dioxide (CO_2); it acts in the same way in the human body because, when inhaled, it takes the place of oxygen by binding to the blood's haemoglobin to form a stable molecule, carboxyhaemoglobin.

9 For example, NO and H_2S are more prevalent in the smoke from coconut shells and mangrove wood (Anoh, Outtara and Ossey, 2016)

(close to 76 percent), ophthalmic conditions (about 49 percent), and ear, nose and throat infections (more than 87 percent). As demontarted by Mambo-Gnakalé (cited in (Anoh, Outtara and Ossey, 2016), these women also suffered from anaemia (17 percent) and high blood pressure (23 percent).

Less fuelwood and other fuels are used with the FTT, resulting in a reduction of toxic fumes and harmful pollutants in the atmosphere (e.g. PAHs, CO_2, CO, VOC, NO, H_2S, SO_2). On a larger scale, these emissions have a negative environmental impact in terms of climate change.[10] Because the FTT consumes less fuelwood, as it has been demonstrated (Ndiaye, Sodoke Komivi and Diei-Ouadi, 2015; Ziehi, 2016), i.e. 0.8 kg of fuelwood per kg of fish vs 3–5 kg of fuelwood using traditional systems, it releases less toxic gas into the atmosphere (Anoh, Outtara and Ossey, 2016), thus preserving fish smokers' health and the environment. In contrast, traditional kilns emit CO contents well above the normal level as decreed in Order No. 01164 of 4 November 2008, which regulates the release and emissions by installations classified for environmental protection.[11] According to this order, the maximum permissible concentration of CO is 50 mg/m^3 for a maximum permissible flow strictly greater than 1 kg/h. The normal operation of FTT kilns is based on the complete combustion of fuel and the separation of the cooking and smoking stages.[12]

1.2 Rationale for the study

Despite all of these undeniable comparative advantages, it must be recognized that these alone are not enough to motivate the decision to invest in this system. No study to date has, to our knowledge, compared the different fish smoking systems' economic performance in terms of profitability. The kiln prototypes used in Côte d'Ivoire have been classified on the basis of health, safety and economics, which are essential criteria to this classification. This is why the knowledge of these aspects underlies this new system's adoption by processors and its dissemination on a larger scale. This comparison is of prime importance in relation to FAO's Strategic Objective 4, given the plan to extend this system to fisheries and aquaculture in other continents, Asia in particular.

With regard to Côte d'Ivoire, the country of reference for the FTT's introduction in small-scale fisheries, the major question raised is, can the number of these prototypes be increased, without risk, and extended to other fishing communities in the country, as provided for in the National FTT Extension Programme?[13] In other words, are these prototypes financially and economically profitable to justify such an extension? If so, what is the optimal number to implement in view of the present state of fisheries resources and their potential? These are all questions that this study proposes to provide answers to and, thus, motivate a decision. This study is based on the following assumptions:

i. in addition to food safety, food security and environmental benefits, as described above, the FTT kilns used to smoke fish in Côte d'Ivoire are more cost-effective both financially and economically than other kilns (Chorkor kiln and traditional kilns in drums and clay in this case);

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[10] It is now established (Anoh, Outtara and Ossey, 2016) that climate change is the result of an increase in average temperatures caused by greenhouse gases accumulation in the Earth's atmosphere, the most important of which is CO_2. Because traditional fish smoking systems consume more wood than the FTT, they release more CO_2 (and other toxic gases such as CO and volatile organic compounds) into the atmosphere.

[11] Available at http://www.envipur.com/docs/reglementation/ARRETE%20SIIC%20-%20REJETS%20DES%20EMISSIONS.pdf

[12] In the remainder of the report, the definition of smoking is taken from the Codex Alimentarius (CODEX STAN 311 – 2013): "Smoking" is a process of treating fish by exposing it to smoke from smouldering wood or plant materials" with a view to preserving and flavouring it. This is done through hot smoking (as opposed to cold smoking in temperate countries). Smoking is, according to the cultural dictionary, "the method of preservation by smoking" or "the duration of the smoking operation". However, both terms are interchangeable.

[13] The implementation of this programme was authorized by the Council of Ministers of 20 July 2016 on the basis of the recommendations of the TCP/IVC/3501 project feedback workshop, which took place in Daloa from 14 to 16 March 2016. (available at https://www.gouv.ci/doc/1469096151CCM_20%2007%202016_V3%20(SGG)%20(003)vf.pdf).

ii. in which case, their adoption by processors and their wide dissemination are justified on all of these levels if the internal and external environment (micro, meso and macro level) of their current use is favourable.

This wide dissemination will undoubtedly lead to increased pressure on fisheries resources. And even if many processors smoke imported frozen fish, the state of the fisheries resources in territorial waters should be able to sustainably support the additional pressure. In other words, because large quantities of fish can be smoked with the FTT (i.e. 3 tonnes per processing facility per day), available fish stocks and fisheries potential should support the resulting additional needs for fish.

1.3 Purpose and objectives of the study

1.3.1 Purpose

The purpose of the present study is to ensure a progressive and viable shift of fish processors (both smallholder and medium-holder) from traditional fish smoking systems to the FTT with regard to fish smoking. This should help policy-makers and interested private investors make informed investment decisions about this new system.

1.3.2 Objectives

The overall objective of this study is to determine the profitability of fish smoking using the new FTT system on the basis of a clearly established diagnosis. The study has three specific objectives:

i. compare the economic, social and environmental benefits, as well as the technical performance of the FTT[14] smoking system versus traditional systems;
ii. compile an income statement of a standard processing and marketing unit of products obtained with the FTT; and
iii. highlight the priorities for an enabling environment (including policy and institutional) that will foster its adoption by processors and its widespread dissemination, as well as update national PAH regulations.

1.4 Report structure

Apart from this introductory chapter, which sets out the study's context, rationale, merit, purpose and objectives, this report contains seven more chapters:

Chapter 2: Methodological approach.
Chapter 3: Policy, legislative, regulatory and institutional framework.
Chapter 4: Terms of use of FTT processing facilities, target groups' structure and organization.
Chapter 5: Comparative analysis of different fish smoking systems.
Chapter 6: FTT and traditional kilns comparative profitability study results.
Chapter 7: Priorities for an enabling environment for FTT adoption by processors and its large-scale dissemination.
Chapter 8: Conclusions and recommendations.

[14] For simplicity, the rest of the report refers to the FTT or FTT system instead of the FTT-Thiaroye.

CHAPTER 2: METHODOLOGICAL APPROACH

The mission was conducted in three phases: (i) preparatory phase, mainly dedicated to a literature review and the preparation of survey forms; (ii) execution phase with briefings, debriefings, field surveys, data collection and analysis; and (iii) closure phase, including the preparation of this study report and the mission report, the presentation of study findings and their validation, finalizing the reports and submitting them to FAO for approval. The chapter also explains the difficulties encountered in this context.

2.1 Preparatory phase

2.1.1 Literature review

Pertinent documents were reviewed as soon as the contract was signed. The fishery officer of the Products, Trade and Marketing Branch of FAO's Fisheries and Aquaculture, Policy and Resources Division provided most of these documents, which covered, among other things, studies carried out in Côte d'Ivoire and in other countries regarding the sanitary and environmental impact of different fish smoking systems, the PAH content of fish depending on the type of fuel or packaging used, as well as TCP/IVC/3501 project reports. These were supplemented at home and in the field with other related documents, including those dealing with fisheries and fish marketing in Côte d'Ivoire. These provided an overview of the country's fisheries and, more particularly, the fish smoking systems in use.

2.1.2 Checklists and survey forms

At the same time, survey forms were drawn up including a strengths, weaknesses, opportunities and threats (SWOT) matrix, mainly the advantages and disadvantages of the various fish smoking systems, as well as the cash flows with costs on the one hand, and benefits on the other. These were designed as checklists, with the view that they would be completed on site through semi-structured interviews. Other survey forms focused on the determinants of FTT adoption (Annex 8) and the loans granted to processors by local financial institutions (Annex 9).

2.2 Execution phase

2.2.1 Briefings and debriefings

The field mission was organized around briefings and debriefings with relevant officials of FAO in Côte d'Ivoire (FAOCI), as well as with institutional partners in Abidjan, namely those from the Direction de la Formation, de la Vulgarisation et de la Valorisation des Produits (Training, Extension and Product Valorization Directorate, DF2VP), the Intergovernmental Organisation for Marketing and Cooperation Services for Fishery Products in Africa (INFOPÊCHE), the Laboratoire National d'Appui au Développement Agricole (National Support Laboratory for Agricultural Development, LANADA) and the Institut de Géographie Tropicale (Institute of Tropical Geography, IGT).

Debriefings were organized with the FAO Representative in the presence of the National Animal and Fisheries Resources Expert and, at times with the Focal Point of the Multipartner Programme Support Mechanism (FMM/GLO/103/MUL). The purpose was to assess the progress of the field mission, take corrective action as needed, and plan the remaining activities with full knowledge of the facts.

2.2.2 Field surveys and data collection

This mission also included field surveys with the National Animal and Fisheries Resources Expert and the FMM Focal Point. Three of the four pilot FTT processing facilities set up under the abovementioned

TCP – Abobo-Doumé (suburb of Abidjan), Braffedon (Grands Ponts Region) and Guessabo in the Haut-Sassandra Region (Figure 1) – were each visited.[15]

Figure 1. Locations of pilot FTT-Thiaroye facilities and study areas in Côte d'Ivoire, as of 30 September 2017

Source: G.N. Etamé and Mindjimba. Map conforms to United Nations Côte d'Ivoire map, February 2020.

Local traditional and administrative authorities and local MIRAH officials were met during these field surveys, as well as several women fishmongers and processors (those who use the FTT or traditional systems, or both). Interviews with these women focused on the various smoking systems used. These interviews, combined with direct msseasurements and observations of activities, focused on comparing the systems in question in terms of advantages and disadvantages, as well as costs and benefits.

These interviews were conducted either with individual key informants or a limited number of informants in the case of institutional partners and traditional processors because they usually operate individually, or with focus groups comprising FTT processors because they are organized in cooperative societies. These groups included 15 interviewees on average, and interviews lasted between an hour and an hour and a half, depending on the number of participants. Overall, FTT processors were more willing to be interviewed than traditional processors. Thus, the participatory approach was adopted in this context. Some data collected were quantitative (cash flows), while others were qualitative (SWOT).

15 The Marcory-Anoumabo processing facility (Abidjan), visited only during the national stakeholder validation workshop from 15 to 17 November 2016, is not included in the analysis.

At FAO's request, complementary surveys were carried out in Abobo-Doumé and Guessabo in August 2017 with the assistance of a consultant. The objective was to elucidate the determinants of FTT adoption based on a relevant questionnaire (Annex 8). This questionnaire included the identification of respondents, whether or not they belonged to a socioprofessional group or a cooperative society, their use (or not) of FTT kilns, and the determinants of these kilns' adoption.

The second questionnaire (Annex 9) related to the loans granted to respondents by local financial institutions. It aimed to determine the extent to which these operators' empowerment, structure and organization constituted confidence factors in that regard. This questionnaire was administered to a random sample of 45 women fish processors (using FTT and/or traditional kilns) and fish wholesalers at Abobo-Doumé and Guessabo.

2.2.3 Data analysis methodology

This consisted of entering, processing, validating, cross-checking and analysing the data collected in the field using Excel software, version 2010.

Financial and economic analysis: Based on the NPV method of cash flows, the financial and economic analysis involved the calculation of the profitability of kilns, with a particular focus on the FTT. Thus, in addition to the NPV and corresponding cash flows, the financial and economic internal rate of return (IRR) was calculated, together with the profitability index (PI). Fillowing similar studies (Mindjimba, 2001; Mindjimba, Meke Soung and Dissaké, 2001), control ratios were also calculated and included the benefit-to-cost ratio (B/C) and the net benefit-to-investment ratio (N/I or N/K) or profit-to-investment ratio.

These different parameters were calculated according to the formulas below:

$$\text{NPV} = -I_0 + \frac{\sum_{t=1}^{t=n}(B_t - C_t)}{(1+r)^t} \quad (1)$$

Where:

- I_0 denotes the initial investment;
- B_t denotes the annual benefit in year t;
- $1C_t$ denotes the annual cost in year t;
- $Bt - Ct = CFt$ is the cash flow during year t;
- t denotes the number of years (project lifetime);
- r denotes the discount rate or opportunity cost of capital;
- $(1+r)^t$ is the compounded interest factor or discount factor.

Conventionnally, the IRR corresponds to the discount rate that breaks even the NPV according to the following formula:

$$-I_0 + \frac{\sum_{t=1}^{t=n}(B_t - C_t)}{(1+r)^t} = 0 \quad (2)$$

However, there are cases where no discount rate breaks even the NPV (e.g. when all cash flows are positive). In this case the IRR was calculated using the following alternative formula:

$$\text{IRR} = r_a + \frac{NPV_a(r_b - r_a)}{(NPV_a - PV_b)} \quad (3)$$

Where:

- r_a represents the lowest discount rate chosen (i.e. the 10 percent discount rate per annum used in the calculation of the NPV minus 10 percent, or 9 percent);

- r_b denotes the highest discount rate chosen (i.e. the 10 percent discount rate per annum used in the calculation of the NPV increased by 10 percent, or 11 percent);
- NPV_a denotes the net present value corresponding to the lowest discount rate r_a;
- NPV_b denotes the net present value corresponding to the highest discount rate r_b.

$$\text{PI} = \frac{NPV}{I_0} \tag{4}$$

Financial capacity of kilns: As shown below, the financial capacity of kilns is mainly computed according to the NPV and IRR methods. Despite its limitations, the latter is widely used, especially by financial institutions. These limitations are extensively discussed in the specialized literature. Some of them include: (i) "it does not provide information on the expected net margin over the valuation period"; (ii) nor does it "help in assessing whether the envisioned production capacity is satisfactory or not"; (iii) as shown above, there are two rather than one formula to calculate the IRR, when no discount rate breaks even the NPV; (iv) "it is difficult to calculate when all the NPVs are positive"; and (v) the same NPV may correspond to more than one IRR, given the NPV's bell-shaped curve.

This is why both IRR and NPV were chosen as parameters for the analysis, and the above control ratios only served to confirm analysis results. Thus, kilns are considered profitable when their NPV is positive; the higher the NPV, the more profitable the kilns are, and their IRR is strictly higher than the discount rate (or interest rate of the investment capital), or when the IRR and control ratios B/C and N/I are greater than 1 (Mindjimba *et al.,* 2001). Conversely, kilns are not profitable when their NPV is negative, the IRR is lower than the discount rate, and the control ratios are lower than 1; in which case the investment capital is higher than the present value of the benefits, so no investment should be made.

Investment depreciation: This was calculated using the straight-line method and the annuity amount was determined accordingly.

Basis of analysis: The analysis does not consider the FTT processing facility (that includes the shed,[16] equipment and solar energy supply system), but rather the improved kilns housed on each processing facility as a unitary system. Two kiln prototypes were selected for this: the FTT Banda kiln with two compartments (one used for cooking and the other for smoking), and the FTT Banda and Altona kiln types installed at the Abobo-Doumé and Guessabo pilot processing facilities (Table 1).[17] They are designated as prototypes 1 and 2, respectively, in the analysis. The first was chosen in this context because, unlike other prototypes that contain either a cooking or smoking compartment only, it fulfils all of the necessary functions (i.e. cooking, smoking, drying and storage).

Table 1. Characteristics of the two FTT kiln prototypes selected for the analysis

Characteristics	Prototype 1	Prototype 2
FTT Banda 1	1 cc + 1 cs	2 cc
FTT Banda 2	-	1 cc + 1 cs
FTT Altona	-	1 cc + 1 cs
Cost (XOF)	857 600	2 845 200
Selection criterion	Fulfils all necessary functions (cooking, smoking, drying and storage).	Corresponds to the frame of different kiln types installed on a processing facility.

cc = cooking compartment, cs = smoking compartment

[16] In comparison, FTT kilns in other countries (as with the first prototypes in Cameroon) have been installed under a simple shelter, not on a processing facility. The fact that CMATPHA members have built four of these processing facilities around Abidjan reflects processors' desire to take charge of their own activities; they are expecting external support to set up improved kilns.

[17] The rest of the report shows that, in addition to the FTT Banda kiln prototype described in the first case, these include another FTT Banda with a dual compartment kiln for cooking, and an FTT Altona kiln with a dual compartment (one of which serves for cooking, and the other for smoking).

The second prototype, which corresponds to the different kiln types installed at a processing facility, was selected in the wake of the National FTT Extension Programme across the country. Therefore, any study of this system's profitability must take into account the approach adopted to this end, which aims to guide the types of interventions to be implemented and decisions to be made to adopt this system. In fact, physically protecting this system or locating it under a shed complies with standards, so a cost-benefit analysis is clearly warranted.

Sensitivity and risk analysis: This supplemented the profitability analysis. It takes into account the uncertainty inherent in fish smoking's seasonality and unpredictability. Moreover, it assesses the effects of changes in the assumptions made on the kilns' financial capacity in terms of management and investment opportunities in this area (Mindjimba *et al.,* 2001). Thus, the break-even points of the key variables (corresponding to a nil NPV) were calculated, as were the sensitivity indices (SIs). It should be recalled that the SI is the measure of the ratio of the relative change of the IRR (or the NPV) to the relative change of the variable tested (Mindjmba, 2001; Mindjimba *et al.*, 2001). Some of the variables of particular interest in this regard are the optimal capacity of a standard system and the number of processing facilities to be set up in relation to fisheries potential and food supply.

Analysis of strengths, weaknesses, opportunities and threats (SWOT) and FTT adoption determinants: Although the SWOT analysis results for the different smoking systems have highlighted some of these determinants, as noted above, a specific questionnaire was used to better understand them. Respondents were asked to prioritize up to 10 determinants among a list of 20 possible determinants. These determinants were ranked according to the so-called ranking model and scored from 1 to 10, from the least to the most determining one. This model quantifies qualitative variables, with factor scores being considered as continuous, and mean scores calculated accordingly. Only 23 of the 45 respondents (51 percent) who use FTT kilns expressed their perceptions. Therefore, they were selected for the analysis. As this sample size was considered too small (a minimum of 30 respondents would have been ideal in this case) to produce statistically significant results, it did not seem appropriate to analyse the effect of certain variables (e.g. respondents' age, seniority in the profession, and education level) on these determinants.

2.3 Closure phase

2.3.1 Presentation of study findings and their validation

The study findings were presented during the national stakeholder validation workshop organized by FAO and MIRAH in Grand-Bassam from 15 to 17 November 2016. The workshop's theme was: *"*Sustainable Development Strategy of the Gender Sensitive Fisheries Value Chain*"*. The objective was to inform participants of the development of a strategy in this area with a view to better mainstreaming the gender dimension into the development of fish value chains. As such, according to the terms of reference of the workshop, participants were able to share, exchange and visualize the challenges faced by the sector's stakeholders, gender issues, their interdependencies and the proposals formulated on the basis of the studies carried out. This workshop also created synergies and complementarity between the different sectors and concerned ministerial departments, agencies, and technical and financial partners.

2.3.2 Submission of the report and its validation

The draft study report was submitted to FAO and MIRAH for comments. The present version has incorporated those comments that were deemed relevant by FAO.

2.4 Difficulties encountered, and limitations of the study

The lack of data on cash flows and, thus, income statements was the main difficulty encountered in this study. The few data available are not detailed enough. For example, the data collected on a day-to-day basis at the Abobo-Doumé processing facility concern: (i) the quantities of fresh fish (broken down by

species) intended for smoking on behalf of third parties; (ii) the quantities of wood required and the costs; (iii) the cost of the smoking; and (iv) the net benefit for the Women Fish Traders and Processors Cooperative of Abidjan (CMATPHA). At the Braffedon processing facility, these data relate to the quantities of fresh and smoked fish by species. Finally, at the Guessabo processing facility, only the quantities of smoked fish were collected.

Under these conditions, the necessary data were collected during smoking sessions at Braffedon and Guessabo. These were extrapolated as much as possible to the raw data from the existing records and cross-checked with those collected through semi-structured interviews with fishmongers and processors. Thus, raw data were detailed according to the needs of the analysis and on the basis of the fish species concerned and the fishing seasons.

CHAPTER 3: POLICY, LEGISLATIVE, REGULATORY AND INSTITUTIONAL FRAMEWORK

This framework defines the policy and institutional environment in which fisheries activities in general, and fish smoking in particular, are practised in Côte d'Ivoire in terms of structures and transformation processes. Its influence in this context is undeniable because it determines, in connection with the third specific objective of this study, the conditions under which processors adopt the FTT, and this innovaton's large-scale dissemination to the whole country, as well as updating national PAH regulations.

3.1 Policy framework

In Côte d'Ivoire, fisheries and fish processing are governed by strategy documents such as National Development Plans (NDPs),[18] including the current NDP, which covers the period 2016–2020 (following the 2012–2015 NDP), as well as other legislative and regulatory reference documents described below.

3.2 Legislative and regulatory framework

The dissemination of processing facilities housing FTT kilns to other fishing communities of the country is in line with the relevant legislative and regulatory framework. In particular, this dissemination forms part of the National FTT Extension Programme. The following reference documents have been drawn up in the context of the NDPs:

- Fisheries and Aquaculture Law No. 2016-554 of 26 July 2016.[19] Article 2 of this aims, inter alia, to "protect, conserve and manage in a sustainable and rational way fisheries resources as a national heritage, for present and future generations".
- The Livestock, Fisheries and Aquaculture Strategic Development Plan for the period 2014–2020, adopted in February 2014, aims, in particular, at reducing post-harvest losses, and thus increasing national artisanal fisheries production.[20]
- The Fisheries and Aquaculture Development Master Plan for 2010–2025 was developed in May 2009 with FAO's technical assistance. The plan is "based fundamentally on the national vision of economic and social development as well as the underlying national and international strategies in the quest for rational, sustainable and profitable fisheries resources management in Côte d'Ivoire".

Toxic substance releases and emissions into the atmosphere are governed by Order No.°01164.

3.3 Institutional framework

Fisheries and aquaculture in Côte d'Ivoire are statutorily managed by MIRAH. In addition to MIRAH, several other institutional partners are involved in fishery products processing in the country. According to Ziehi (2016), among these are:

[18] By these plans, the 2006 Policy Letter on Fisheries and Aquaculture is repealed.
[19] Available at http://extwprlegs1.fao.org/docs/pdf/ivc159952.pdf
[20] Effect 3 of Strategic pillar 2 on improving fisheries productivity and competitiveness. (available at http://faolex.fao.org/docs/pdf/ivc146471.pdf).

- ministries such as the Ministry of Agriculture and Rural Development; the Ministry of Budget and State Assets Portfolio; the Ministry of the Interior and Security; the Ministry of Environment and Sustainable Development; the Ministry of Commerce, Handicrafts and Small and Medium Enterprises Promotion; the Ministry of Public Health and Hygiene (MSHP); the Ministry of Higher Education and Scientific Research; the Ministry of Women and Family Promotion and Child Protection;
- local authorities (regional councils and municipalities);
- laboratories such as the Laboratoire National d'Appui au Développement Agricole (National Support Laboratory for Agricultural Development) (LANADA); and
- other partners such as INFOPÊCHE and non-governmental organizations (NGOs).

These partners fall under different administrations. For example, local authorities report to the Ministry of the Interior and Security, and are statutorily in charge of implementing and monitoring developmental projects in their area of competence; LANADA is under the Ministry of Agriculture and Rural Development; the Félix Houphouët-Boigny University (UFHB), IGT and the University Hospital Centre are all attached to the Ministry of Higher Education and Scientific Research; and Côte d'Ivoire's Anti-pollution Centre (CIAPOL) is under the supervision of the Ministry of Environment and Sustainable Development. The collaborative and consultative mechanisms that already exist between most of these institutions should be strengthened. These mechanisms are usually formalized through the Fisheries Advisory Committee,[21] and through memorandums of understanding for specific studies.

[21] Law No. 67–47 of 2 February 1967 establishing the Fisheries Advisory Committee. This law is implemented through decrees, including Decree No. 82-956 of 27 October 1982 and Decree No. 66-399 of 13 September 1996. The Committee, which comprises all sectors' actors and the various institutions involved, intervenes in sustainable fisheries management (maritime, lagoon and inland) and in fish trade.

CHAPTER 4: TERMS OF USE OF FTT PROCESSING FACILITIES, TARGET GROUPS' STRUCTURE AND ORGANIZATION

This chapter describes how target groups use pilot FTT facilities and how they are structured and organized. It also reviews the IGAs that these groups practise in addition to smoking products, including ancillary jobs that have emerged through this new technology. The chapter gives a glimpse of the technical performance of this innovation, and some determinants of its adoption. These issues are examined in more detail in the following chapters.

4.1 Terms of use of FTT processing facilities

4.1.1 Abobo-Doumé's processing facility

Although FAO handed over this processing facility to CMATPHA in May 2013, it was not until October 2013 that the cooperative society (SCOOP) actually started using it. In the meantime, this SCOOP had to be restructured and reorganized.

4.1.2 Guessabo's processing facility

This processing facility has been in use since April 2016 by four groups of women members of the agricultural cooperative simplified society (SCOOPS) Amakpa,[22] each for three days in a row. The wait is so long that, like their peers at the Braffedon processing facility, members of these different groups continue to use their traditional kilns simultaneously.

4.1.3 Braffedon's processing facility

This processing facility has been in use since August 2016 (i.e. during the good fishing season), although it had been officially inaugurated four and a half months earlier in March, during the off-fishing season. Beneficiaries have come together in four SCOOPs: Emim-Oyi (from Braffedon), United Sisters and Viwo (from Grand-Lahou), and Watchrin-Öwoun (from Lahou-Kpanda).

As the Abobo-Doumé processing facility is the oldest, its users have gained more experience in managing it compared to users of other processing facilities. FAO and/or MIRAH could organize exchange visits to the Abobo-Doumé facility for users of more recent facilities, with the two professionals being responsible for monitoring and supervising them. Indeed, at the time of the study, the users of the Braffedon and Guessabo processing facilities were being monitored by two fisheries professionals assigned by FAOCI as part of the FMM. These professionals were to collect data and information on these facilities, among other duties.

4.2 Target groups' structure and organization

FAO has facilitated the structuring of women fish smoker groups for the management of the four FTT pilot processing facilities mentioned above. Most of these groupings have a SCOOP status. The four SCOOPs that use the Braffedon facility have organized themselves by random draw to use the facility in turn. These SCOOPs are governed by the Uniform Act on Co-operative of the Organization for the Harmonization of Business Law in Africa, and have subsequently formed a union.

However, it became apparent after some time of operation that some women were not using these processing facilities. This is particularly the case for Viwo members, although some of them have benefited from the FAO training on the use of these facilities. Some of the reasons women gave for not using the facilities were: (i) the distance of about 20 kilometres from their home in Grand-Lahou to Braffedon where the facility is located, resulted in additional transport costs; and (ii) the low collective capacity of the existing FTT kilns compared to the individual use of traditional kilns, especially for smoking of small pelagic fish such as *Sardinella* sp.

[22] Amakpa means "form a group" in the local language.

All of these processing facilities are underutilized, well below their load capacity of 3 tonnes of fresh fish per day. This state of affairs is due to insufficient raw materials. These raw materials should be secured by improving the existing cold chain by adding more equipment such as refrigerated rooms (according to market needs, the state of fisheries resources and frozen fish availability). These will complement the existing preservation equipment (e.g. freezers and coolers) at the processing facilities.

4.3 Related income-generating activities

Fishing in Côte d'Ivoire, as in most other countries, is a seasonal activity and is marked by fluctuations in the availability of food on the market, and the quantities of fish to smoke. Thus, apart from fish smoking, processors use FTT-processing facilities for other related IGAs, with the most important (in terms of volume and income) being:

1. selling salt;
2. marketing fresh and frozen fish using the installed preservation equipment (freezers and coolers);
3. selling water and ice;
4. savings (tontine[23] and internal contributions);[24]
5. selling basins or pots;
6. selling food bags and packaging; and
7. smoking fish and meat products for third parties through "smoking contracts".

Other ancillary crafts (e.g. metal carpenters, blacksmiths, welders, fish dressers, loaders, cutters) have developed around these processing facilities, and provide livelihoods for many households. In total, as stated in recent surveys (Diomandé, undated; FAO, 2016a), 3 807 actors (of which 95 percent are women) from different socioprofessional categories were recorded in 2016.

As analysed in Subsection 7.1.3, local microfinance institutions (MFIs) trust fish processors more and more given this structuring and organization, especially those using the Abobo-Doumé processing facility. Indeed, MFIs are now more willing to lend them microcredit. The results of this study should encourage MFIs and other technical and financial partners to provide more support in this area. To do this, these results are as realistic as possible because they are based on data collected in the field.

[23] A tontine in sub-Saharan Africa is a semi-informal revolving savings and credit association made up of members who know each other personally, usually in the context of trust-based social or professional relationships, and who agree to contribute a fixed sum to a pool that redistributes the funds collected on agreed dates. The cycle is complete when each member has received his or her quota. The association can then dissolve or reorganize for a new cycle. In general, these associations offer members interest-free loans. These loans are available in limited and short-term quantities and can be used for any purpose (Popiel, 1994; Thillairajah, 1994).

[24] In 2015, according to CMATPHA records (CMATPHA, undated), members saved more than XOF 47.4 million (USD 78 400) through this mechanism, and generated interest of more than XOF 2.4 million (USD 4 028) on behalf of this SCOOP (at an annual interest rate of 5 percent).

CHAPTER 5: COMPARATIVE ANALYSIS OF DIFFERENT FISH SMOKING SYSTEMS

This chapter compares the various fish smoking systems used in Côte d'Ivoire, both traditional systems and the FTT. After briefly describing them, the chapter reviews the main types of fuel these systems use. It also analyses the strengths, weaknesses, opportunities and threats (SWOT) of these systems. Finally, it presents fish production, the main fish species targeted, and the corresponding fishing seasons.

5.1 Brief description of smoking systems

5.1.1 Traditional systems

Three traditional systems are used for smoking fish: (i) cut-up metal drums, with a hole at the base for the furnace (Figure 2), or two or three connected sections of open drums (Figure 3); (ii) barrels made of mud or clay (Figure 4); and (iii) the Chorkor kiln (Figure 5). Some barrel sections are generally used for cooking fish, and others such as connected barrel sections, mud or clay barrels and Chorkor kilns are used for drying and storage. Cooking takes two to six hours on average depending on the fish species (lean fish cook faster than fatty fish) and their size (the larger the fish, the longer the process). Drying takes six to eight hours. The entire process lasts between eight and fourteen hours on average. These kilns are usually housed under rudimentary sheds (Figure 6). Processors generally work in unsanitary conditions (Figure 7).

Figure 2. Traditional cut-up metal drums kiln at Abobo-Doumé

© FAO/K. Mindjimba

Figure 3. Traditional kiln made with three connected sections of open drums at Grand-Lahou

© FAO/K. Mindjimba

Figure 4. Traditional clay kiln at Guessabo

© FAO/K. Mindjimba

Figure 5. Chorkor kiln at Grand Lahou

© FAO/K. Mindjimba

Figure 6. A smokehouse at Guessabo

© FAO/K. Mindjimba

Figure 7. Unsanitary environment in which processors traditionally smoke fish in Abobo-Doumé

© FAO/K. Mindjimba

5.1.2 The FTT system

As various studies demonstrate (Ndiaye *et al.*, 2015; Randrianantoandro, 2015), the FTT is based on three types of existing improved kilns – the Banda, Chorkor and Altona – and corrects the deficiencies in all of these. Two FTT Banda double compartment kilns have been installed at each processing facility. In one kiln, both compartments are used for cooking, while for the other kiln, the first compartment is used for cooking, and the second compartment is used for smoking, drying and storage; this particular kiln is also equipped with a filter for purifying the emitted smoke (Figure 8). The FTT Chorkor kiln, which has one compartment, was only installed at the Braffedon and Marcory-Anoumabo facilities. The FTT Altona kiln includes either a cooking compartment (Braffedon and Marcory-Anoumabo facilities) or two compartments, one of which is used for cooking and the other for smoking, drying and storage (Abobo-Doumé and Guessabo facilities) (Figure 9). The fish are then transferred from one compartment to another, and from one type of kiln to another at the end of each phase. Overall, this is a smoking-drying process. Clearly, the first two facilities (Abobo-Doumé and Guessabo) do not include a Chorkor kiln, while the other two (Braffedon and Marcory-Anoumabo) do; the difference with the first two lies in the number of compartments in the Altona kilns.

Figure 8. FTT Banda kiln with a smoke filter at the Guessabo processing facility

© FAO/K. Mindjimba

Figure 9. FTT Altona kiln with two compartments at the Guessabo processing facility

© FAO/K. Mindjimba

These kilns, built with refractory materials, are systematically sheltered under a shed (Figure 10). The facility houses not only the kilns described above, but also preservation equipment (e.g. freezers, isotherm coolers) and products packaging systems (e.g. vacuum packaging machines). The power supply for lights and the preservation equipment is provided by photovoltaic solar panels. Thanks to the FTT, fish processors can also add value to their fishery products by making sausages, croquettes, fish "samosas", and by using the resulting fat (Ziehi, 2016). Some processors have been trained in this field by an FAO consultant.

Figure 10. Secured shed housing the FTT processing facility at Braffedon

© FAO/K. Mindjimba

Table 2 compares these systems according to relevant criteria. Although these criteria are classified as technical, economic, social and environmental, they interact with each other.

Table 2. Comparison of traditional and improved fish smoking systems

Criteria	Smoking systems		
	Traditional kiln made with three connected sections of open drums	**Chorkor kiln**	**FTT kiln**
TECHNICAL CRITERIA			
Type of construction	Rudimentary	Improved	Constructed on existing improved kiln models (Banda, Chorkor, Altona) while addressing their shortcomings
Length of procedure[a]	Long (1/2 to 3 days)	Average (1/2 to 1 day)	Short (3–5 hours, depending on fish species)
Fire and smoke control	Very limited	Limited	Very high
Smoking technique	Simultaneous cooking (smoking) and drying	Separate cooking (smoking) and drying	Separate cooking (smoking) and drying compartments
Smoking type	Direct	Direct	Indirect
Fish fat collection device	Absent	Absent	Available
Smoke filtering device	Absent	Absent	Available
ECONOMIC CRITERIA			
Cost of the kiln	Low (XOF 15 000)	Medium (XOF 200 000)	High (>XOF 0.86–2.85 million, see details in Chapter 6)b
Smoking capacity[c]	Small (150–200 kg/day)	Medium (200–300 kg/day)	Large (0.5–3 t/day)[b]
Quantity of wood needed	High (3–5 kg wood/kg fish to be processed)	Medium (>0.8 wood/kg fish to be processed)	Small (0.8 kg wood/kg fish to be processed)
Life span of kiln	Short (2 years)	Medium (3–15 years)[d]	Long (>15 years for the frame and 3 to 12 years depending on the components)
Earnings	Average[e]	Average[e]	High[f]

Criteria	Smoking systems		
	Traditional kiln made with three connected sections of open drums	Chorkor kiln	FTT kiln
Opportunity to practise other activities and to create ancillary jobs	Limited	Medium	Very high
SOCIAL CRITERIA			
Exposure to heat, smoke and toxic gases	Frequent	Frequent	Very low
Effects on health and occupational safety	Prevalence of eye and respiratory diseases that can cause death	Prevalence of eye and respiratory diseases that can cause death	Limited risks of occupational diseases
Safety and quality of smoked fish	Fish of lesser quality	Fish of lesser quality	Safer and higher-quality fish
PAHs[g] and metallic trace elements[h]	High (61 µg/kg in PAHs)	High (69 µg/kg in PAHs)	Low (0.9 µg/kg in PAHs)
ENVIRONMENTAL CRITERIA			
Environmental impact	Negative (e.g. toxic gas emissions into atmosphere, deforestation)	Negative (e.g. toxic gas emissions into atmosphere, deforestation)	Limited (e.g. low toxic gas emissions into atmosphere, reduced wood consumption)

Notes:

a. The smoking sessions the consultant attended on the Braffedon and Guessabo processing facilities produced a conversion factor of nearly 2.3; because of repeated re-smoking (and therefore of being more and more dehydrated) and the intensity of the fire, this coefficient is higher and reaches 3 for fish smoked with traditional systems.

b. Depending on whether it is the double-compartment (the first for cooking and the second for smoking) FTT Banda kiln, or this type of kiln associated with another Banda double compartment kiln for cooking, and a dual compartment FTT Altona kiln (the first for cooking and the second for smoking).

c. Variable depending on kiln size, number of racks and fish species.

d. Variable depending on the materials used (kneaded clay, clay, mud or cement bricks).

e. Traditional processors also experience higher physical, quality and economic post-harvest losses (PHLs). However, the estimated PHLs by Ziehi (2016) (i.e. more than 16 tonnes, representing more than XOF 2.4 million or USD 4 005 per year and per processor in Grand-Lahou), seem exaggerated.

f. Not only those derived from fish smoking, but also ancillary activities, through which users of these improved processing facilities can better ensure their children's education, as well as their own empowerment (FAO, 2016a). Operating costs are, in fact, reduced (and therefore revenues are increased) thanks to lower fuel consumption. Another source of additional revenue is the production of fish-based baked sweet and savoury goods. CMATPHA's records (CMATPHA, undated) also show that this SCOOP spends XOF 565 000 (USD 935) each year on average for charity and social activities.

g. Significantly higher (usually more than 40 to 60 times depending on fish species) than authorized maximum limits on the European market according to Commission Regulation (European Union) 2015/1125 of 10 July 2015 amending Regulation (EC) No 1881/2006 as regards maximum levels for polycyclic aromatic hydrocarbons in Katsuobushi (dried bonito) and certain smoked Baltic herring. (available https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32015R1125&from=EL).

h. The metallic trace element notion tends to replace that of heavy metals (mercury, lead, cadmium). Accessed https://en.wikipedia.org/wiki/Trace_metal on 10 September 2018.

Sources: Bomfeh (2016); Bomfeh *et al.* (2016); FAO (2016a); Ndiaye, Sodoke Komivi and Diei-Ouadi (2015); Traoré (undated); Zinsou and Wentholt (1989).

As shown in Table 3, the PAH content of FTT products is at least 60 times lower than that of products smoked with other systems.[25] The PAH content in FTT products is also between 3 and 13 times lower than the European Union standards, suggesting that these products could be marketed in such a demanding market as the European market in terms of quality assurance and control. In contrast, PAH levels for products from other systems are considerably higher.

Table 3: Level of contamination of smoked fish and fishery products according to the type of kiln used

Types of kiln	Levels by PAH type (µg/kg)	
	B(a)P	Sum of four PAHs[a]
Drum section	37.0	61.0
Chorkor	50.0	69.0
FTT-Thiaroye	0.6	0.9
European Union maximum levels[b]	2.0	12.0

B(a)P = benzo(a)pyrene, one of the most toxic and carcinogenic PAHs, according to Auby *et al*. (2013).
Notes:
a. benzo(a)pyrene, benzo(a)anthracene, benzo(b)fluoranthene and chrysene.
b. According to European Commission Regulation (European Union) 2015/1125 of 10 July 2015.
Source: Bomfeh (2016).

5.1.3 Types of fuel used

Various types of fuel are used for smoking fish in Côte d'Ivoire. These are listed in Annex 10. Various studies (Bomfeh *et al*., 2016; Ndiaye, Sodoke Komivi and Diei-Ouadi, 2015; Traoré, undated) have compared their respective characteristics in terms of advantages and disadvantages, and found that some wood species are more harmful than others; they are therefore more damaging for fish smoking (Table 4). As various studies demonstrate (Bomfeh *et al*., 2016; Maga, cited in Djessouho, undated), the wood species and the type of fuel used greatly influence the chemical composition of the smoke during combustion. For example, rubber wood (like other softwoods) should be avoided: although relatively abundant, it has very high PAH contents.

Table 4. Effect of fuel type used on PAH levels in fish and fishery products smoked with the FTT system

Types of fuel	Levels by PAH type (µg/kg)	
	B(a)P	Sum of 4 PAHs[a]
Wood charcoal	0.24	2.30
Esa wood (Ghana)	3.16	38.98
Neem wood (Ghana)	7.08	28.86
European Union maximum levels[b]	2.00	12.00

B(a)P = benzo(a)pyrene, one of the most toxic and carcinogenic PAHs, according to Auby *et al*. (2013).
Notes:
a. benzo(a)pyrene, benzo(a)anthracene, benzo(b)fluoranthene and chrysene.
b. According to European Commission Regulation (European Union) 2015/1125 of 10 July 2015.
Sources: Bomfeh *et al*. (2016); Traoré (undated).

[25] An empirical experiment conducted by CMATPHA members highlighted the difference between smoked fish from traditional kilns and those from the FTT. By comparing the running water in which they had previously dipped in a bucket for about two hours, the two types of products from the same raw material, and by repeating the experiment four or five times, they found that in the first case the water had become yellowish and bitter, while in the second case the water and the smoked fish had changed little. The water in the first bucket thus leached some of the smoke in the fish, and appropriate testing could attribute this to the presence of PAHs.

On the contrary, other fuel types are strongly recommended. This is particularly the case with hardwoods (red) and coconut shells. Although burning mangrove wood generates low PAHs, its use should be limited and controlled, given the ecological and economic goods and services mangroves provide, especially in terms of: (i) aquatic and fisheries resources, where they play a vital role as a spawning and nursery habitat for many aquatic species; (ii) coastal protection; and (iii) livelihoods of riparian communities. The use of charcoal significantly reduces fuelwood consumption.[26] Indeed, as charcoal burns completely, it is easier to obtain controlled PAH content and safety standards in products.[27] Likewise, adding stones such as siporex stones on FTT kilns or pieces of baked earth retains heat, thus reducing the required amount of charcoal by about 50 percent (Ndiaye, Sodoke Komivi and Diei-Ouadi, 2015).

5.2 Strengths, weaknesses, opportunities and threats analysis

A SWOT analysis (or scoping analysis) was conducted with women fish processors and fishmongers, as well as with institutional partners, on the use of different smoking systems. The results of this analysis are presented in Tables 5 and 6 for traditional systems and the FTT, respectively. The results focus on internal factors (strengths and weaknesses), and external factors (opportunities and threats) that have a positive or negative effect on a particular system. As these systems are used in the same environment, it is not surprising that their external factors differ very little.

Strengths represent strong aspects, available resources and comparative advantages, while weaknesses express weak points, aspects to avoid or improve. Opportunities stem from technological innovations, government policy in this area, and eating habits, while threats are obstacles and non-compliance with quality standards. Most of the criteria reviewed are in Table 2 and follow substantially the same nomenclature (i.e. technical, economic, social and environmental criteria).

[26] When used with charcoal, pieces of wood are normally used for incandescence; once the charcoal becomes incandescent, the pieces of wood must be removed from the fire.

[27] Conversely, as various studies demonstrate (Anoh, Outtara and Ossey, 2016); Bomfeh, 2016), incomplete wood combustion results in high PAH and CO concentrations; this is why the smoke emitted by traditional kilns has a much higher content in these two compounds (along with low levels of other toxic gases mentioned above) than FTT kilns.

Table 5. Analysis of strengths, weaknesses, opportunities and threats (SWOT) for traditional fish smoking systems

SWOTs		
INTERNAL FACTORS	**STRENGTHS**	**WEAKNESSES**
	– Simplicity of construction, with inexpensive local materials (e.g. clay, earth, barrels) – Uses family labour – Transportable (drums) and usable at any time – Uses indigenous skills in smoking process and kiln use	– Long process (1/2 to 3 days depending on fish species); there is a need to re-smoke unsold product, which is tedious – Need to deposit the racks and allow them to cool so that they may be switched over the fireplace (tedious work) – Need to regularly return the fish one by one to the racks to make the smoking uniform – Makeshift shelter (rudimentary smokehouses) – Fish exposed to the weather (open racks) and infestation risk by flies (and other vectors), airborne particles and wood dust – Short life span of kiln (two years) – Relatively high post-harvest losses[a] (e.g. poorly dried fish), and, therefore, rapid rancidity, hence the need to re-smoke fish and use more fuel, thus resulting in lighter fish that sell at a lower price – Smoked fish are generally charred due to intense fire, and tend to crumble and break; additionally, they have abnormally high PAH levels (61–69 µg/kg) – Prevalence of eye and respiratory diseases owing to inhalation of smoke and toxic gases, especially CO and CO_2, which can cause death – Uncomfortable working conditions and fatigue owing to frequent exposure to heat, smoke and toxic gases – High density of processors within the same area, and a high concentration of heat, smoke and toxic gases[b] – Risk of skin infections and typhoid fever resulting from lack of personal hygiene and unsanitary work environment – Risk of difficult relations with spouses due to the persistent smell of smoked fish (lack of personal hygiene)[c]
EXTERNAL FACTORS	**OPPORTUNITIES**	**THREATS**
	– Establishment of the FTT[d] – High demand for smoked fish (around 35% of catches is smoked) – Existence of national regulations on releases and emissions of greenhouse gases into the atmosphere[e] – Existence of national regulations governing PAH reduction[g]	– Establishment of the FTT[d] – Use of untreated well-water and rainwater to wash fish prior to smoking – Deforestation and mangrove forest ecosystems degradation[f] – Strengthening regulations on environmental protection

Notes:

a. Globally estimated in recent surveys (Diomandé, undated; FAO, 2016b) at 23 317 tonnes of fish per year, worth about XOF 7 billion (USD 11 585).

b. According to a recent study carried out in some fishing communities in the country (Anoh, Outtara and Ossey, 2016), the more smokers are concentrated in the same area (as in Grand-Lahou), the more they develop (60 percent of them) pulmonary diseases (bronchitis in particular) related to their activity, and vice versa; that is, when they are more dispersed, as in Braffedon, where only 35 percent of processors have such pathologies. Moreover, the length of time processors have practised this activity is correlated with their health status; thus, the longer processors have

been smoking fish, the more they tend to develop these diseases, and vice versa (the lesser the seniority, the lesser they develop such diseases). The FTT has been specifically designed to solve this problem (and many others).

c. A recent study conducted in the Yopougon-Abobo-Doumé fishing community (Mambo-Gnakalé, cited in (Anoh, Outtara and Ossey, 2016) found that 55.3 percent of the women fish smokers interviewed had difficult relations with their husbands.

d. The establishment of the FTT can be both an opportunity (in terms of process improvement) and a threat (in terms of disappearance of these processes) for traditional systems. The threat here is perceived from the point of view of traditional systems, and not from the goal of improving them.

e. As with the establishment of the FTT, the aforementioned Order No. 01164 can be both an opportunity (in terms of process improvement) and a threat (in terms of non-compliance) for traditional fish smoking systems.

f. See Subsection 6.3.2.

g. Livestock, Fisheries and Aquaculture Strategic Development Plan, 2014–2020.

Sources: Anoh, Outtara and Ossey (2016); UEMOA (2012); Ziehi (2016); Mindjimba *et al*. (2019); field surveys.

Table 6. Analysis of strengths, weaknesses, opportunities and threats (SWOT) for the FTT fish smoking system

SWOT		
	STRENGTHS	**WEAKNESSES**
INTERNAL FACTORS	– Equipment can easily be installed[a] – Fish protected against risk of contamination thanks to covered smoking racks – Possibility of collecting fat drippings from fish through the fat collection device, which can be re-used (e.g. soap making, cooking oil and other by-products) – Usable in all seasons, regardless of weather conditions – Reduced smoking time (about three to five hours, depending on fish species (i.e. lean or fatty)[b] – Long life span of kiln (> 15 years for the frame, and 3–12 years for the components) – Reduced PHLs, smoked-dried fish can be preserved for a long time – Flexibility with the possibility of drying fish and manufacturing value-added fishery co-products (e.g. sausages, cake, fish "samosas") – Possibility of undertaking other tasks or other IGAs (e.g. selling salt, food packaging, water, ice, savings) – Increased revenues (see Chapter 6 on profitability) – Demonstrated financial and economic profitability (see Chapter 6) – Structuring and organization of processor in SCOOP and their keen interest in this system – Reduced drudgery and, therefore, improved working conditions and comfort for processors (very low exposure to heat, smoke and toxic gases)[c] – Safer and higher-quality fish; very low PAH levels according to regulatory limits (0.9 µg/kg); firm texture, golden colour	– Long wait (collective use in turn) due to limited number of improved processing facilities and kilns (e.g. Abobo-Doumé and Braffedon processing facilities for more than 300 smokers) – Difficult to use at any time according to the processors' needs – Relatively high investment, more than XOF 0.86–2.85 million (USD 1 419–4 709) (out of reach of the average small-scale fish processor) depending on the kiln prototype and the number of compartments – Poor smoking technique mastery and use of improved processing facilities by some processors – Inability to use family labour on a community infrastructure

	– Less environmental impact (saving fuel with reduced wood consumption, and therefore better protection of forests and mangroves, less deforestation)	
EXTERNAL FACTORS	**OPPORTUNITIES**	**THREATS**
	– High demand for fish and fishery products – Potential outlets for healthy, higher-quality smoked fish – Relatively affordable fish price (compared with meat)	– Misuse of improved processing facilities that may cause malfunctions (e.g. obstruction of smoke evacuation valves) owing to insufficient training of users[d]
	– Improvement of the fisheries sector regulatory framework (see Subsection 3.2) – Implementation of the National FTT Extension Programme to other fishing communities in the country – Strong involvement of local authorities such as regional councils and municipalities (provision of sites for the construction of improved processing facilities, financing of sheds), as well as other development partners – FAO support, including provision of working capital – Willingness of technical and financial partners (case of AfDB) to support this programme	– Distance of the improved processing facilities for some potential users (e.g. 18 km from Grand-Lahou to the Braffedon facility) – Use of (untreated) well-water and rainwater to wash fish prior to smoking – Low level of consumer readiness or purchasing power to pay a higher price for FTT products

Notes:

a. Equipment made of local materials (refractory materials and recycled materials).
b. By reducing the smoking time, processors can increase the number of smoking sessions or conduct other activities simultaneously (including during the smoking process).
c. The ember furnace protects processors against heat because it slides into the kiln and concentrates all the heat. These processors are also equipped with gowns, hygiene masks, gloves and hats offered by FAO; in addition, they work on tables and with other necessary materials provided by FAO (see Figure 11).
d. Some processors who have been trained in this area have transferred their knowledge to other group members.

Sources: Anoh, Outtara and Ossey (2016); Ziehi (2016); Mindjimba *et al*. (2019); field surveys.

Figure 11. Fish smokers equipped with gowns, hygienic masks, gloves and hats at the Guessabo FTT facility

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The SWOT analysis shows that the FTT has more strengths and fewer weaknesses than traditional systems. Among the few weaknesses of this new system is the relatively high investment cost (see Chapter 6 for more details). Other weaknesses include the fact that, due to the limited number of improved processing facilities, many women continue to use traditional smoking systems. This is linked to consumers' difficulty in paying higher prices for FTT products compared to traditional products because of the former's higher quality in an environment where the level of awareness of the existence of the FTT still seems relatively low. Based on the results of this study, the dissemination programme for these improved processing facilities across the country will need to reverse this trend. The ideal, as shown by the results of this study, would be that, eventually, the FTT would completely replace traditional systems. The use of untreated well-water or rainwater to wash fish prior to smoking poses a threat to all these systems.

5.3 Fish production

5.3.1 Main target fish species

The main target fish for smoking varies according to the area: in the maritime and lagoon waters, the main species for smoking are small pelagic fish (mainly *Sardinella* sp. and *Ethmalosa* sp.), mullet and tuna. In inland waters, *Chrysichthys* sp. (chews and catfish), carp and tilapia, as well as several other species such as *Alestes* ("red tail"), *Heterotis niloticus* ("Cameroon"), *Hemichromis fasciatus* ("Mariam mossi") are the main fish used for smoking.

In general, processors purchase fresh fish from women fishmongers, rarely from fishers at the landing sites (the latter usually sell the fish to their wives). Some processors negotiate contracts with fishers, usually by funding their fishing units, thus guaranteeing regular fish supplies. Table 7 indicates the current purchase price of some marine fish caught in Ivorian territorial waters and imported frozen fish observed at the Abidjan and Braffedon markets.

Table 7. Purchase price of some marine fish caught in Ivorian territorial waters, and imported frozen fish in the markets of Abidjan and Braffedon, October 2016

Species	Measurement unit	Fish quantity (kg)	Measurement unit price (XOF) for the 1st purchase[a]	Kg unit price (XOF) for the 1st purchase[a]
LOCAL FISH				
Sardinella	Basin	66	25 000	380
Tuna	Basin (or pot)	25	25 000	1 000
Mullet	Cardboard box	20	12 500	625
Crevalle jack	Basin (or pot)	25	20 000	800
Rainbow runner	Basin (or pot)	25	25 000	1 000
Various fish	Basin (or pot)	25	25 000	1 000
IMPORTED FROZEN FISH				
Small lesser African threadfin	Cardboard box	20	22 500	1 125
Medium lesser African threadfin[b]	Cardboard box	20	37 500	1 875
Large lesser African threadfin	Cardboard box	20	30 000	1 500
Hake	Cardboard box	15	13 500	900
Gilthead sea bream	Cardboard box	20	28 000	1 400

Notes:

a. Fishers' prices at the Abobo-Doumé and Braffedon (local fish) landing sites, and fish-shop prices at the port of Abidjan (imported frozen fish).

b. Processors' preference according to market needs.

Source: Interviews with a few fish smokers in Abobo-Doumé (Abidjan) and Braffedon (Grand-Lahou).

5.3.2 Fishing seasons

Like fish species, fishing seasons vary depending on the area: on the coast, the good fishing season is from mid-July to mid-September for pelagic species, and from mid-September to November for demersal species. The "off-season", corresponding to the shortage of fish, extends from December to June. Relatively large amounts of mullet and carp are landed in May and June. In inland fisheries, the good season normally lasts three months, from October to December.

CHAPTER 6: FTT AND TRADITIONAL KILNS COMPARATIVE PROFITABILITY STUDY RESULTS

This chapter is part of the overall objective of the study, which is to determine fish smoking cost-effectiveness when using the FTT through a clearly established diagnosis. The first section analyses the required investment costs according to the two selected kiln prototypes. The second section addresses Objective 2 and presents the respective income statements of these kiln prototypes. After having specified the necessary data, it describes the prototypes in question, then examines the possibility of defining fresh-smoked fish conversion coefficients for Côte d'Ivoire, and compares the different systems' income statements for a smoking session - the profitability analysis for traditional systems has not been considered relevant. The third section deals with the financial and economic profitability analysis, including the sensitivity analysis. The fourth and last section studies the market through fishery products supply and demand, the usage capacity of FTT kilns, and finally the markets for FTT products.

6.1 Investment cost of FTT kilns

The installation of FTT kilns (excluding equipment, shed, solar panels and land) costs between XOF 857 600 and 2 845 200 (equivalent to USD 1 419 and 4 709), depending on whether it is a prototype 1 (Table 8) or a prototype 2 (Table 9).[28]

Table 8. Cost of an FTT Banda kiln or prototype 1

Id	Item	Date of acquisition or inauguration	Unit	Qty	Unit price. (XOF)	Amount (XOF)	Life span (years)	Depreciation (XOF)
1	Masonry	14 March 2016	Flat fee	1	237 600	237 600	10	23 760
2	Paint	14 March 2016	Flat fee	1	15 000	15 000	1	15 000
3	Lid	14 March 2016	Part	4	23 750	95 000	12	7 917
4	Mesh (rack)	14 March 2016	Part	4	10 000	40 000	3	13 333
5	Ember furnace	14 March 2016	Part	1	210 000	210 000	5	42 000
6	Fat collection tray	14 March 2016	Part	1	100 000	100 000	5	20 000
7	Smoke generator	14 March 2016	Part	1	160 000	160 000	5	32 000
Total						**857 600**		**154 010**

Note: This is a dual compartment Banda FTT kiln, one for cooking and the other for smoking. By comparison, an FTT Banda kiln with two cooking compartments costs XOF 1 007 600.

[28] An improved processing facility costs more than XOF 17.7 million (USD 29 306) and includes, in addition to the kilns (XOF 2 845 200 or USD 4 709), miscellaneous equipment (almost XOF 1.3 million or USD 2 139), solar panel (XOF 3 570 000 or USD 5 908), and shed (XOF 10 million or USD 16 550).

Table 9. Cost of FTT Banda and Altona kilns or prototype 2

Id	Item	Date of acquisition or inauguration	Unit	Qty	Unit price (XOF)	Amount (XOF)	Life span (years)	Depreci-ation (XOF)
1	Masonry	14 March 2016	Flat fee	1	475 200	475 200	10	47 520
2	Paint	14 March 2016	Flat fee	1	30 000	30 000	1	30 000
3	Lid	14 March 2016	Part	8	23 750	190 000	12	15 833
4	Mesh (rack)	14 March 2016	Part	8	10 000	80 000	3	26 667
5	Ember furnace	14 March 2016	Part	3	210 000	630 000	5	126 000
6	Fat collection tray	14 March 2016	Part	3	100 000	300 000	5	60 000
7	Smoke generator	14 March 2016	Part	1	160 000	160 000	5	32 000
8	2 compartment Altona kiln	14 March 2016	Part	1	980 000	980 000	10	98 000
Total						**2 845 200**		**436 020**

Note: The Braffedon and Marcory-Anoumabo processing facilities each has the same types of Banda kilns, but one single compartment Altona kiln for cooking, and one single compartment Chorkor kiln for smoking. The total cost of these kilns amounts to XOF 2817 800 (USD 4 663); that is XOF 27 400 (USD 45) less.

6.2 Income statement of a typical FTT unit

6.2.1 Data specification

Apart from the abovementioned investment, the following data are essential for the establishment of an income statement (formerly known as operating profit). Conventionally, these data are grouped into two categories: variable and fixed expenditures, expenses or costs; and product profits or revenues. These data are broken down by type, quantity and value, and are meant to be collected every day of operation.

Variable expenditures or operating expenses include:

i. the fresh fish purchased for smoking (quantity and value per species, reduced if necessary by self-consumed and donated quantities); and
ii. inherent expenditures (e.g. fuel, water and other raw materials purchasing, transport, communication, distribution or marketing costs).[29]

Products come mainly from:

i. smoked fish sales (same details as for fresh fish, including possibly self-consumed and donated quantities) – the revenue from these sales corresponds to the production sold or turnover earned during the period considered;
ii. products from IGAs; and
iii. the residual value of the investment and equipment.

Annual expenditures and revenues have been calculated using the following assumptions and ratios:

i. **Quantity of fresh fish purchased**: 30 kg of fish of various species (Sardinella, tuna, barracuda or false pike, various fish) – equivalent to one hundredth of the nominal capacity of all kilns of a typical FTT unit for 220 days considering the rest days and maintenance of these kilns, as well as the seasonality of fish supplies (i.e. 6.6 tonnes);
ii. **Fresh fish purchasing price and cost**: fish bought at current prices (see Table 7 for some species) (i.e. XOF 5 707 500 or USD 9 446);

[29] Participation in radio and television programmes (RTI's programme Matin Bonheur or Radio Attecoubé) or announcements in the official journal are some examples of marketing expenses incurred by CMATPHA in 2015.

iii. **Fuelwood quantity and cost**: 0.8 kg of red wood ("thousand-feet") for every 1.0 kg of fish, corresponding to roughly 5.3 tonnes of wood (reduced by half to 2.6 tonnes by using siporex stones), at the purchase price of XOF 250 (USD 0.4) per roughly 4 kg batch, or XOF 165 000 (USD 273);
iv. **Charcoal quantity and cost**: 0.4 kg for every 1.0 kg of fish, or 2.64 tonnes of charcoal (similar to wood, reduced by half to 1.32 tonnes by using siporex stones), at the purchase price of XOF 2 500 (USD 4) a 115-kg bag, or about XOF 28 700 (USD 47);
v. **Siporex stones quantity and cost**: basin of about 10 kg (stones that can be reused several times), at the purchase price of XOF 2 700 (USD 4);
vi. **Water quantity and cost**: 100 litres (XOF 50/20-litre can to wash 100 kg of fish, i.e. 6 600 litres in total at a cost of XOF 16 500 or USD 27);
vii. **Transport cost**: XOF 250 (USD 0.4) for transporting XOF 1 000 (less than USD 2) worth of wood, XOF 500 (USD 0.8) for a 115-kg bag of charcoal, and XOF 600/basin (almost USD 1/basin) for about 66 kg of fresh fish, for a total cost of XOF 107 000 (USD 177);
viii. **Labour**: XOF 500 (USD 0.8) to descale a 20-kg cardboard box of fish, amounting to XOF 165 000 (USD 273);
ix. **Fresh-to-smoked conversion coefficient**: 2.3;
x. **Self-consumed and donated smoked fish quantity and value**: 230 kg (8 percent), of which 200 kg of self-consumed small pelagic fish at the price of XOF 900/kg (USD 1.50/kg), and 30 kg of donated barracuda and various fish at the average price of XOF 3 500/kg (almost USD 6/kg) for a total value of XOF 285 000 (USD 472);
xi. **Sold smoked fish quantity and value or turnover**: 2.91 tonnes sold between XOF 900/kg and 3 500/kg (i.e. XOF 8 514 000 or USD 14 091);
xii. **Kiln depreciation:** according to the straight-line method, annuity and net depreciation value (NDV) determined accordingly, given that these kilns were installed on 14 March 2016; [30]
xiii. **Selected IGAs:** those that do not require cold equipment (this is the case for selling food packaging, basins and internal savings, except for the selling of salt).

Table 10 presents the fresh fish purchase prices and their unit selling prices when smoked, used in the analysis.

Table 10. Purchase price of fresh fish and selling price when smoked

Species	Unit purchase price fresh (XOF/kg)	Unit purchase price smoked (XOF/kg)	Fresh-to-smoked conversion coefficient
Sardinella and other small pelagic species	250	900	2.3
Tuna and other similar species	1 000	3 200	2.3
Barracuda (false pike) and various fish species	1 000	3 500	2.3

6.2.2 Selected kiln prototypes

The following analysis focuses on the two kiln prototypes. These differ only in their investment cost; the other expenditures and products being identical because they are based on data collected in the field. The reasons for choosing them have been explained in Chapter 2. These two prototypes reflect investment possibilities in this area, depending on the chosen prototype. Unsurprisingly, the analysis results differ very little, considering the double-compartment FTT Banda kiln as prototype 1 (see Table 8), and the Braffedon and Marcory-Anoumabo FTT kilns as prototype 2 (see Table 9 notes) based on the same assumptions as above.

[30] Depreciation was calculated taking into account the purchase value, each component's life span, and therefore the depreciation rate and annuity, as well as the start date of kiln related activities. The 2016 annuities (Year 0, 2026 being the terminal year) are calculated prorata temporis knowing that the kilns were set up during the year.

Other necessary data are taken into account in the analysis. These include fixed expenditures or monthly overheads (e.g. personnel expenses, kiln servicing and maintenance costs and potential taxes). Likewise, the results for operating costs are obtained by the difference between the revenue amount and the expenditure amount. Although these data are collected on a daily basis, the resulting income statement normally covers a fiscal year. A positive operating result (i.e. revenues higher than expenditures) means that the kilns generate profits. In contrast, a negative result (i.e. revenues lower than expenditures) means that these kilns generate losses. The respective projected financial statements for kiln prototypes 1 and 2 are given in Annexes 1 and 2. These give an objective overview of the kilns' performance. In this way, they differ from an accounting table in that they do not include financial income and expenditures (such as interest paid on loans, losses on financial investments), exceptional expenses and revenues, that is, not directly related to smoking operations (e.g. sales of property, grants, subsidies, tax fines, damages), and income taxes.

6.2.3 Fresh-to-smoked fish specific conversion coefficients

Starting with the quantities of fresh fish for smoking collected, as well as smoked fish quantities at the first sale, will make it possible to determine fresh-to-smoked conversion coefficients, and to break them down by category of fish species (lean fish and fatty fish) and by process type (traditional systems and FTT). In doing so, these coefficients will be specifically used for Côte d'Ivoire, rather than using those applicable in other countries, even if they are comparable in this respect.

6.2.4 Comparison of a smoking session by system

The data from the smoking sessions that the consultant attended at Braffedon and Guessabo were extrapolated to suppplement the missing data from the records kept by the SCOOPs in these facilities. Table 11 compares the income statements of a smoking session for the different fish smoking systems used.

Table 11. Comparative income statement of a fish smoking session for the different systems used

Item	Types of systems		
	Clay barrel	Drum with three connected sections	FTT Banda kiln[a]
1. OPERATING COSTS[b] (XOF)			
Fresh fish quantity (kg)	25	120	120
1.1 Cost of fresh fish	23 000	75 000	200 000
1.2 Cost of wood	2 000	3 000	1 000
1.3 Cost of charcoal	Not determined	Not determined	3 500
1.4 Cost of water	100	200	500
1.5 Transport	1 000	4 000	4 500
1.6 Labour	400	500	3 000
1.7 Land tax	100	100	Not available
TOTAL 1 (COSTS)	26 100	82 800	209 500
2. REVENUES			
2.1 Smoked fish sales	31 000	120 000	290 000
TOTAL 2 (REVENUES)	31 000	120 000	290 000
OPERATING PROFIT	4 900	37 200	80 500
OPERATING PROFIT BY KG OF FRESH FISH	196	310	671

Notes:

a. Prototype 1.

b. Unlike certain similar value-added studies (Kabré, Diarra and Traoré, 2003), the calculation does not take into account: investment costs, other expenditures (e.g. purchasing of raw materials such as food packaging, tax, depreciation, various operating costs), losses and self-consumption, let alone income-generating activities. The approach taken here is comparable to the one used in other studies (Ndiaye and Diei-Ouadi, 2009).

Source: Field surveys.

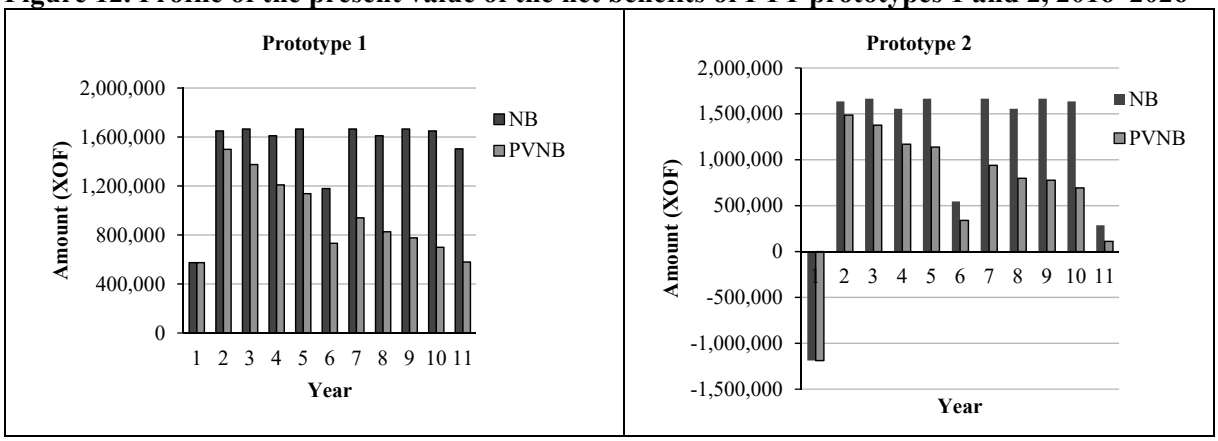
6.3 Profitability analysis

6.3.1 Risk and financial profitability

The analysis shows that the kiln prototypes we are interested in are both financially profitable based on the chosen parameters, namely a discount rate of 10 percent per annum over a period of ten years. Indeed, their NPVs are respectively more than XOF 10.3 and nearly 7.6 million (USD 17 133 and 12 636), for 34.9 and 31.7 percent IRR,[31] and PI of 12.07 and 2.68 respectively. Net cash flows (NCFs) – net profit and NPV – are all positive in the first case because of the relatively low initial investment (XOF 857 600 or USD 1 419) compared to the benefits generated. In the second case, they are negative during the first year of operation (2016) because of the relatively high investment (nearly XOF 11.7 million or USD 19 315), but they become positive starting in the second year (Figure 12). As indicated above, inherent costs are the same in both cases (almost XOF 11.7 million or USD 19 315).

The discounted payback period is 11.8 months for the first prototype, and 4 years and 9½ months (or less than 5 years) for the second one. In other words, the investment with the first prototype can be paid back in less than a year, precisely on 10 March 2017, knowing that these kilns were set up on 14 March 2016. It indicates a very quick return on investment and the low risk in investing in this activity: the shorter the payback period, the lower the risk, and vice versa.

Figure 12. Profile of the present value of the net benefits of FTT prototypes 1 and 2, 2016–2026



NB = net benefits (or income); PVNB = present value of net benefits. Both represent net cash flows (NCFs).

In the second case, the investment can be paid back only at the end of the fourth year, precisely after 45 and a half months: 9 ½ months the first year from date of installation, and 36 months between the second and fourth year. The return on investment is rather slow, but the risk of investing in this activity is relatively low. It goes without saying that smoking more fish can shorten this delay. The ten-year period (2016–2026) used in this context takes into account the kilns' expected economic life knowing that most of its components can be depreciated in 10 to 12 years. Establishing these kilns has both a spatial dimension (as advocated by the government) and temporal dimension.

6.3.2 Economic profitability and socioeconomic benefits

This supplements the financial analysis through the lens of not only the kilns, but also the processing facilities and the community in general. Although several methods may be applied, safety, environmental, sanitary and socioeconomic criteria have been favoured in this case. Indeed, in terms of food safety and environmental impact, the FTT makes it possible to market safer and higher-quality products than those from traditional systems. In addition, the FTT reduces PHLs and fuelwood consumption: according to estimates (Diomandé, undated; FAO, 2016a), these PHLs amount to

[31] The discount rate that breaks even the NPV (according to the conventional IRR formula) is 114.3 percent in this case. The NPV's bell-shaped curve explains this difference.

23 317 tonnes per year (for a value of approximately XOF 7 billion or USD 11.6 million), to which must be added 112 000 tonnes of wasted wood (worth XOF 2.24 billion or USD 3.7 million).

In terms of public health, studies have shown (Anoh, Outtara and Ossey, 2016, in particular) that FTT users are less exposed to smoke-related pathologies than those who use traditional systems. Inherent health costs, which are estimated at XOF 753 250 or USD 1 247 a year (for medical consultation and hospitalization costs), can be considered opportunity costs in the economic evaluation.[32] It appears that FTT kilns are not only financially profitable but are economically profitable as well: even if their IRR are comparable, 35.6 and 33.7 percent for the first and second prototype, respectively, 0.7 and 2 points higher than the financial IRR, their NPV is significantly higher (more than XOF 15.8 and 13.1 million, or USD 26 215 and 21 714, amounting to 1.6 and 1.8 times more, respectively, when including the above-mentioned health aspects (see Annex 7).

At the social level**,** CMATPHA's records (CMATPHA, undated) show that in 2015, the cooperative spent XOF 565 000 (USD 935) for charities besides personnel expenses.

On the economic front, profits generated by these kilns contribute not only to their own growth and that of the processing facilities that shelter them in terms of added value, but also to stimulate trade and the development of the local economy such as through the purchasing of raw materials or intermediate consumption (IC), sale of healthy and quality products, various services including fish and meat smoking for others, sale of small water bags. As demonstrated above, fish smoking has a gross value added (GVA) of more than XOF 2 million (USD 3 370), for a sold production or turnover greater than XOF 8.5 million (USD 14 090), and an IC of nearly XOF 6.5 million (USD 10 720) that encompasses the purchasing of raw materials, transporting them, the self-consumed and donated production, and personnel expenses.

Apart from processing fish and meat products for themselves and for third parties, women also perform other related activities using FTT kilns that also add value to these products. In 2015, according to the available data summarized in Annex 3, all of these activities (marketing of smoked fish, food packaging and basins) generated a GVA of more than XOF 2.4 million (USD 4 025) for a turnover of just over XOF 10.74 million (USD 17 775), and ICs of nearly XOF 8.3 million (USD 13 750)]. Also in 2015, CMATPHA members mobilized more than XOF 47.37 million (USD 78 400) in internal savings and generated interest of more than XOF 2.4 million (USD 4 028) on behalf of their SCOOP.

In terms of job creation, according to available statistics (Diomandé, undated; FAO, 2016a), 3 807 actors are involved in the four pilot processing facilities. These include artisans, in addition to fish processors and fishmongers. Estimates suggest that there are 70 000 to 400 000 direct and indirect jobs in small-scale fisheries nationwide (National Development Plan, 2012–2015). Fish processing, in particular, is dominated by women (an estimated 95–99 percent of the operators on the four processing facilities in question) and so provides jobs and income for many women and their families, as well as their children's education, with most women depending on the income for their livelihoods.

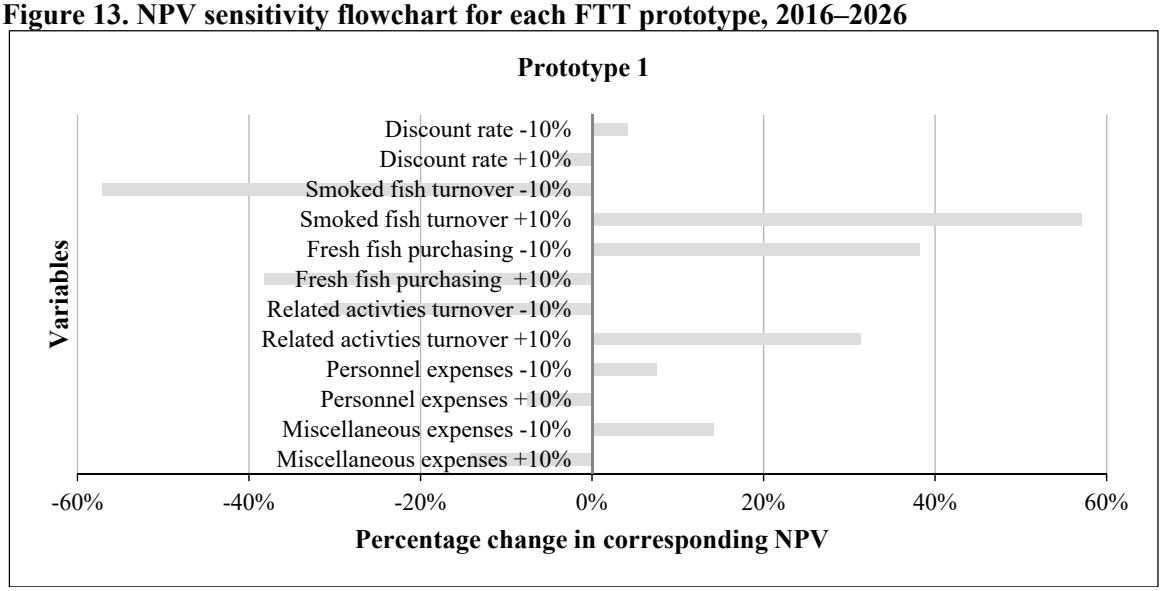
In summary, the safety, environmental, food, sanitary and socioeconomic benefits of the FTT are well-established.

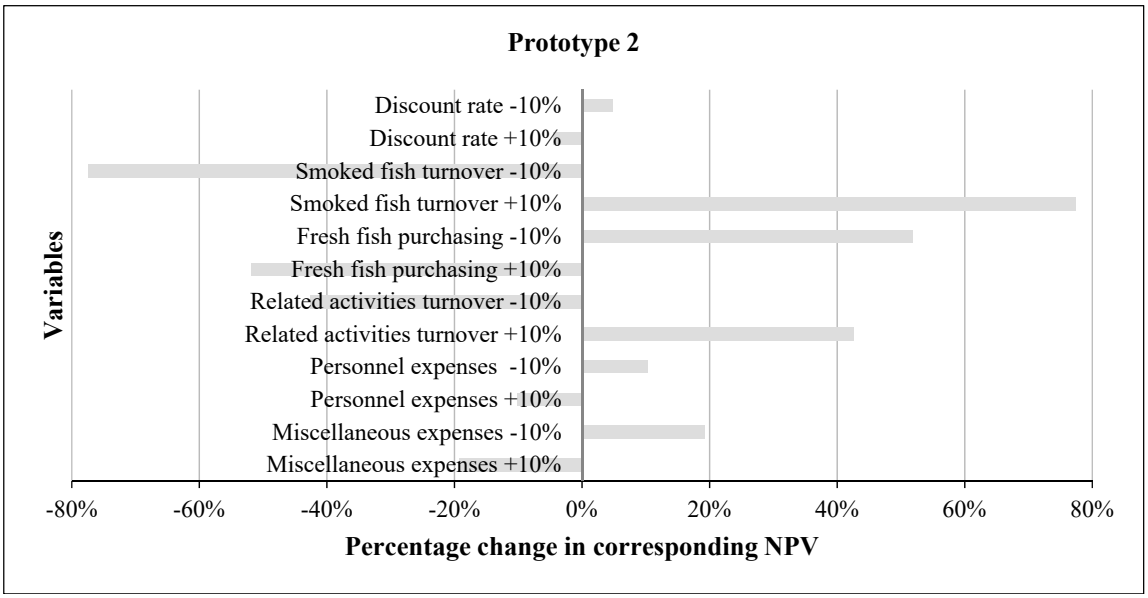
[32] The anecdotal case of Mrs Elizabeth Ohouo, a CMATPHA member specialized in fish smoking at the Abobo-Doumé FTT processing facility, whose sight has improved since then according to FAO (2016a) and the CMATPHA president can be cited.

6.3.3 Sensitivity analysis

According to this analysis results, the FTT kilns' financial capacity (and especially their NPV whatever the prototype) is particularly sensitive, in one way or another, to variables such as smoked fish marketing, fresh fish purchasing, related activities and miscellaneous expenses. In fact, a 10 percent increase in smoked fish sales increases the NPV by more than 57 percent and more than 77 percent, respectively (a fall in the same rate makes it drop in the same proportions). A 10 percent increase in fresh fish purchasing for smoking causes the NPV to drop by more than 38 percent and almost 52 percent, respectively (a fall in the same percentage, on the contrary, makes it increase at the same percentage). A 10 percent increase in turnover from related activities raises the NPV by more than 31 percent and about 43 percent, respectively (a fall in the same percentage makes it, on the contrary, fall by the same percentages). The kilns' financial capacity is less affected by personnel expenses and the capital discount rate (see Figure 13 and Annex 6 for more details).

Figure 13. NPV sensitivity flowchart for each FTT prototype, 2016–2026





The break-even point analysis of the key variables (i.e. those having the greatest effect on the kilns' financial capacity) also shows that the two prototypes are respectively profitable with a minimum processing capacity of 5.3 and 5.7 tonnes of fresh fish per year, equivalent to 2.3 and 2.5 tonnes of smoked fish. This capacity could be increased to more than 8.9 and almost 9.4 tonnes of fresh fish if fish smoking were to completely substitute related activities, everything else being equal, including the purchase of raw materials (Table 12).[33] Thus, these related activities provide substantial income for processors and include the diversification of by-products and enhancing their value (e.g. sausages, croquettes, fish "samosas", use of fish fat), for which other FTT kilns are planned. As mentioned previously, the diversification of co-products and their valorization achieve the same objective.

Table 12. Break-even points for key variables according to each FTT prototype kiln

Variables	Actual	Break-even point	Variation rate (%)	Occurrence probability
PROTOTYPE 1				
Smoked fish turnover (XOF)	8 514 000	6 820 444	-19.9	Very plausible
Smoked fish quantity (kg)	2 910	2 331	-19.9	Very plausible
lwe fish quantity (kg)	6 600	5 287[a]	-19.9	Very plausible
Fresh fish purchasing (XOF)	5 707 500	7 199 346	+26.1	Very plausible
Fresh fish quantity (kg)	6 600	8 325[a]	+26.1	Very plausible
Turnover assuming smoked fish turnover substitutes related activities (XOF)	13 193 150	11 499 593	-12.8	Very plausible
Smoked fish quantity (kg)	2 910	3 930	+35.1	Very plausible
lwe fish quantity (kg)	6 600	8 914	+35.1	Very plausible
Related activities turnover (XOF)	4 679 150	3 187 296	-31.9	Very plausible
Miscellaneous expenses (XOF)	2 116 200	3 608 684	+70.5	Plausible
PROTOTYPE 2				
Smoked fish turnover (XOF)	8 514 000	7 413 677	-12.9	Very plausible
Smoked fish quantity (kg)	2 910	2 534	-12.9	Very plausible
lwe fish quantity (kg)	6 600	5 747[a]	-12.9	Very plausible
Fresh fish purchasing (XOF)	5 707 500	6 807 819	+19.3	Very plausible
Fresh fish quantity (kg)	6 600	7 872[a]	+19.3	Very plausible
Turnover assuming smoked fish turnover substitutes related activities (XOF)	13 193 150	12 092 827	-8.3	Very plausible
Smoked fish quantity (kg)	4 509	4 133	-8.3	Very plausible
lwe fish quantity (kg)	10 227	9 374	-8.3	Very plausible
Related activities turnover (XOF)	4 679 150	3 578 825	-23.5	Very plausible
Miscellaneous expenses (XOF)	2 116 200	3 216 989	+52.0	Plausible

lwe = live weight equivalent.

a. The break-even point for fresh fish quantities differs depending on whether either smoked fish marketing, or purchasing fresh fish as raw material are considered because these items are exclusive in the analysis (when changing one variable, the others are kept constant).

These results highlight the possibility of increasing revenues, particularly the turnover from fish selling and the corresponding quantities of fish while minimizing costs as much as possible. They also reflect the wide margin for disseminating FTT kilns in the country. However, this dissemination will need to take into account current and future food availability (i.e. fisheries potential and market needs). The parameters that must be taken into account to determine the optimal number of kilns to be installed are:

- The kilns' nominal processing capacity (i.e. 3 tonnes of fresh fish per site per day or 660 tonnes per year over 220 days considering rest days and maintenance of the kilns, as well as fish supplies' seasonality);

[33] By comparison, and although the conditions cannot be directly transposed from one country to another, the break-even point of the FTT processing facility established in the DRC is at nearly 20 tonnes of fresh fish per year (Bungubetshi, G. undated. Plan d'affaire PFT/FTT. Draft).

- Food availability, estimated at about 327 870 tonnes of fishery products in 2013 (FAO, 2016b);
- The fisheries potential of maritime waters, estimated at 80 000–120 000 tonnes per year, according to Shep *et al*. (2016), depending on environmental conditions, and particularly the magnitude of the upwelling in previous years;
- The proportion of catches usually used for smoking, estimated at around 35 percent (UEMOA, 2012; Shep *et al*., 2016);
- The proportion of self-consumed and donated fish (in the range of 8–10 percent of the catch based on field survey results);
- The number of processors (current and potential); and
- Funding opportunities.

Based on these parameters, the number of improved processing facilities could be increased from the current 4 units to 25 (i.e. 21 additional units of the same capacity). In doing so, the total processing capacity would increase from the current 2 640 tonnes to 16 500 tonnes, or 6.25 times more.

6.4 Market analysis

6.4.1 Supply and demand for fishery products

As stated previously, according to available statistics (FAO, 2016b), the supply of fishery products in Côte d'Ivoire in 2013 was estimated at 327 870 tonnes, distributed as follows: domestic production at 81 705 tonnes; imports at about 318 660 tonnes; and exports at 72 495 tonnes. There is no known non-food use of fishery products in the country. With a population estimated that year at nearly 20.3 million people, this food availability corresponded to a per capita fish supply of 16.1 kg. According to the same source, in 2014 the population was estimated at more than 22.1 million people. If the same per capita fish supply were maintained, the supply of fish would be estimated at 356 730 tonnes.

6.4.2 FTT kiln use capacity

The field visits showed that all of the FTT kilns at all of the processing facilities are underutilized. The same observation has been made in other countries, such as the Democratic Republic of the Congo.[34] There are several reasons for this. While in the Democratic Republic of the Congo, underutilization is due to the low working capital for fish purchasing, in Côte d'Ivoire underutilization is mainly due to two factors: (i) the absence of working capital until recently, and (ii) the non-finalization of contracts with identified remunerative markets. In addition, during the off-fishing season, the processing facilities in coastal Abobo-Doumé, Braffedon and Marcory-Anoumabo, in this case, offset the decline in catches by imported frozen fish, which is not the case for Guessabo in the hinterland, which mainly depends on local production.

6.4.3 Market outlets for FTT fishery products

In Côte d'Ivoire, despite their superiority in terms of food safety and quality, fish smoked with FTT kilns are currently marketed in the same markets as smoked fish from traditional kilns. This is also the case in other countries, such as the Democratic Republic of the Congo[35] and the United Republic of Tanzania (Kissai and Mgawe, 2017) in particular where this new technique has been introduced. In general, both types of products are sold at the same prices. In addition, although, as indicated in Subsection 5.1.2, all pilot FTT facilities have been equipped with vacuum packaging machines; processors do not systematically pack FTT products and do not label them. Field surveys did not highlight specific marketing channels for these products.

[34] FTT kilns recently installed in this country are used at less than 1 percent of their capacity (i.e. 340 kg compared with 1 200 kg of fresh fish per day (Bungubetshi, G. undated. Plan d'affaire PFT/FTT. Draft.

[35] Bungubetshi, G. undated. Plan d'affaire PFT/FTT. Draft.

FTT processors must, therefore, contract the most lucrative markets identified for these new products, including supermarkets, diplomatic representations and international organizations, resident expatriates, tourists, restaurants, school canteens,[36] barracks, hospitals, universities, boarding schools, export market, including the European market. This will require compliance with these market requirements in terms of quality assurance and quality control, traceability and regularity of supplies. It would also be necessary to agree on payment terms, and to set up model stalls in places such as Braffedon and Guessabo, where processors usually sell their products by the road and are, therefore, exposed to the risk of traffic accidents.[37] Hence, the importance of FTT product promotion and consumer awareness campaigns in this regard.

Administrative authorities and other local dignitaries already buy FTT products on a regular basis. A European national recently passing by Guessabo has also bought these products and, according to the team in place, said that these products would easily be sold in Europe because of their safety and quality. Therefore, these products can be exported and meet European market requirements. In addition to the above requirements, this would require that processors master the smoking technique, and that the products be better packaged. The four FTT pilot facilities have been equipped for this purpose.

Similarly, CMATPHA members have taken a number of initiatives to boost their sales, including the possibility of exporting products to the European Union. To do this, members will need to have a valid export license in accordance with current regulations.[38] Other strategies that processors and fishmongers could implement include:[39]

- organizing bulk purchases and sales of products – the purpose of group purchasing is to reduce the dependence of these processors and fishmongers on fishers, while group sales help to strengthen their market supply capabilities;
- strengthening win-win partnerships by establishing producer sales offices to strengthen fish processors and fishmongers' organizational capabilities and improve marketing channels for their products;[40] and
- establishing a market information system for fishery products (INFOPÊCHE could provide technical assistance to this end).

[36] As stated in a recent survey (INFOPECHE, 2014), 5 800 school canteens were identified throughout the country.

[37] Charles Kapie, personal communication, 14 November 2016.

[38] There are two categories of agreement according to current regulations: the agreement linked to the profession (here fish processing), and the health certification related to quality assurance of products for export. The second category is the one discussed here.

[39] These strategies and many others were discussed during the national stakeholder validation workshop mentioned above.

[40] These offices act as marketing agencies for small producers; some already operate in the agricultural sector in Côte d'Ivoire.

CHAPTER 7: PRIORITIES FOR AN ENABLING ENVIRONMENT FOR FTT ADOPTION BY PROCESSORS AND ITS LARGE-SCALE DISSEMINATION

With regard to the study's third objective, this chapter highlights the priorities for an enabling (including policy and institutional) environment for the FTT adoption by processors, and its large-scale dissemination. Because the FTT is still in a pilot phase, it is important to analyse the determinants of its adoption, whether they are endogenous (e.g. the structuring of target groups and other actors, their empowerment, kiln and equipment management capacity, marketing strategies) or exogenous (e.g. policy, legislative, regulatory and institutional framework, market conditions). Thus, the chapter first reviews the key lessons learned from this innovation and the conditions for its widespread adoption and dissemination. It then reviews the appropriate priority actions to be implemented. Finally, it explores the conditions for updating national PAH regulations.

7.1 Main lessons learned from the FTT, and the determinants for its widespread adoption and dissemination

7.1.1 Main lessons learned from the FTT

Several lessons can be learned from the FTT regarding planning and implementation, management and monitoring and evaluation. These are summarized as follows:

i. In keeping with decentralization, the involvement of local (administrative, municipal, traditional and territorial agencies) authorities alongside the competent technical services is essential to ensuring the success of the processing facilities set-up and their sustainability (e.g. raising stakeholders' awareness and organizing producers), providing sites and their servicing including creating or rehabilitating access roads and partially financing the infrastructure (as done by the Regional Council of Haut-Sassandra for the shed housing the Guessabo facility).
ii. A participatory approach should be systematically adopted, one that involves all stakeholders (producers, technical services and local authorities mentioned above, institutional partners) in all phases.
iii. The processing facility implementation site should be chosen carefully, usually a compromise of several criteria (e.g. accessibility, distance, viability, security) in order to reach out the largest number of potential users.[41]
iv. Equipment must be sized according to market needs, the state of the fisheries resources and their availability.
v. The types of equipment must be adapted to each site's specificities, including user needs and the main target fish species (i.e. large trays for small fish).
vi. The setting up of child-care facilities could also prove indispensable.
vii. The awareness of processors, consumers, decision-makers and competent authorities must be raised about the comparative advantages of the FTT, in particular, the fact that healthy and higher-quality products are the result of using this innovation.[42]
viii. FTT processing facilities' management must be entrusted to formally constituted processor groups whose management capacity is strengthened, thereby increasing their empowerment.
ix. These processors must also master smoking, using the FTT system, and to that end, they will need to be appropriately trained.
x. In addition, they must be monitored and supported by the competent authorities (e.g. in terms of smoking techniques and kiln utilization, maintenance, bookkeeping and functional accounting); in the absence of regularly recorded cash flow data, it is difficult to determine these kilns' profitability.

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41 According to a recent study (Anoh, Outtara and Ossey, 2016), the effects of FTT are more noticeable among fishing communities with high concentrations of processors (Grand-Lahou) than among those where they tend to smoke fish on an individual basis (Braffedon).

42 There are reports of consumers in some markets who are hesitant before FTT-processed fish because of their "paleness"; they are actually of a golden colour as opposed to the blackish colour of fish from traditional systems, which they wrongly attribute to insufficient smoking, preferring the darker fish (usually charred) they are more accustomed to.

xi. The related income-generating activities, apart from fish smoking, enhance the profitability of the FTT kilns and the facilities in which they are housed. They also attest to the versatile use of these kilns to process not only fish, but also by-products by enhancing their value.
xii. Setting up FTT facilities favours technology transfer to local artisans such as metal carpenters, blacksmiths, welders and cutters to manufacture FTT components.

7.1.2 Determinants of FTT adoption

Respondent profile: In total, 45 women (FTT and traditional) processors and fishmongers from Abobo-Doumé and Guessabo responded to the questionnaire regarding FTT adoption (Annex 8). Of these, 23 used FTT kilns, and expressed their perceptions on it. Nine women (39 percent) reside in Abobo-Doumé, while the remaining 14 (61 percent) live in Guessabo. Their ages range from 27 to 56, the average of which is almost 40. Most of these women (15 out of 23, or more than 65 percent) are illiterate; 6 of them (or slightly more than 26 percent) completed primary school; 1 (more than 4 percent) started secondary school but did not complete it; and only 1 (more than 4 percent) had a university level education. On average, these women have been smoking fish for more than 14 years (the most senior in this activity for 32 years).

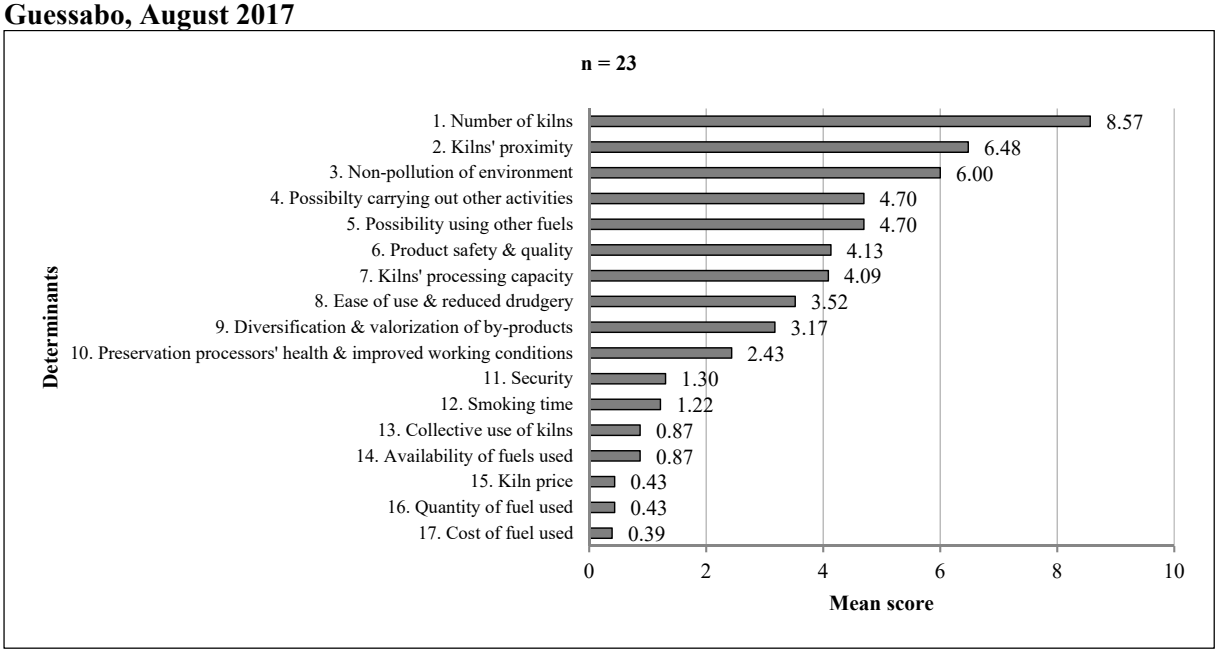
Main determinants: As shown in Figure 14, of the 20 possible determinants, respondents focused on 17 of them. The most decisive factors – assuming that FTT kilns can increase women processors' revenue through a better selling price of fish and access to more rewarding markets and thus this factor constitutes, as for any economic agent, the primary objective pursued by these processors – are:

i. *The number of kilns* in relation to the processors' needs (mean score of 8.57 out of 10): the larger the number of kilns available, the higher their level of adoption, and vice versa (the smaller this number, the lower their level of adoption);
ii. *The kilns' proximity* to users' dwellings (mean score of 6.48): the closer they are located to users' residences, the higher the likelihood that these users will adopt them, and vice versa (the farther the kilns, the lower the likelihood for adoption); the case of Grand-Lahou processors on the Braffedon processing facility illustrates this;
iii. Preservation or non-pollution of the environment (mean score of 6.00);[43]
iv. The possibility of conducting other activities concurrently with fish smoking, as well as the use of non-wood fuels (mean score of 4.70); and
v. *The safety and superior quality of finished products*, especially their lower PAH content (mean score of 4.13).

The main determinants for the FTT kilns adoption are their number, their proximity to the target groups' residences, and the protection of the environment.

[43] It should be recalled that the fight against climate change, of which environmental pollution is one of the causes (Anoh *et al*., 2016), is the objective of Sustainable Development Goal #13.

Figure 14. Determinants for the FTT adoption as perceived by processors in Abobo-Doumé and Guessabo, August 2017



Other determinants are the kilns' processing capacity (mean score of 4.09), ease of use and reduced drudgery (mean score of 3.52), diversification and valorization of by-products (mean score of 3.17).

Preservation of processors' health (due to a lower exposure to heat, smoke and toxic gases) and improved working conditions only appears at the 10th position (mean score of 2.43). As detailed above, market conditions and consumer behaviour with regard to FTT products and those from traditional kilns explain this. Indeed, at the moment, these two types of products are sold on the same markets, generally at the same prices. In addition, some consumers are still hesitant before FTT products because of their paleness.

Other determinants, however, do not seem to have significantly influenced processors' decision to adopt the FTT: security, and in particular, the protection of products against theft (mean score of 1.30); smoking time (mean score of 1.22); the collective use of kilns (mean score of 0.87); kiln price (mean score of 0.43); the quantity of fuel used per smoking session in relation to the quantity of fish (mean score of 0.43); and fuel costs (mean score of 0.39). Processors seem to be comfortable with the collective use of kilns in light of their limited number in relation to needs. Similarly, the fact that the cost of these kilns is only ranked 15th is due to the financing of the pilot processing facilities and their equipment by FAO and local authorities, and not by the processors themselves.

These results are in line with the above lessons learned and the perceptions of the processors who participated in the stakeholder validation workshop held in Grand-Bassam from 15 to 17 November 2016.

In summary, the FTT adoption depends mainly on sociodemographic determinants (number of kilns in relation to the target groups' needs), geographical (proximity of the kilns to groups' residence), and environmental (protection and non-pollution of the environment) determinants. The FTT kilns' technical characteristics are also important because processors can carry out other activities while smoking fish, use other fuels, smoke larger quantities of fish, and diversify and valorize by-products. The same is true of health determinants (safety and higher-quality products).

7.1.3 Granting microcredit

Local microfinance institutions trust fish processors more and more by lending them microcredit owing to the structuring and organization of these processors in cooperative societies.

Sixteen of the twenty-one (more than 76 percent) CMATPHA fish processors and fishmongers who expressed their views on microcredit (see questionnaire in Annex 9) stated that their structuring and organization in SCOOP resulted in local MFIs trusting them more and more by lending them microcredit; the other five members (almost 24 percent) felt that it was because of their reputation and creditworthiness. In fact, between 2014 and 2016, 10 of them benefited from short-term microcredit, generally for one year, worth a total of XOF 3.6 million (USD 5 960) from a savings and credit cooperative for their activities, whereas previously, in 2001, only one had benefited. Although these are individual microcredit schemes, CMATPHA has acted as a peer lending guarantee.

7.1.4 FTT's sustainability and replicability

The FTT's sustainability can be judged by four dimensions (or pillars): economic, environmental, sociocultural and institutional.[44]

i. It should be recalled that some of the economic benefits of this system are increased revenue and job creation, including ancillary jobs.
ii. The FTT also contributes to the protection of the environment because of its reduced consumption of wood and other fuels, and lower pollutant emissions.
iii. At the sociocultural level, the FTT's benefits include, among others: the preservation of users' health and the improvement of their living and working conditions; integration of gender issues due to the strong involvement of women, as well as youths in related professions; technology transfer through training in areas such as product smoking techniques and new trades; and healthy and higher-quality products on the market that are highly appreciated by consumers.
iv. At the institutional level, the policy, legislative, regulatory and institutional framework in place is conducive to the FTT dissemination across the country.

These four dimensions of sustainability are complementary and interact with each other so that the effects of one dimension affects other dimensions, and the services provided by one serve the others.

In summary, the above determinants are likely to ensure the FTT adoption by more processors. Therefore, they favour its spatiotemporal expansion (i.e. its durability and replicability) in other fishing communities. These determinants fulfil all of the FTT's sustainability dimensions: economic, environmental, sociocultural and institutional. The pilot processing facilities teach us, in particular, that the types of kiln and equipment to be put in place must be adapted to the implantation site's specificities. In this context, a number of priority actions need to be carried out. These are discussed in the next section.

7.2 Priority actions

The following actions could be prioritized or facilitated by FAO and/or MIRAH for the FTT adoption by a larger number of women processors and its wide dissemination. Based on the preceding analysis, these actions tend to identify the internal and external environment (micro, meso and macro level) and to define favourable and conducive conditions for doing so.

[44] Many authors, such as those from the Organisation for Economic Co-operation and Development, distinguish three main dimensions of sustainability: economic, environmental and social. Others differentiate the demographic (similar to the social dimension) and technological dimensions. The institutional dimension (or governance by other authors) and the cultural dimension to transform it into a sociocultural dimension were added. These two dimensions are deemed relevant in this case.

7.2.1 At the FTT processing facility level

i. **Strengthen the capacity of women processors** in smoking techniques, using and maintaining the kilns and the FTT processing facilities in which they are housed; keeping records of income statements, accounting, exchange of experiences between SCOOPs, business strategies, including finalizing contracting processes with new, more profitable identified markets. **Develop the capacity of local artisans (metal carpenters, blacksmiths, welders and cutters)** to manufacture, assemble and maintain FTT components, in view of disseminating this new technology;
ii. **Improve the monitoring mechanism** to systematically collect and record all load quantities and values (e.g. purchasing fresh fish, fuel, water, packing and packaging, transportation, labour, taxes) and all product quantities and values (e.g. sale of smoked fish and other products), knowing that some of these variables are to be collected on a daily basis, while others will be collected monthly or annually;
iii. **Strengthen good hygienic practices in general, and systematically treat well-water or rainwater** that is used to wash utensils and fresh fish that is to be smoked, according to prevailing standards.

7.2.2 At the local and regional level

i. **Raise awareness and educate people** about the comparative advantages of FTT products;
ii. **Adopt a participatory approach involving all stakeholders**, including relevant local authorities and territorial bodies, in every stage, in particular during improved processing facility planning, site selection and provision, awareness raising and educating the people.

7.2.3 At the national level

i. **Update national regulations on PAHs**[45] **so that other countries can learn from the Ivorian experience in this domain.** This will ensure product traceability and quality control with the objective of ensuring that PAH and metallic trace element levels in market products do not exceed national and international standards, and that these standards are respected and upheld throughout the value chain;
ii. **Revitalize the Fisheries Advisory Committee,** which currently only meets sporadically;
iii. **Identify and encourage other donors and development partners** (e.g. AfDB, IFAD, EC) to provide funding (if not FTT processing facilities, at least the kilns). given the favourable policy and institutional framework, particularly via the FTT dissemination programme to other fishing communities across the country, and the results of this study underpin it;
iv. Set up new FTT processing facilities and a monitoring and evaluation mechanism for these.

These actions are summarized in Table 13.

[45] Very few countries in Africa and Asia (apart from Ghana and India among the best-known cases) have PAH regulations. In addition, as it has been demonstrated (Djessouho, undated), traditional fish smoking systems used in these countries (including, as noted above, Côte d'Ivoire) do not comply with the principles and recommendations of the Codex Alimentarius Code of Practice CAC RCP-68- 2009 in this regard.

Table 13. Priority actions for the FTTadoption by processors and its large-scale dissemination

Id	Actions	Expected results	Monitoring and performance indicators	Frequency implementation	Leading agency/ partner
1	**At FTT platform level**				
1.1	Strengthen the capacity of women processors and local artisans	Processors and local artisans' capacity strengthened and put into practice	Number of training / retraining workshops organized and number of women and men participants	Quarterly	FAOCI / MIRAH / FMM / Institutional partners[a] / Women processors
1.2	Set up loads and products collecting and recording data mechanism	Expenditures and revenues systematically collected and recorded	Records kept Income statements produced Improved processing facility activities and products report	Daily	FTT processing facility personnel
1.3	Strengthen GHPs and systematically treat water (well-water and rainwater) used to wash fresh fish and utensils	GHPs strengthened Water (well-water and rainwater) previously treated	BPHs implemented Number of treated water sources Quantity of treated water Test results	According to relevant standards	MSHP / Women processors FTT processing facility personnel
2	**At municipal and regional levels**				
2.1	Raise awareness and educate people about FTT products' comparative advantages	Populations sensitized and educated	Number of sensitized and educated people	Continuous	FAOCI / MIRAH / FMM / Institutional partners[a] / Women processors / FTT processing facility personnel
2.2	Involve all stakeholders, including competent local authorities in every phase	Local authorities involved Appropriate sites made available	Number of appropriate sites made available Quality of sites made available	Continuous	FAOCI / MIRAH / FMM / Institutional partners[a] / Women processors / FTT platform personnel
3	**At national level**				
3.1	Update PAH regulations for food products	PAH regulations for food products updated	Level of regulation enforcement Number of fines imposed on offenders	One-time, then context specific	MIRAH / FMM / FAOCI / Institutional partners[a] / Women processors
3.2	Revitalize Fisheries Advisory Committee	Committee revitalized	Number of meetings held Type and number of relevant actions	Continuous	MIRAH / FMM / FAOCI / Institutional partners[a] / Women processors
3.3	Identify other donors and development partners able to finance FTT kilns and/or improved processing facilities	Donors and development partners identified and motivated	Number of donors and development partners identified, motivated and funding	Continuous	MIRAH / FMM / FAOCI / AfDB / IFAD / EC
3.4	Set up 21 new FTT processing facilities and monitoring and evaluation mechanism	FTT processing facilities and M & E mechanism put in place	Number of FTT processing facilities and M & E mechanism implemented and functional	Continuous	FAOCI / MIRAH / FMM / AfDB/ IFAD / CE / Institutional partners[a] / Women processors

[a] For example, LANADA, INFOPÊCHE, UFHB, Regional Councils, non-governmental organizations.

CHAPTER 8: CONCLUSIONS AND RECOMMENDATIONS

8.1 Conclusions

This study has determined the FTT kilns' profitability. The study results are consistent with previous studies in Côte d'Ivoire and other countries that have explicitly demonstrated the FTT's technical superiority for smoking fish compared to other systems, be they improved (such as the Chorkor kiln) or traditional (earth or clay barrel sections).

Results prove that this new system is profitable at both the financial and economic perspective. It requires an initial investment of either XOF 857 600 or 2 845 200 (USD 1 419 and 4 709), depending on whether it is a single prototype kiln or if the kiln is installed on a standard pilot processing facility. Indeed, the kilns' NPV amounts to more than XOF 10.3 million (USD 17 133) and more than XOF 7.6 million (USD 12 636), respectively, corresponding to an IRR of 34.9 percent and 31.7 percent, respectively, based on a discount rate of 10 percent per annum over 10 years.

The results of this study confirm those of previous ones regarding the FTT kilns' superiority to traditional kilns for fish smoking from technical, health and environmental perspectives. In addition, the study demonstrates the financial and economic profitability of this innovation.

According to the results of the sensitivity analysis, all items (whether expenditures or products) do not have the same effect on the financial capacity (NPV and IRR) of the FTT kilns: the most important are, in descending order, fish smoking and marketing (in either direction); fresh fish purchasing; revenues from related IGAs; and miscellaneous expenses. In contrast, this capacity is less dependent on items such as personnel expenses and the discount rate (the decrease in this rate, however, has significantly more effect than its increase). IGAs (e.g. the sales of food packaging, basins, internal savings) thus contribute to increasing women processors' revenues and include diversifying and valorizing by-products (e.g. sausages, croquettes, fish "samosas", use of fish fat), and other FTT kilns are planned for other communities throughout the country.

Thus, the analysis of break-even points of the key variables shows that the two kiln prototypes selected are only profitable if they generate an annual turnover of nearly XOF 11.5 and 12.1 million (USD 19 032 and 20 014) for smoked fish sales, respectively, more than 3.9 tonnes and more than 4.1 tonnes corresponding to a capacity of more than 8.9 tonnes, and nearly 9.4 tonnes of fresh fish per year when fish smoking entirely substitutes income-generating activities. The break-even point is close to 5.3 and more than 5.7 tonnes of fresh fish (i.e. more than 1.6 and 1.7 times less) when income-generating activities are taken into consideration. This reflects the wide dissemination margin for FTT kilns across the country in terms of nominal processing capacity (i.e. 3 tonnes of fresh fish per facility and per day), fisheries potential, food supply and market needs, among other things. Twenty-five improved processing facilities (i.e. an additional 21 units) can be set up.

These processing facilities convey several lessons, which mainly stress the need to adopt a participatory approach in the planning, implementation and follow-up, as well as for carefully choosing the site where they will be installed, and for adapting the equipment to local conditions and market needs. These facilities also promote the need to: (i) build awareness of the population and the target groups; (ii) entrust the FTT processing facilities' use and management to well-structured and organized target groups by strengthening their capacity to do so; and (iii) monitor and evaluate their activities in a timely manner in order to take corrective action as needed.

Target groups perceive that the most crucial determinants to adopt the FTT are mainly of a sociodemographic nature (number of FTT kilns available in relation to the needs), geographical (proximity of these kilns), and environmental (non-pollution). Health and safety determinants (on the one hand, safety and quality of the products, and on the other, preserving processors' health and

improving their working conditions) appear respectively only at the 6th and 10th ranks. These results stem from unsatisfactory market conditions and unaware consumer behaviour, which do not clearly differentiate between FTT and traditional products, especially in terms of quality and price.

These conclusions highlight the need when planning to install and implement FTT processing facilities, to pay particular attention to the key parameters that have the greatest effect (in either direction) on these processing facilities' financial capacity. Therefore, combining this need with the lessons learned has implications on making a decision to disseminate these acilities across the country.

8.2 Recommendations

Based on the results and the conclusions made, the key recommendations from the study are the following:

i. **Increase the number of FTT processing facilities from the current 4 units to 25** (21 additional units of the same capacity); in so doing, the total processing capacity would increase from 2 640 tonnes of fish to 16 500 tonnes on the basis of 220 days of operation per year, taking into account the number of rest days and those used to maintain the kilns as well as the seasonality of fish supplies.
ii. **Choose the location of the FTT processing facilities so that the largest number of potential users are reached out,** with the knowledge that the effects of the FTT are more noticeable among fishing communities with a high concentration of women fish processors than among communities where women tend to smoke fish on an individual basis.
iii. **Select and adapt the equipment to be used according to the specificities of each site**, and in consideration of the main fish species targeted and market needs.
iv. **Strengthen good hygienic practices in general, and systematically treat well-water and rainwater** used to wash utensils and raw fish prior to smoking, according to prevailing standards.
v. **Raise awareness and educate** processors, consumers, decision-makers and competent authorities about the FTT's comparative advantages over traditional fish smoking systems, including placing healthy and higher-quality products on the market through appropriate outlets, including, in agreement with competent authorities, broadcasting videos produced by FAO on this new technology on local television channels. Processors, in particular, should be educated about the preservation of their health and of that of the environment, and the need to better package and label their products.
vi. **Target more rewarding markets for FTT products** (e.g. supermarkets, diplomatic representations and international organizations, resident expatriates, tourists, restaurants, the external market, including the European market) by meeting these markets' requirements in terms of quality assurance and control, traceability and regularity of supplies, and **explore the possibility of setting up model market stalls**.
vii. **Strengthen the capacity of fish smokers and government staff responsible for providing monitoring and support** (regarding, among other things, smoking techniques, the use of FTT kilns and their maintenance, bookkeeping and income statements, monitoring and commercial strategies). **Also strengthen the capacity of local artisans (metal carpenters, blacksmiths, welders and cutters)** to manufacture and assemble FTT components and ensure their maintenance, after having identified and selected them according to clear criteria.
viii. **Encourage additional learning** by promoting and/or organizing exchanges of experiences between FTT processing facilities for processors and government staff responsible for providing monitoring and support.
ix. **Strengthen collaboration mechanisms among institutional partners** by revitalizing the Fisheries Advisory Committee.
x. **Update national regulations regarding PAHs** (so that other countries can draw on the Ivorian experience in this domain), with a view to guaranteeing fishery products' traceability and quality control. The objective is to ensure that PAH and metal trace element contents in products do not exceed national and international standards, and that these standards are respected and upheld throughout the value chain.

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Annex 1. Projected financial statement for FTT Banda prototype 1 kiln (XOF), 2016–2026

ID	ITEM	YEAR										
		2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
I	**EXPENDITURES**											
I.1	Equipment net depreciation value (NDV)	735 250	15 000	0	55 000	0	485 000	0	55 000	0	15 000	237 600
I.2	Raw fish purchasing	4 534 500	5 707 500	5 707 500	5 707 500	5 707 500	5 707 500	5 707 500	5 707 500	5 707 500	5 707 500	5 707 500
I.3	Fuel purchasing	145 645	196 400	196 400	196 400	196 400	196 400	196 400	196 400	196 400	196 400	196 400
I.4	Water, self-consumption, donations and fish descaling	402 100	466 500	466 500	466 500	466 500	466 500	466 500	466 500	466 500	466 500	466 500
I.5	Raw material purchasing for other income-generating activities	1 409 370	1 774 050	1 774 050	1 774 050	1 774 050	1 774 050	1 774 050	1 774 050	1 774 050	1 774 050	1 774 050
I.6	Transport and maintenance	115 000	145 000	145 000	145 000	145 000	145 000	145 000	145 000	145 000	145 000	145 000
I.7	Personnel expenses	890 000	1 122 500	1 122 500	1 122 500	1 122 500	1 122 500	1 122 500	1 122 500	1 122 500	1 122 500	1 122 500
I.8	Miscellaneous expenses	1 675 000	2 116 200	2 116 200	2 116 200	2 116 200	2 116 200	2 116 200	2 116 200	2 116 200	2 116 200	2 116 200
	TOTAL I (EXPENDITURES)	9 906 865	11 543 150	11 528 150	11 583 150	11 528 150	12 013 150	11 528 150	11 583 150	11 528 150	11 543 150	11 765 750
II	**REVENUES**											
II.1	Equipment residual value	0	0	0	0	0	0	0	0	0	0	75 550
II.2	Smoked fish sales	6 764 000	8 514 000	8 514 000	8 514 000	8 514 000	8 514 000	8 514 000	8 514 000	8 514 000	8 514 000	8 514 000
II.3	Marketing of other products that generate income	3 717 320	4 679 150	4 679 150	4 679 150	4 679 150	4 679 150	4 679 150	4 679 150	4 679 150	4 679 150	4 679 150
	TOTAL II (REVENUES)	**10 481 320**	**13 193 150**	**13 193 150**	**13 193 150**	**13 193 150**	**13 193 150**	**13 193 150**	**13 193 150**	**13 193 150**	**13 193 150**	**13 268 700**
	OPERATING RESULTS	**574 455**	**1 650 000**	**1 665 000**	**1 610 000**	**1 665 000**	**1 180 000**	**1 665 000**	**1 610 000**	**1 665 000**	**1 650 000**	**1 502 950**

Note: The NDV amounts and the kilns' residual value and their components are rounded up to five, ten, hundred or thousand, as the case may be.

Annex 2. Projected financial statement for FTT kiln prototype 2 (XOF), 2016–2026

ID	ITEM	YEAR										
		2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
I	**EXPENDITURES**											
I.1	Equipment net depreciation value (NAV)	2 498 810	30 000	0	110 000	0	1 120 000	0	110 000	0	30 000	1 455 200
I.2	Raw fish purchasing	4 534 500	5 707 500	5 707 500	5 707 500	5 707 500	5 707 500	5 707 500	5 707 500	5 707 500	5 707 500	5 707 500
I.3	Fuel purchasing	145 645	196 400	196 400	196 400	196 400	196 400	196 400	196 400	196 400	196 400	196 400
I.4	Water, self-consumption, donations and fish descaling	402 100	466 500	466 500	466 500	466 500	466 500	466 500	466 500	466 500	466 500	466 500
I.5	Raw material purchasing for other income-generating activities	1 409 370	1 774 050	1 774 050	1 774 050	1 774 050	1 774 050	1 774 050	1 774 050	1 774 050	1 774 050	1 774 050
I.6	Transport and maintenance	115 000	145 000	145 000	145 000	145 000	145 000	145 000	145 000	145 000	145 000	145 000
I.7	Personnel expenses	890 000	1 122 500	1 122 500	1 122 500	1 122 500	1 122 500	1 122 500	1 122 500	1 122 500	1 122 500	1 122 500
I.8	Miscellaneous expenses	1 675 000	2 116 200	2 116 200	2 116 200	2 116 200	2 116 200	2 116 200	2 116 200	2 116 200	2 116 200	2 116 200
	TOTAL I (EXPENDITURES)	**11 670 425**	**11 558 150**	**11 528 150**	**11 638 150**	**11 528 150**	**12 648 150**	**11 528 150**	**11 638 150**	**11 528 150**	**11 558 150**	**12 983 350**
II	**REVENUES**											
II.1	Equipment residual value	0	0	0	0	0	0	0	0	0	0	75 550
II.2	Smoked fish sales	6 764 000	8 514 000	8 514 000	8 514 000	8 514 000	8 514 000	8 514 000	8 514 000	8 514 000	8 514 000	8 514 000
II.3	Marketing of other products that generate income	3 717 320	4 679 150	4 679 150	4 679 150	4 679 150	4 679 150	4 679 150	4 679 150	4 679 150	4 679 150	4 679 150
	TOTAL II (REVENUES)	**10 481 320**	**13 193 150**	**13 193 150**	**13 193 150**	**13 193 150**	**13 193 150**	**13 193 150**	**13 193 150**	**13 193 150**	**13 193 150**	**13 268 700**
	OPERATING RESULTS	**-1 189 105**	**1 635 000**	**1 665 000**	**1 555 000**	**1 665 000**	**545 000**	**1 665 000**	**1 555 000**	**1 665 000**	**1 635 000**	**285 350**

Note: The NDV amounts and the kilns' residual value and their components are rounded up to five, ten, hundred or thousand, as the case may be.

Annex 3. Estimate of the value added for smoked fishery products and a few related income-generating activities on a typical FTT unit, 2015

ID	ITEM	AMOUNT (XOF)
I	**SOLD PRODUCTION OR TURNOVER**	
I.1	Smoked fish sales	8 514 000
I.2	Packaging and food bags sales	844 200
I.3	Basin (pots) sales	1 382 000
	TOTAL I (TURNOVER)	**10 740 200**
II	**INTERMEDIATE CONSUMPTION (IC)[a]**	
II.1	Raw fish to be smoked purchasing	5 707 500
II.2	Fuel purchasing	196 400
II.3	Water to wash fish before smoking purchasing	16 500
II.4	Packaging and food bags purchasing	624 550
II.5	Basins (pots) purchasing	1 148 000
II.6	Transport and raw material loading (fresh fish and basins)	145 000
II.7	Labour (fish descaling)	165 000
II.8	Production self-consumption, donations	285 000
II.9	Basin (pots) losses	20 000
	TOTAL II (IC)	**8 307 950**
	GROSS VALUE ADDED (GVA)	**2 432 250**

a. Excluding other operating expenditures and income, exceptional expenses and income, personnel expenses and depreciation allowances, all items however taken into account in the projected financial statement (Annexes 1 and 2 above) and the financial profitability assessment (Annexes 4 and 5 below).

Sources: CMATPHA (undated); author's calculations.

Annex 4. Financial profitability assessment for FTT Banda prototype 1 (XOF), 2016–2026

Year	Costs	PVC	GB	PVGB	NB	PVNB	Cumulative PVNB
0	9 906 865	9 906 865	10 481 320	10 481 320	574 455	574 455	**574 455**
1	11 543 150	10 493 773	13 193 150	11 993 773	1 650 000	1 500 000	**2 074 455**
2	11 528 150	9 527 397	13 193 150	10 903 430	1 665 000	1 376 033	3 450 488
3	11 583 150	8 702 592	13 193 150	9 912 209	1 610 000	1 209 617	4 660 105
4	11 528 150	7 873 882	13 193 150	9 011 099	1 665 000	1 137 217	5 797 322
5	12 013 150	7 459 221	13 193 150	8 191 908	1 180 000	732 687	6 530 009
6	11 528 150	6 507 340	13 193 150	7 447 189	1 665 000	939 849	7 469 858
7	11 583 150	5 943 987	13 193 150	6 770 172	1 610 000	826 185	8 296 043
8	11 528 150	5 377 967	13 193 150	6 154 702	1 665 000	776 735	9 072 778
9	11 543 150	4 895 422	13 193 150	5 595 183	1 650 000	699 761	9 772 539
10	11 765 750	4 536 206	13 268 700	5 115 658	1 502 950	579 452	10 351 991
		81 224 652		**91 576 643**	**NPV =**	**10 351 991**	
					IRR =	**34.9 %**	

PVC = present value of costs. GB = gross benefits. PVGB = present value of gross benefits. NB = net benefits.
PVNB = present value of net benefits. NPV = net present value. IRR = internal rate of return.

- Profitability index (PI) = 12,07.
- Benefit-to-cost ratio (B/C) = 1.14.
- Net benefit-to-investment ratio (N/K) = 1.92.
- Compounded interest factor or discount factor $(1 + r)^t$ at a 10 percent discount rate per annum.
- **Conclusion: Prototype 1 is financially profitable.**

Annex 5. Financial profitability assessment for FTT prototype 2 (XOF), 2016–2026

Year	Costs	PVC	GB	PVGB	NB	PVNB	Cumulative PVNB
0	11 670 425	11 670 425	10 481 320	10 481 320	-1 189 105	-1 189 105	-1 189 105
1	11 558 150	10 507 409	13 193 150	11 993 773	1 635 000	1 486 364	297 258
2	11 528 150	9 527 397	13 193 150	10 903 430	1 665 000	1 376 033	1 673 291
3	11 638 150	8 743 914	13 193 150	9 912 209	1 555 000	1 168 295	**2 841 586**
4	11 528 150	7 873 882	13 193 150	9 011 099	1 665 000	1 137 217	**3 978 803**
5	12 648 150	7 853 506	13 193 150	8 191 908	545 000	338 402	4 317 205
6	11 528 150	6 507 340	13 193 150	7 447 189	1 665 000	939 849	5 257 055
7	11 638 150	5 972 211	13 193 150	6 770 172	1 555 000	797 961	6 055 015
8	11 528 150	5 377 967	13 193 150	6 154 702	1 665 000	776 735	6 831 750
9	11 558 150	4 901 784	13 193 150	5 595 183	1 635 000	693 400	7 525 150
10	12 983 350	5 005 643	13 268 700	5 115 658	285 350	110 015	7 635 165
		83 941 479		**91 576 643**	**NPV=**	**7 635 165**	
					IRR=	**31.7%**	

PVC = present value of costs. GB = gross benefits. PVGB = present value of gross benefits. NB = net benefits. PVNB = present value of net benefits. NPV = net present value. IRR = internal rate of return.

- Profitability index (PI) = 2.68.
- Benefit-to-cost ratio (B/C) = 1.14.
- Net benefit-to-investment ratio (N/K) = 0.57.
- Compounded interest factor or discount factor $(1 + r)^t$ at a 10 percent discount rate per annum.
- **Conclusion: Prototype 2 is financially profitable.**

Annex 6. Sensitivity analysis results according to the two selected FTT kiln prototypes

Variables	Value	Percentage change with respect to baseline situation	Corresponding NPV (XOF)	Percentage change in NPV	IRR (%)	Percentage change in IRR	SI
PROTOTYPE 1							
Discount rate (%)	11.0	+10	9 949 047	-3.9			
Discount rate (%)	9.0	-10	10 782 962	+4.2			
Smoked fish turnover (XOF)	9 365 400	+10	16 259 875	+57.1	+35.4	1.4	0.1
Smoked fish turnover (XOF)	7 662 600	-10	4 444 107	-57.1	+33.2	-4.8	0.5
Fresh fish purchase (XOF)	6 278 250	+10	6 391 529	-38.3	+34.9	-2.3	-0.2
Fresh fish purchase (XOF)	5 136 750	-10	14 312 453	+38.3	+34.9	1.1	-0.1
Related activities turnover (XOF)	5 147 065	+10	13 598 858	+31.4	+39.8	14.2	1.4
Related activities turnover (XOF)	4 211 235	-10	7 105 124	-31.4	+38.8	11.2	-1.1
Personnel expenses (XOF)	1 234 750	+10	9 573 263	-7.5	+34.8	-0.3	0.0
Personnel expenses (XOF)	1 010 250	-10	11 130 719	+7.5	+35.0	0.3	0.0
Miscellaneous expenses (XOF)	2 327 820	+10	8 884 178	-14.2	+34.6	-0.6	-0.1
Miscellaneous expenses (XOF)	1 904 580	-10	11 819 804	+14.2	+35.0	0.5	0.0
PROTOTYPE 2							
Discount rate (%)	11.0	+10	7 293 741	-4.5			
Discount rate (%)	9.0	-10	7 999 143	+4.8			
Smoked fish turnover (XOF)	9 365 400	+10	13 543 049	+77.4	33.5	+5.7	0.6
Smoked fish turnover (XOF)	7 662 600	-10	1 727 280	-77.4	23.5	-25.7	2.6
Fresh fish purchase (XOF)	6 278 250	+10	3 674 703	-51.9	31.7	-10.9	1.1
Fresh fish purchase (XOF)	5 136 750	-10	11 595 626	+51.9	31.7	+4.4	0.4
Related activities turnover (XOF)	5 147 065	+10	10 882 032	+42.5	37.4	+18.1	1.8
Related activities turnover (XOF)	4 211 235	-10	4 388 297	-42.5	33.5	+5.7	0.6
Personnel expenses (XOF)	1 234 750	+10	6 856 437	-10.2	31.3	-1.3	0.1
Personnel expenses (XOF)	1 010 250	-10	8 413 892	+10.2	32.0	+1.1	0.1
Miscellaneous expenses (XOF)	2 327 820	+10	6 167 351	-19.2	30.8	-2.7	0.3
Miscellaneous expenses (XOF)	1 904 580	-10	9 102 978	+19.2	32.3	+2.0	0.2

NPV = net present value. IRR = internal rate of return. SI = sensitivity index.

Annex 7. Medical costs for diseases related to smoke resulting from fish smoking activities (XOF)

Type of disease	Medical examination cost	Average prescription cost	X-ray[a]	Functional respiratory assessment	Sinus CT scan	Number of examinations/year	Average cost of hospitalisation	Number of hospitalisations/year	Yearly total
I. RESPIRATORY PATHOLOGIES									
Asthma	3 500	11 750	5 000	14 000		1 every 3 months for 6 months, then once a year	55 000	Undetermined (the more accommodating the patient, the less she/he is hospitalized)	
COPD	3 500	14 000	5 000	6 000		1 every 6 months	55 000	Undetermined (the more accommodating the patient, the less she/he is hospitalized)	
Perennial rhinitis	3 500	10 000	5 000			Undetermined (the more accommodating the patient, the less she/he consults a doctor)	0	0	
Sinusitis	3 500	10 000			5 000	Undetermined (the more accommodating the patient, the less she/he consults a doctor)	Hospitalization if surgery (rare)	Undetermined	
Subtotal I	***14 000***	***45 750***	***15 000***	***20 000***	***5 000***		***110 000***		***209 750***
II. OCULAR DISEASES									
Ametropia[b]	3 500	50 000				1 examination every 2 years	0	0	
Allergic conjunctivitis	3 500	10 000				Undetermined	0	0	
Staphyloma peri-papillaris	3 500	0				1 examination	0	0	
Eye allergy	3 500	10 000				Undetermined	0	0	
Pterygoid	3 500	5 000				Undetermined	0	0	
Hypertensive retinopathy	3 500	Undetermined				Undetermined	0	0	
Subtotal II	***21 000***	***75 000***							***103 000***
TOTAL	**35 000**	**120 750**	**15 000**	**20 000**	**5 000**		**110 000**		**312 750**

COPD = chronic obstructive pulmonary , Félix Houphouët-Boigny University (UFHB).

Annex 8. Questionnaire 1 – Determinants for the adoption of FTT kilns

QUESTIONNAIRE 1 [a]
DETERMINANTS FOR THE ADOPTION OF FTT KILNS

Surveyor's name: ---------- Title: ---------- Date: -----/-----/-----Survey #: ----------

SURVEYED PERSON'S DETAILS

Name: ---------- Location: ---------- Age: ---------

1. Marital status: ☐ Married ☐ Single ☐ Divorced/separated ☐ Widow
2. Number of dependent minor children: M: --------- F: ---------- Number of adult children: M: ---------- F: ----------
3. How many of them help you in this activity? Minors: M: -------- F: ---------- Adults: M: ---------- F: ----------
4. Does your spouse help you in this activity? ☐ Yes ☐ No If yes, how? ----------
5. Profession: ☐ Fish smoker ☐ Fishmonger ☐ Fishmonger and fish smoker
   ☐ Other activities (if yes, which ones): ----------
6. Is fish smoking and/or marketing it your main activity? ☐ Yes ☐ No
7. If yes, how long have you been doing this?: ----------
8. Education level reached: ☐ Completed primary school ☐ Incomplete primary school
   ☐ Completed secondary school ☐ Incomplete secondary school ☐ University studies
   ☐ No education
9. Can you read? ☐ Yes ☐ No
10. Can you write? ☐ Yes ☐ No

MEMBER OR NOT OF A COOPERATIVE SOCIETY (SCOOP) OR A SIMPLIFIED COOPERATIVE SOCIETY (SCOOPS)

11. Are you a member of a SCOOP or a SCOOPS? ☐ Yes ☐ No
12. If yes, which one: ----------
    Number of members: ----------

USE OR NON-USE OF FTT KILNS

13. Do you use FTT kilns? ☐ Yes ☐ No
14. If yes, since when? ----------
15. How many times a week do you smoke fish (during the peak season, the off-season)? ----------
16. How many times a week do you use the FTT to smoke fish during the week? ----------
17. Which kiln do you use the other times and for what reason(s) do you combine the kilns? (prioritize these reasons from the most determining to the least determining):
18. (a)---------- (b) ---------- (c) ----------…(d) ----------

DETERMINANTS FOR THE ADOPTION OF FTT KILNS

19. Assuming that FTT kilns or any improved kiln can increase your income thanks to better fish prices and access to more rewarding markets, which of the following factors do you think most influence your preference for these improved kilns compared to traditional ones, in descending order (from the most critical to the least determining)?

Id[b]	Factors[c]	Rank	Score (to be attributed a posteriori by the surveyor)[d]
1	The kilns' location (FTTs' closeness to your home)		
2	Security (protection against product thefts)		
3	The number of kilns available		
4	Kiln capacity (smoked fish quantity)		
5	Their cost		
6	Time needed to smoke the fish		
7	Collective use of the kilns		

Id[b]	Factors[c]	Rank	Score (to be attributed a posteriori by the surveyor)[d]
8	Preserving your health (less exposure to heat and smoke)		
9	Easy to use (not demanding in terms of physical efforts)		
10	Finished products quality and safety (especially lower PAH content in fish after smoking)		
11	The possibility of carrying out other activities while smoking the fish (carrying out other pursuits while the smoking takes place)		
12	The amount of fuel used per smoking session /given quantity of product		
13	Diversifying by-products and enhancing their value		
14	Other fuels can be used (e.g. butane gas, agricultural by-products such as corn and millet cobs, coconut husks or fibber)		
15	Does not pollute the environment		
16	Cost of the types of fuel used		
17	Availability of fuels used		
18	PAH content of fuels used		
19	Kilns usable regardless of weather conditions (rain, wind, etc.)		
20	Any other factor (please specify)		

Notes:

[a] Questionnaire to be administered individually to as many FTT and traditional fish smokers and fishmongers as possible (processors will be surveyed separately, even if grouped by SCOOP/SCOOPS).

[b] Although 20 factors are included in the list, each processor interviewed should prioritize only 10 among those deemed most important.

[c] To define these factors, use simple terms that are easily understood by women fish smokers and fishmongers.

[d] Score between 1 (last rank corresponding to the least determining factor) to 10 (first rank corresponding to the most determining factor).

Annex 9. Questionnaire 2 – Loans granted by financial institutions to SCOOP and SCOOPS

QUESTIONNAIRE 2 [a]
LOANS GRANTED BY FINANCIAL INSTITUTIONS TO SCOOP AND SCOOPS [b]

Surveyor's name: ----------Title: ---------- Date: -----/-----/----- Survey #: ----------
SCOOP or SCOOPS name: ---------- Location: ----------

1. As a SCOOP or SCOOPS, have you ever benefitted from a loan from a local financial institution? ☐ Yes ☐ No
2. If yes, please provide the information below:

Factors	Financial institution 1	Financial institution 2	Financial institution 3
Name			
Date loan 1 granted			
Amount requested			
Amount granted			
Interest rate			
Duration			
Grace period			
Guarantees required			
Activity(ies) financed			
Date loan 2 granted			
Amount requested			
Amount granted			
Interest rate			
Duration			
Grace period			
Guarantees required			
Activity(ies) financed			

3. Did you encounter difficulties to reimburse these loans? ☐ Yes ☐ No
4. If yes, which ones? ----------
5. Which of the following factors, in descending order (from the most influential to the least influential), do you think drive /motivate these financial institutions to give you loans? ☐ Your empowerment ☐ Your structuring/organization in a SCOOP or SCOOPS ☐ Your reputation/creditworthiness

   ☐ Other (please specify): ----------
6. Would you say that you could have obtained the same loans if you had not been a member of this SCOOP or SCOOPS?

   ☐ Yes ☐ No
7. Have you ever benefitted from an individual loan from a local financial institution? ☐ Yes ☐ No
8. If yes, please provide the information below:

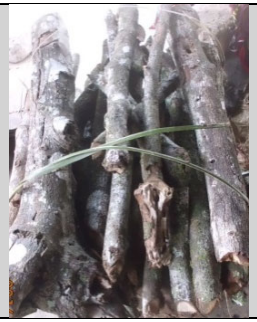
Factors	Financial institution 1	Financial institution 2	Financial institution 3
Name			
Date loan granted			
Amount requested			
Amount granted			
Interest rate			
Duration			
Grace period			
Guarantees required			
Activity(ies) financed			

Notes:

[a] Questionnaire to be administered to SCOOP/SCOOPS.

[b] In addition to this questionnaire, examine reports and other documents from the concerned SCOOP and SCOOPS.

Annex 10. Main types of fuel used for smoking fish and their characteristics

Fuel type	Photo	Usage	Characteristics		Recommendation in terms of toxicity Highly recommended To be used with caution To be forbidden
			Advantages	Disadvantages	
Rubber wood		Cooking of the fish[a]	Available and affordable	Toxic (especially the bark)	
Mangrove wood		Cooking of the fish[a]	Produces low PAHs	Its use is to be limited and controlled given the ecological and economic attributes of mangroves, especially for aquatic and fisheries resources (spawning and breeding grounds for many species)	
Cacao wood		Cooking of the fish[a]		Seasonal availability; risk of contaminating smoked fish because of pesticide residues	

Fuel type	Photo	Usage	Characteristics		Recommendation in terms of toxicity Highly recommended To be used with caution To be forbidden
			Advantages	Disadvantages	
Coffee tree wood[b]		Cooking of the fish[a]		Same as for cacao	
Red wood (thousand-feet)[b]		Cooking of the fish[a]	Produces very low PAHs; Results in quality products	Expensive and limited availability (in Braffedon in particular)	
Akpa wood (Tetrapleura tetraptera)[b]		Cooking of the fish[a]	Hardly studied	Little studied	
Coco husks[c]		Activate combustion	Available and inexpensive; No demonstrated toxicity	Incomplete combustion	

Fuel type	Photo	Usage	Characteristics		Recommendation in terms of toxicity ■ Highly recommended ■ To be used with caution ■ To be forbidden
			Advantages	Disadvantages	
Charcoal[d] (bags each containing 115 kg on average)		Cooking and drying of the fish[1]	Produces quality products		■
Siporex stones		Retain heat, and therefore reduce required amount of coal by about 50% (not used in traditional kilns)	Reusable several times		■
Butane gas		Experimentation phase at the Abobo-Doumé platform		Pale products (risk of some consumers rejecting them)	■
Vegetable sponge (inside the smoke filter on a FTT Banda kiln)		Filter acid tars that give the smoked fish a blackish colour and an unpleasant taste, signs of potential PAH contamination			■

a. Used in conjunction with charcoal, pieces of wood are normally used for incandescence; once the charcoal becomes incandescent, they must be removed from the fire.
b. Photos by Traoré (undated).
c. Photo by Anoh (2016).
d. According to Ndiaye, Sodoke Komivi and Diei-Ouadi (2015), it normally takes 0.4 kg of charcoal to smoke 1 kg of fish.

Sources: Bomfeh *et al*. (2016); Ndiaye, Sodoke Komivi and Diei-Ouadi (2015); Traoré (undated).