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Pre-scaling up of fish smoking technology in selected Oromia water bodies, Ethiopia

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Abstract
Fish smoking technology is advantageous preservation methods in area where fish production is surplus and needs to be stored for long period. This activity was conducted in selected Oromia Water bodies for four consecutive years from 2014-2017 with the objective of pre-scale up of fish smoking technology, enhance the skill and knowledge of Fishermen and creating better linkage with different stakeholder. For this study water, bodies were purposively selected based on fish production potential and from each water bodies Fishery cooperatives were selected based on convenience of the site to disseminate the technology, land ownership, market access, accessibility for all fishery cooperatives and interest of fishermen in collaboration with experts of the respective Zone and districts. After awareness creation about technology, Altona Oven was constructed at each selected water body. Personal observation, informant interviews and group discussion used as data collection methods. Some descriptive statistics used for quantitative data as well as explanation of ideas and feedback was analyzed using qualitative narration. At each site One Farmer Research Extension Group (FREG) member having from 12-30 fishermen and a total of five FREGs were established to popularize the technology. A total of 116 participants were exposed to awareness creation. Mini field day was organized in collaboration with stakeholders at each district and a total of 152 participants were involved in the exercise. The fishermen feedback indicated that fish smoking technology was highly preferred by the fishermen in the area due to its efficiency, effectiveness, ease to implement and ability to produce testy fish. Since the fish smoking technology have positive feedback from fishermen we recommend to Livestock and fishery offices at district and zonal level in collaboration with other stakeholder should work on the wider scaling up of this technology.

Keywords: Pre-scaling up, fish smoking, fishermen, Freg, Altona oven

1. Introduction
The Ethiopian economy is heavily dependent on the agricultural sector (Dawit *et al*. 2013a) [1]. The agricultural sector suffers from poor cultivation practices and frequent drought, but recent joint efforts by the Government of Ethiopia and donors have strengthened Ethiopia's agricultural resilience, contributing to a reduction in the number of Ethiopians threatened with starvation (EEP, 2014) [2]. Being the dominant sector, agriculture contributes about 46.3% of the total gross domestic product (GDP), 60% of exports, and 80% of total employment (EEP, 2015) [3]. The country depends on the inland waters for the supply of fish as a cheap source of animal protein. It can also indirectly contribute by providing revenue for purchasing food for deficient areas (Dawit *et al*., 2013a) [1]. The country has a number of lakes and rivers with substantial quantity of fish stocks. There are 10 major lakes with a total area of 7,400 km2 and a combined length of 7,185 km of major rivers (Brook, 2012) [4]. Many artificial water bodies have also been stocked with fish for fishery (Brook, 2012) [4]. Fisheries production in Ethiopia is under-exploited while current demand exceeds supply by about four-fold. One of the big and immediate challenges of the country is addressing the problems of food security and poverty. Artisanal freshwater fishery is one of the most important economic activities in Ethiopia (FAO, 2012) [5]. Improvements in fishery sector would contribute to poverty alleviation and environmental sustainability in Ethiopia (Global Fish Alliance, 2010) [6]. Still some nations have limited access and supply to fish and fishery products with little awareness in new technology. Fish is a highly nutritious food(70-84% water, 15-24% protein, 0.1-22% fat and 1-2% minerals) for providing high quality protein and income to many people in the developing world (Ojutiku *et al.*, 2009) [7]. Fish is an affordable and accessible source of protein for approximately 400 million Africans (Ayilu *et al*., 2016) [8].

However, fish is one of the most perishable of all the foods because it is a suitable medium for growth of microorganisms after death (Ojutiku *et al.*, 2009) [7]. Given the perishable nature of fish, a satisfactory method for prolonging the shelf-life of fish products that ensures quality and a continuity of supply with a minimum of waste has been the ultimate goal. Fish preservation is the method of extending the shelf life of fish and other fishery products by applying the principles of chemistry, engineering and other branches of science in order to improve the quality of the products. Preservation prolongs shelf life and increases protein availability to people throughout the year. Post-harvest, handling, processing and transportation of fish require particular care in order to ensure proper quality and safety. Retaining the nutritional value of the fish, preserving the benefits of its rich composition and avoiding costly and debilitating effect of fish-borne diseases are vital. Many different techniques have been used to preserve fish quality and to prolong shelf life. Techniques are designed to inhibit or reduce the metabolic changes that lead to fish spoilage by controlling specific parameters of the fish and/ or its environment. Fish invariably become putrid within a few hours of capture unless they are preserved or processed in some way to reduce this microbial and autolytic activity. If fish is not sold fresh, preservation methods should be applied in order to extend shelf life. Salting, smoking and drying have all continued as preservation techniques virtually unaltered from prehistory to the present day. Smoking is a process of treating fish by exposing it to smoke from smoldering wood or plant materials. This process is usually characterized by an integrated combination of salting, drying, heating and smoking steps in a smoking chamber. It is based on the concerted action of enzymes and heat which bring about protein and lipid changes in the salted raw material, partial dehydration, further decrease in water activity by the added salt and impregnation with smoke components. Smoking is a method of preservation affected by the deposition of naturally produced chemicals resulting from the pyrolysis of wood in combination with drying and after salting (Abera, 2010) [9]. The reasons for smoking fish are varied but, the process has proved relevant to: prolonging shelf life, enhancing flavor, reducing waste at times of bumper catches, storing for the lean season, increasing protein availability to people throughout the year as well as making fish easier to pack, transport and market. Abera *et al*., 2009 [10] note that 40 kg the fire wood (fuel) is required to smoke 100 kg of fish using Altoona oven From the result of evaluation and verification fish smoking technology was done from 2009 to 2013 year in different major sites of Oromia water bodies. Fish smoking technology was verified at Gedab Asasa, Dole, Kotola, Korkeadi, Beseka and Koka reservoirs. The responses of fishermen indicate that the technology is best option to decrease postharvest lose when the production is high and increases their income. All fishermen and other stakeholder who participate on demonstration through whole process agreed with the ideas of wider dissemination of the technology at selected Oromia water bodies. Based on the result of first demonstration, pre-scaling up in fish smoking technology was initiated to popularize at fish potential Lakes, Rivers and Reservoirs.

Objective

- To pre-scale up of Fish smoking technology in the study area.
- To enhance strengthen better linkage with fishermen, Researcher and extension agent.

2. Methodology

2.1 Description of the study area

The research was conducted in East Showa Zone at Lake Zeway, West Hararghe Zone at Chercher Lake, Horo Guduru Wellega Zone at Finchawa Reservoirs, Guji Zone at Genale Rivers and Jima Zone at Gelgal-gibe Reservoir from 2014-2017.

2.1.1 Lake Zeway

Lake Zeway is one of the freshwater Rift Valley lakes of Ethiopia. It is located about 160 kilometers South of Addis Ababa. The districts holding the lake's shoreline are Adami Tullu Jido Kombolcha, Dugda and Zeway Dugda. On the average, the lake is located at an elevation of 1650 meter above sea level and the lake is shallow and has an open water area of 434 km2 and shoreline length of 137 km, a maximum depth of 8.9 m and an average depth of 2.5 m (Von Damm and Edmond, 1984) [11]. The maximum length and width of the lake is 32 km and 20 km, respectively (LFDP, 1997) [12]. There are two main feeder rivers to Lake Ziway; namely, Meki originating from Gurage Mountains in the north-west and Ketar from the Arsi Mountains in the east; and it has one out flow in the south through Bulbula River, draining into Lake Abijata. Lake Ziway contains five main Islands: Tullu Guddo (4.8 km2), Tsedecha (2.1 km2), Debresina (0.3 km2), Funduro (0.4 km2) and Gelila (0.2 km2). Debresina and Gelila have only a few inhabitants, the other three are inhabited by several hundreds of people (Yared, 2003) [13]. Technologies such as fish smoking technology was demonstrated at Tullu Gudo under Lake Zeway condition.

2.1.2 Chercher Lake

Chercher Lake is located in West Hararghe Zone of Oromia Regional State. The Lake has an area of 800 hectares. The lake is found in eastern part of the country in Hararghe Zone, and 362 km far from the capital city, Addis Ababa. The lake is located at an elevation of 1,650 meter above sea level and have 1.5m mean depth.

2.1.3 Fincha Reservoir

Fincha reservoir is one of the reservoirs in Ethiopia used for hydroelectric power generation. The reservoir is found in the Western part of the country in Horro Guduru Wollega Zone, 286 km far from the capital city, Addis Ababa. The reservoir, situated at 9°33'N/37°24'E is surrounded by four administrative Districts, namely Jimma Genet in South-West, Horro in West, Guduru in East and Southeast and Abay Choman in North and Northeast. It has an area of about 350 km2 at an elevation 2000 meter above sea level. The reservoir has a mean depth of 7 m, maximum depth of 17 m with the temperature of 23^0C, dis-solved oxygen 9.4 mg/l, pH 6.4, conductivity 78.3 µs/cm and secchi Disk of 130 cm. The reservoir has an out flow called river Finchawa which generates the Electric power and also used for irrigation (Fincha sugar Factory) then join with river Abay.

2.1.4 Genale River

The south western parts of eastern high land of Ethiopia are mainly drained by Genale and Dawa rivers. According to materials published by the Ethiopian Central Statistical Agency, the Ganale has a total length of 858 km (533 m), of which 480 km (300 mi) are inside that country. Genale River

which forms the border between Bale and Borena Zones, and lies to the east of the Borena Zonal capital, Negele. The Genale River forms a major part of the Genale–Dawa–Weyb basin, the third-largest in the country in terms of land area, draining 168,000 km² of southern Ethiopia. The river rises in the Sidamo highlands, flowing south-east to Dolo on the Somalia border. The major tributaries are the Welmel, Dumal and Web, all originating in the Bale Mountains. The lower section of the Genale river valley is described under Bogol Manyo–Dolo

2.1.5 Gilgel-gibe Reservoir

Gilgel-gibe reservoir is located 250 km Southwest of Addis Ababa and 75 km Northeast of Jimma City. It covers an area of 51 km2 at an altitude of 1670 meters above sea level. The four districts bordering the reservoir are Omonada, Sekoru, Tiroafeta and Kersa with 6, 4, 5 and 2 Kebeles (smallest administrative unit) within ten kilometers from the shore line of the dam, respectively.

2.2 Site and fishermen cooperative selection

For this study, water bodies were selected purposively for pre-scaling up of Fish smoking technology package based on fish production potential by Batu Fish and Other Aquatic Life Research Center technical staff in collaboration with experts of the respective Zone and districts. At the beginning of the implementation awareness creation was made to introduce the objective of the activity and expected output. Five water bodies were selected purposively based on convenience of the site to disseminate the technology. From selected water bodies one fishery cooperative was selected purposefully based on land owned, market outlet, accessibility for all fishery cooperative on the water body and interest of fishermen. One Farmer Research Extension Group (FREG) was established at each site. Participatory training method was given for member of FREG during implementation of for sharing knowledge's, skills and experience on fish smoking technology.

2.3 Materials

A material needed to conduct this pre-scaling up activity was basic research raw materials to produce Altona Oven. In addition to Altona oven, the other inputs required to prepare smoked fish are salt, plastic bucket, acacia woods/fuel, trays, round iron (6 mm), knife, processing table, fresh and uniform fish, fire, timber and nails.

2.4 Altona oven construction

Different procedures of smoking have been developed in various parts of the world in accordance with the properties of the locally available raw materials, the prevailing weather conditions, and the general level of technology. For under taking fish smoking technology, Altona Oven is one of the main components to implement the activity. The oven originated in the former Federal Republic of Germany and was introduced in the 1970s by the German Volunteer Service to fish smokers at Biriwa, a fishing community in the Central Region of Ghana. After arranging all necessary material Altona Oven was constructed in participatory approach at each site with FREG members and other stakeholder. The oven consists of two compartments: combustion/ firing chamber which can be constructed from burnt bricks or mud bricks or cement bricks (Figure 1), with a stokehole at the bottom of the front wall and the smoking unit, which is fixed by concrete on top of the combustion chamber, is enclosed and has a chimney. The standard dimension of oven is (Figure 2) 170 cm (width) x 150 cm (length) x 202.5 cm (height). The dimension of adopted oven is 100 cm (width), 128 cm (length) and 175 cm (height). The fish are skewered through the eyes with metal rods and hung in the enclosed chamber for smoking.

Fig 1: Front view of adopted simple Altoona oven

Before taking smoking the fish were gutted and washed using clean water and salting. Smoking requires a certain amount of drying prior to smoking to help produce the pellicle. Racking or hanging of fish aids in the formation of the pellicle, reduces drying time during smoking and provides maximum exposure of the fish to the smoke. So it was hang to drip either on racks or in the kiln.

Fig 2: Fish gutted, brined and tendered ready for smoking using Altoona oven

2.5 Methods and technology transfer approaches

FREGs were used for this technology pre-scaling up at selected site. At each site one FREG which contain 15 to 30 Fishermen was established and all activities were undertaken with these FREG members, Development Agents and experts. Practical training was given twice at each site related to fish smoking technology. After awareness creation about technology Altona Oven construction were done at each site for consecutive four years at selected water bodies and fishery cooperative by Researcher, technical assistance from the center, FREGs members, Development Agent, Zone and Districts level fishery experts.

2.6 Method of data collection and analysis

Primary data on water bodies and fishermen cooperative selected, FREGs established, fishermen's, Development Agents and experts trained, Altona Oven constructed, feedback and attitudes of the fishermen towards the technology were collected from the site through personal observation, informant interviews and group discussion. Secondary data also collected from respected Woreda livestock office, literature and research reports. Quantitative data analyzed using descriptive Statistics like mean and percentage and presented in table. Simple calculation was done to determine net benefit using variable cost and income generated from selling smoked fish per smoking cycle. On the other hand, data that cannot be captured through quantitative analysis was analyzed qualitatively using explanation of ideas and opinion.

3. Results and Discussions

3.1 Training for fishermen and other stakeholders

The project key stakeholder fishermen's, Development Agent and experts capacity built through two round theoretical and practical trained conducted at respected site. Training given mainly focused on Fish smoking technology. Besides training, FREG member, DAs and experts participated in regular fish smoking technology establishment such as material preparation, Oven construction, fish selection, gutting, brining/salting, racking/hanging, drying and smoking at each pre-scaling up sites for four consecutive years. As indicated in Table 1, a total of 101fishermen, 8 Development Agents and 7 Fishery Experts were participating in training program. Extension agent and participant fishermen disseminate information shared from training to non-participant fishermen.

Table 1: Training participants on fish smoking technology

Year	Site	Fishermen		Development Agent		Experts	
		Male	Female	Male	Female	Male	Female
2014	Chercher lake	12	0	1	0	2	0
	Zeway lake	27	0	3	0	2	0
2015	Fincha Reservoirs	15	0	1	0	0	0
2016	Genal Revers	13	1	1	0	0	0
2017	Gilgal-gibe Reservoirs	33	0	2	0	3	0
Total		100	1	8	0	7	0

***Source*:** Own data results, 2014-2017.

3.2 Mini field day

Mini field day was jointly organized in collaboration with Zone and Districts level Livestock and Fishery offices and participants Fishermen at Lake Zeway, Chercher Lake, Genale River, Gilgle-gibe and Fincha reservoirs to create opportunities for stakeholders to see and learn from the demonstration promotions and evaluation the performance of technology and get fishermen feedback for better improvement (Table 2). Over a four years project implementation period between 2014-2017 years a total of 153 participants have attended the program (Table 2). At each site on the objective fish smoking technology brief explanation was given for participants. Stakeholder from FREGs and non FREG member participate and evaluate the technology. On the field work Fishermen, Administrators, Researcher, Experts, Development Agents and other stakeholders were invited to give feedback. All participants gave positive response with the technology at each site.

Table 2: Participants of mini field day in four years in selected water bodies.

Year	Site	Total participant	Fishermen	Das	Experts	Local farmers	Researcher
2014	Chercher lake	19	12	1	2	2	2
	Zeway lake	39	27	3	2	5	2
2015	Fincha Reservoir	34	15	1	-	16	2
2016	Genal River	18	13	1	-	2	2
2017	Gilgel-gibe reservoir	43	30	2	3	6	2
Total		153	97	8	7	31	10

***Source*:** Own Data results, 2014-2017

3.3 Economic advantage of the technology

The Altona Oven is a fixed asset which can be used for 10 years after once established. The product is layered with salt at 10% of the weight of the fish to be salted and in average a total of five fish is measured 1kg in weight. The technology was handling/ was able to handle/handled 120 fish population (24kg) in one smoking cycle. As indicated in Table 3, the total cost of the technology per smoking cycle was 387 Ethiopian birr. Average selling price of the smoked fish at local market was 10Ethiopian Birr. From this price fishermen gained 6.77 Ethiopian birr per fish and generated a total of 813Ethiopian birr per smoking cycle.

Table 3: Farmers economic gained in per smoking cycle

Items	Cost
Fire wood/Fuel	35 birr
Salt	12 birr
Fish	240birr
Labor cost	100 birr
Total cost	387birr
Income gained per smoking cycle	1,200birr
Net benefit per smoking cycle	813birr

3.4 Fishermen feedback

As depicted in Table 4, among the fishermen interviewed at Finchewa Reservoir 93.33%, 86.66%, 80% and 100% indicated that Fish smoking technology is good because it is cost effective, produces testy fish, saves time and reduces/minimizes post harvest losses. In general, the result of assessment feedback revealed that smoking technology was highly preferred by fishermen in the study area because it is cheap since it uses locally available materials and easy to apply, produces dry fish with good test, time effective (takes only three hours), reduces post-harvest loss, profitable and provides opportunity for improving women participation in fishing activities. After pre-scaling up, the wider scaling up/out activities will be owned and huddled by Oromia Livestock and Fishery Office in collaboration with different key actors in the area with close supervision by Batu Fish and Other Aquatic Life Research center. Furthermore, this result was presented to link the relevant stakeholders (BFAALRC, Fishermen, Oromia Livestock and Fishery Office) for sustainability of the technology.

Table 4: Fishermen feedback on the technology at the selected water bodies

Parameter	Fincha Reservoirs(N=15)			Genal River (N=14)			Gilgal-gibe Reservoirs (N=33)		
	Item	Freq.	%	Item	Freq.	%	Item	Freq.	%
Low cost	Yes	14	93.33	Yes	13	92.86	Yes	28	84.85
	No	1	6.67	No	1	7.14	No	5	15.5
Good test	Yes	13	86.66	Yes	13	92.86	Yes	29	87.88
	No	2	13.34	No	1	7.14	No	4	12.12
Time effective	Yes	12	80	Yes	10	71.43	Yes	25	75.76
	No	3	20	No	4	28.57	No	8	24.24
Reduce post- harvest loss	Yes	15	100	Yes	14	100	Yes	32	96.97
	No	-	-	No	-	-	No	1	3.03

Source: Own data results, 2014-2017Source: Own data results, 2014-2017.

4. Conclusions and recommendations

The result of assessment feedback revealed that smoking technology was highly preferred by fishermen in the study area due to it need low cost, good test, time effective, reduce post-harvest loss, income change, and produce positive feature for improving women participation in fishing activities. Generally, since the fish smoking technology have positive feedback from fishermen and economic feasible in the study area, we recommend to Livestock and fishery offices at Districts and Zonal level in collaboration with other stakeholder should work on the wider scaling up of this technology. But, as Fishing activity is very sensitive to environment the current situation of the country as well as the study area should be related to fish production, fishermen status before scaling out of the technology.

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