



# Upscaling improved fish smoking kilns: A management perspective for nature-based solutions in Western Africa?



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## ABSTRACT

**Forests remain a crucial domestic energy source for households across West Africa, driving the excessive use of biomass in rural and peri-urban areas. Deforestation from excessive biomass use continues to threaten and alter the supply of biomass available to households, negatively impacting climate, biodiversity, and health, especially for vulnerable women and children. Different cooking solutions have been promoted across the region for their fuel efficiency and emissions performance, including improved fish-smoking kilns (IFKs), which have evolved significantly in recent years, albeit with mixed results. Through literature review, this paper highlights the characteristics, issues, and benefits of IFKs used widely in the region to add knowledge to understanding why such technologies fail to scale beyond experimentation and provide an insight into opportunities and trade-offs of increasing their adoption and achieving impact at scale. Our findings show that IFKs are beginning to generate attractive market opportunities for local communities. However, they will not yield considerable ecological, environmental, and economic benefits without scaled-up finance, enabling policies, regulatory conditions, and participatory governance. This will directly hinder the adoption and spread of alternative clean cooking systems and limit financing for local enterprises. We propose that countries strengthen knowledge co-production systems, increase policy and community learning at scale, and implement innovative approaches and initiatives that enhance meaningful local involvement and community agency to remove these barriers. Our findings have implications for natural resources management, environmental sustainability, local enterprise development, and the mobilization of climate finance.**

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## INTRODUCTION

Nearly 80% of the people in Sub-Saharan Africa depend on traditional biomass, such as fuelwood, animal dung, crop residue and charcoal, for cooking (Barnes and Floor, 1996; UNDP, 2000; Woodwell; 2002; world Bank, 2011),

with far-reaching negative socio-economic and environmental impacts, particularly for the women and children who are heavily involved in the collection, sale, and use of fuelwood (Barnes et al., 2012). Biomass extraction and use as energy is the second-largest contributor of greenhouse gas (GHG) emissions after the energy sector, contributing about 20% of GHGs (IPCC, 2007). The impacts of these transitions on Africa's climate

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are extensively discussed by Munji et al. (2013) and IPCC (2007), primarily because the population relies on the resource as a source of livelihood (FAO, 1994; Feka, 2007; Belhabib et al., 2018).

For instance, the extraction of biomass for fish smoking in communities in the coastal areas of many West African countries is quite pervasive because fish is a significant source of animal protein and livelihood (Béné et al., 2007; Feka, 2007), as well as work and employment (Belhabib et al., 2018). Many fish harvested in these areas is smoked (FAO, 1994) because local communities believe that smoking reduces post-harvest losses and increases shelf life. Furthermore, it adds value to fish in the form of flavour, allows for storage over an extended period, and support trade in distant places with the right market opportunities. Fish smoking is also common because of the lack of access to good roads in rural and peri-urban areas, poor access to and high cost of electricity, and lack of access to more advanced and institutionalized preservation methods. The implication is more people enjoy the resource's economic and social benefits because there is broader access to wood for smoking (Feka, 2007; Beran, 2018).

In this paper, what we considered as fish-smoking is the exposure of fish to smouldering wood materials to reduce its moisture content. This process utilizes enormous quantities of fuelwood (Feka and Ajonina, 2011; Darko et al., 2015), especially mangrove wood that is preferred in place of forest wood, coconut husks, and charcoal because it is cheap, readily available, and high calorific value (Feka, 2005; Feka et al., 2009; Cissoko et al., 2020). Mangrove wood is also believed to add good flavour and a golden-brown colour to smoked fish, improving its marketability (FAO, 1994; Beran, 2018). These reasons are believed to be driving the widespread loss of mangrove forests across coastal communities of countries in the region. This implies that local perceptions and the availability of suitable biomass material are primary determinants of the type of fuelwood used in a given locality (Darko et al., 2015). Moreover, the high demand for mangrove wood partly explains the correlation between fish smoking and ecosystem degradation and depletion (UNEP-WCMC, 2007; Feka and Ajonina, 2011; Feka and Morrison, 2017; Cissoko et al., 2020).

Consequently, Feka et al. (2009) and Cissoko et al. (2020) argue that inefficient, traditional cooking/fish-smoking systems drive excessive fuelwood consumption amongst rural and peri-urban community dwellers. This paper considers full or partially open base systems used for fish smoking as 'traditional'. Traditional kilns in use across West Africa range from large expanded rectangular kilns (*banda*), simple forms of an open fire (tripod), to mud or flat-barrel metal sheets on which fish are placed on racks/grills above a fire (Figure 1). Rectangular kilns have a fixed surface compared to the traditional platforms (*bandas*) (Figure 1a)–found in most of the Gambia,

Senegal, Nigeria, Sierra Leone and Cameroon. *Bandas* have a large smoking surface used for bonga (*Ethmalosa fimbriata*), sardinella, and other small pelagic species. They can be made of rectangular or cylindrical clay or metal structures and are primarily used in Ghana and Liberia (Figure 1b). Generally, traditional kilns are adapted to business and cultural needs and other requirements such as fish size and species, as seen in Cameroon, where sizeable open *bandas* (Figure 1a) are used to preserve small-sized bonga to limit post-harvest spoilage. Despite the adaptations over the years, traditional systems still drive large-scale ecosystem degradation, limit wider access to fuelwood (Anderson and Fishwick, 1984; Woodwell, 2002), and increase the vulnerability of women to indoor and outdoor particulate pollution, lung diseases, and stillbirths (FAO, 1995; Barnes et al., 2012; FAO, 2015). This is due mainly to their inability to control heat, smoke and fuel inefficiency (FAO, 1995, 2015; Barnes et al., 2012).

These drawbacks have led to the emergence and evolution of improved fish-smoking technologies in the last 30 years (FAO, 1995; 2015; Olorok et al., 2007). Examples of IFK models include the Improved Chorkor, Modified Ivory Coast kiln, Altona/Watanabe Smoking Kiln, Magbon Alade Kiln, Kainji Gas Smoking Kiln, Morrison Oven, Modern Landmark Smoker Oven (MLSO), FAO-Thiaroye Technique, the improved *banda*, and the Ahotor Oven (Figure 2). These models (hereafter known as IFKs) have comparative advantages and disadvantages (Olorok et al., 2007; Salau et al., 2014; FAO, 2015). In general, IFKs are credited for their potential to overcome the inefficiencies of traditional fish-smoking ovens effectively, and hence, contribute to avoiding deforestation and biodiversity loss, reducing environmental pollution and meeting users' socio-economic needs to a large extent (Sharma and Dasappa, 2017; Sahan et al., 2018; Cissoko et al., 2020).

However, IFKs have scarcely proliferated beyond experimentation (pilots) due to poor planning on the part of developers. They are often abandoned after the pilot phase or hijacked by elites in a community, leading to poor spread and adoption in the region (FAO, 1995; Personal Observation by Authors in 2019). This is not to say that the technologies have not been significantly deployed in recent years (FAO, 1995; FAO, 2015) or local users are not aware of their comparative advantages and show an increased urge for uptake (Feka, 2005; Massaquoi, 2017; CERATH, 2019; FAO, 2015). Our observation is that whereas user recognition is critical to adoption at scale (Campbell and Ward, 2004), the question of how to make these technologies readily available and usable strategically at the local level remains unanswered. Therefore, this review identifies the key barriers to expanding the adoption, replication, and upscaling of IFKs in West Africa and considers critical triggers and potential outcomes. Overall, the paper (i) provides an overview of the factors limiting the scaling up of IFKs in the region and

(a) Traditional rectangular kilns with fixed surface platforms (bandas)—found in the Gambia, Senegal, Nigeria, Sierra Leone and Cameroon.



(b) Traditional fish smoking kilns made of cylindrical clay or metal structures In Ghana and Liberia.



Figure 1. Examples of traditional fish-smoking Kilns (a-d).



(a) Kiln Improved traditional banda fish smoking



Figure 2. Examples of Improved fish-smoking Kilns (a-c).

(b) Modern Landmark Smoker Oven (MLSO)



(c) Modern Landmark Smoker Oven (MLSO)

**Figure 2.** Contd.

(ii) proposes guidelines for removing current barriers. The work builds on existing literature, field observations, and interviews from the Shama District of Ghana, the Coastal Landscapes of Sierra Leone, and Mouanko, Cameroon.

### **Factors limiting the scaling-up of improved fish-smoking kilns**

IFKs could contribute to avoiding deforestation and enhancing environmental conditions for women and children in rural and peri-urban communities (Inayat, 2011; Rehfuess et al., 2014) because of their fuel efficiency and emissions performance. These benefits have a substantial bearing on household income levels and food security (World Bank, 2011) and show a more significant potential for avoiding deforestation and enhancing environmental performance (Inayat, 2011; Rehfuess et al., 2014). Achieving these outcomes (or successfully scaling-up IFKs) would require addressing the following barriers gleaned from the literature and our work across the region over the last ten years. The obstacles include (i) the cost of new technologies, (ii) inadequate consideration of the local context, and (iii) market failures and lack of investment incentives.

### **The cost of new technologies**

The region's coastline from Mauritania to Angola is littered with rural fishing villages and small peri-urban towns with

little or no access roads (Feka, 2007). The population sizes also fluctuate considerably with the fishing seasons as artisanal fishers migrate (Belhabib, 2017). Hence, seasonal fish migration patterns and the political stability of countries influence the movements of fishers in the region, which limits policy development and the probable establishment of improved fish-smoking kiln programs. Similarly, migrant fishers often view IFK initiatives as a source of harassment (Feka, 2005), especially with scant economic opportunities revolving around fisheries, petty trade, and subsistence agriculture (FAO, 2005; Feka, 2007). This results in low incomes and a lack of capital (FAO, 2015), which is exacerbated by limited access to financial credit and other resources needed to finance the development of improved cooking systems, or afford similar technologies more broadly (Rehfuess et al., 2014).

The implication is that coastal communities' income levels usually contrast with the high cost of improved fishing technologies. The price of such technologies, thus, presents a significant barrier to adoption because they are typically about four times as expensive as the traditional systems (Salau et al., 2014; Hailu et al., 2020). So, despite its preference for saving money from health and fuelwood efficiency gains, the initial cash outlay required to acquire IFKs may prevent more impoverished people from affording them. This means that the socio-economic context of the rural setting is essential to develop and sustain IFKs successfully. A recent survey by the authors in coastal Sierra Leone and Ghana revealed that people in these areas perceive the IFK as an opportunity for proper business development, provided it is not expensive

(Massaquoi, 2017; CERATH, 2019).

### **Inadequate consideration of the socio-economic context, intervention design and poor planning**

The review also finds that most ongoing and past initiatives focus on introducing new technologies without a prior understanding of the socio-economic context.

Consequently, these initiatives are in communities where poverty is widespread, with scarce capital, which often is a determinant for acquiring and maintaining new technologies. These preemptive approaches are often driven by agendas set by development agencies rather than for the interests of fisherfolk in needy communities (Salagrama and King, ND; Roy et al., 2018). For example, when introducing the fish-smoking systems, development agencies give more attention to the control of indoor air pollution, fish hygiene, and health, than to market factors and conditions that incentivize scaling up and sustainability (Bruce et al., 2000; WHO, 2006; Barnes et al., 2012; Alakali et al., 2016). Likewise, other initiatives fail to consider historical and context-specific factors such as fish species, size, socio-cultural issues, and affordability, which characterize some rural and peri-urban communities across West and Central Africa (Nwa et al., 2021).

A technology's capacity (quantity of fish smoked in one smoking session and the species of fish being smoked) and the availability of storage facilities and materials for constructing the IFK influence the local uptake and distribution of the technology. However, there are aspects that could minimize some of these technological needs if adequately integrated into the initiative. For instance, training in fish processing, storage, and adequate linkages to markets (rural road networks) could help offset the need for storage infrastructure (Salagrama and King, ND; Rehfuess et al., 2014). Andah (2000) emphasizes the value of demonstration and sustained capacity-building activities, noting that IFK initiatives may fail if they are locally inappropriate, increasing difficulties in adapting the technology to local conditions.

Furthermore, communities are often attracted to a new systems if they can perceive its need and added value and understand the advantages. Hence it is proper to identify the local conditions and consult the potential users (fish smokers) before initiating such initiatives. For instance, when fuelwood is scarce, community members are more likely to appreciate the benefits they would obtain from the increased efficiency of the new technology, as seen in the case of Mali (a Sahelian country) than in Southern Cameroon (a forested Congo Basin Country). This scenario typifies that rural communities in the Sahel countries of Africa are more willing to adopt improved cookstoves because of the scarcity of wood (Anderson and Fishwick, 1984; Vigolo et al., 2018).

Women constitute the highest number of fish smokers

and often prefer smoking in IFKs because of fuel efficiency and prevailing environmental factors. However, these factors may be specific to a particular geographical region or climate in which they live (Vigolo et al., 2018). Cultural factors (traditions specific to tribes, women's beliefs, and age and education) also matter because they inform individual preferences. For instance, some communities in West Africa believe that smoking fish with mangrove wood is likely to give it a golden-brown colour, making it very attractive for the market (Feka, 2005).

Similarly, most rural dwellers in the region enjoy communal life in aspects related to public services. However, others prefer to keep household food processing and money management private, making it harder to determine their needs or count their stories regarding the use of IFK. Also, some of the existing models in West Africa are designed with sophisticated technical features, which makes their use difficult (Rehfuess et al., 2014; Hailu et al., 2020). These reasons indicate that users' ease of use, size, and perceived safety of the process, should be central in the design of the improved smoking system.

Social capital (diffusion of information) also impacts the adoption of fuel-efficient stoves. Effective information dissemination is essential to adopting new cooking technologies as it ensures a proper understanding of the community's social structure, influencing the degree to which locally generated information is shared and understood. For instance, local communities in the Douala Edea Wildlife Reserve in Cameroon perceived the introduction of IFKs as a new tax regime by the government primarily because of poor awareness of the benefits (Feka, 2005). A recent survey in the Shama District of Ghana also revealed that community members highly underutilized the Modern Landmark Smoker Oven (MLS0) because this new technology was very different from what they currently use (CERATH, 2019). Accordingly, raising awareness and education levels is essential for adoption because it builds knowledge about the technology, which results in more uptake and scaling up. At the same time, ensuring awareness-raising in demonstration projects and training activities increases community acceptability by making the technology appropriate to the local context. This observation implies that designing an IFK intervention requires close and sustained consultation with communities to ensure that the issues to be addressed reflect the priorities of the fisherfolk and not those of the funders.

Weak institutional and legal frameworks in many of the countries in this region also mean that most IFK project proponents come to advance their ideologies rather than solve context-specific issues. During the project development and implementation process, proponents seldom consult communities, government agencies or their legal frameworks to understand and map their projects to community needs (Salagrama and King, ND). Project developers commonly use the piloting approach to

introduce IFK in some countries in the region.

However, a recent field survey by the authors in Cameroon, Ghana, and Sierra Leone reveals that these pilots often end up being abandoned or hijacked by local elites and never achieving the anticipated scaling-up effect (Feka, 2005; CERATH, 2019).

Another issue is the brief duration of IFK initiatives, which means that there is often no post-project follow-up and monitoring. Most initiatives focus on fish smoking and infrastructure development (IFK deployment) with little or no consideration for the marketing of products (Campbell and Ward, 2004). The IFK development deficiencies mentioned above, coupled with the lack of long-term commitment from donor agencies, imply that most of these initiatives are often short-lived, with little or no time for scaling up.

As noted before, monitoring and extension services in IFK interventions are often lacking, although the lessons from such interventions are essential to learning and sustainability.

For instance, bad news or misperceptions about the performance or objectives of a new IFK technology can significantly undermine adoption processes in adjacent communities. Information about modern technology is more intensively diffused in villages, which are likely to have substantial levels of social capital (Vigolo et al., 2018). If the initial success in IFK usage at the village level is relatively low, it negatively influences individual decisions to use the IFK effectively. Hence, it's important to note that building social capital at the grassroots level plays a critical role in facilitating social learning at the process level.

### **Market failures on premium prices and lack of investment incentives**

The price of smoked fish is another significant factor that could incentivize or disincentivize adoption by community entrepreneurs in the region. Nonetheless, price volatility is a challenge facing the commercialization of smoked fish in the region because of weak institutional and fiscal frameworks. Most IFK initiatives seldom consider markets willing to pay for IFK fish, although some studies (FAO, 2015) highlight that products from IFK might fetch much higher prices when compared with those from traditional fish-smoking systems. Consequently, the low costs of smoked fish from traditional smoking systems that abound in the markets might undermine the income gains of enthusiastic community members who want to invest in IFK.

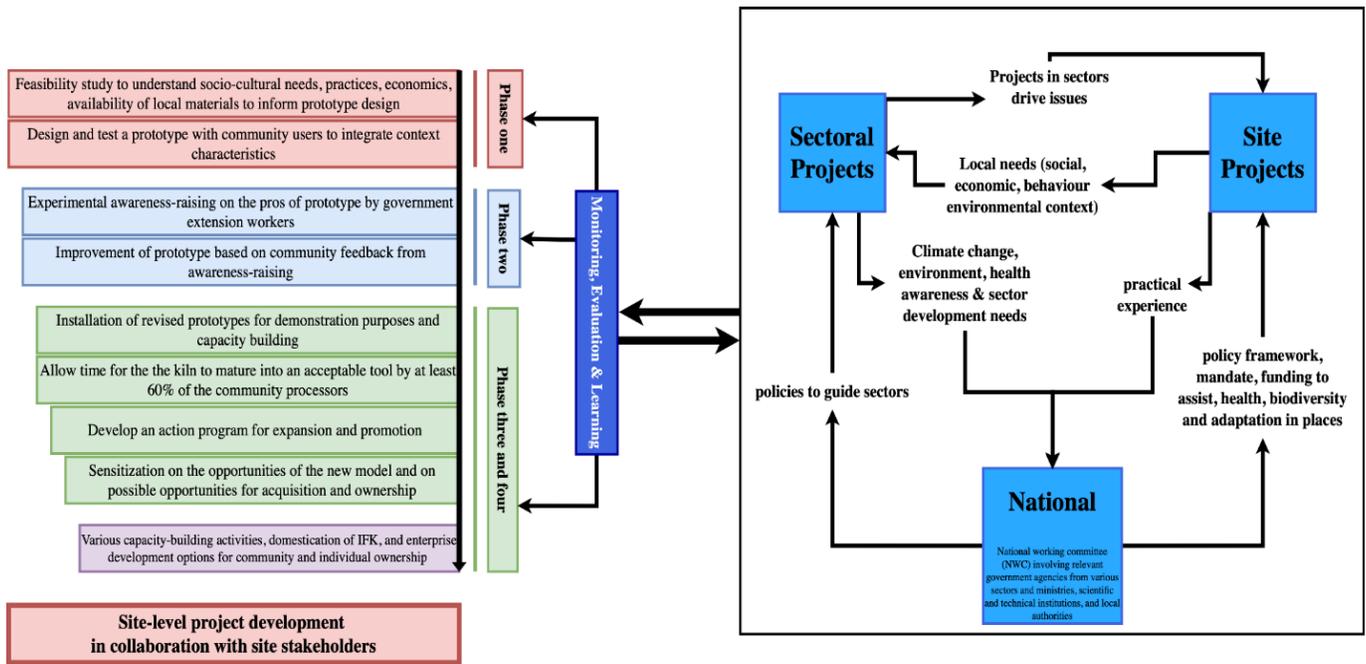
A survey in the Shama District of Ghana revealed that fish smokers only used IFK (*Ahotor*) for fish that attracted premium prices, such as with demand for special ceremonies such as weddings or funerals or export outside of Ghana (CERATH, 2019). Typically (in the

existing market), most community members use the traditional system because they are more conversant with it and can smoke larger quantities of fish (Ibid). In Elmina, Ghana, the Central and Western Fishmongers Improvement Association (CEWEFIA), a non-governmental organization (NGO), stated that community members had to pay a maintenance fee before using their training centre. Despite the meagre maintenance fee (2 Cedis ~ \$0.36/smoking session- 2019 value), CEWEFIA noted that the training centre was underutilized because fish processors only wanted to use it to smoke fish using the IFK for special ceremonies such as weddings or funerals or export.

### **Looking ahead: Scaling up fish-smoking kilns in the region**

In this review, we have highlighted factors limiting the proliferation of IFKs across the region and the benefits inherent in these technologies. IFKs are touted as having significant potential for meeting critical sustainable development goals, including promoting ecosystem conservation, food security, employment, poverty alleviation and human health (Andah, 2000; Barnes et al., 2012; Alakali et al., 2016). Some countries already realize these benefits (Climate Partners, 2022 a,b). However, such benefits could be enhanced with the right incentives and implementation approaches focused on driving sustained access from the ground up. Failure to scale-up IFKs in this manner may exacerbate current levels of ecosystem degradation (cause leakages), enhance environmental pollution, and cause the region to lose out on some of the benefits that nature-based solutions (carbon credits) offer (Climate Partners, 2022 a,b).

An example from the Douala Edea Wildlife Reserve, Cameroon, shows that failure to adopt and scale up efficient fish smoking systems could cause the loss of 65 hectares of mangrove forests annually (Feka et al., 2009). Also notable is the perception that a transition of 154 million households from biomass to improved natural draft stoves could eliminate an estimated 70–80 MT CO<sub>2</sub>e and generate needed financing from carbon credit sales per year (Sharma and Dasappa, 2017). These estimates demonstrate the economic potential of IFKs, as about 4.04% of smoked fish exports from the region are lost annually because of poor quality and standards resulting from the inadequate post-harvest fish smoking in the artisanal sector (Campbell and Ward, 2004). The need to address the barriers described in this review cannot be urgent as smoked fish exports from West African countries to the United Kingdom ranged between \$7.54 million and \$12.21 million in 2003 (Ward, 2004). With the understanding that export values have hiked over time, countries must adopt improved fish smoking systems that deliver other social and ecological benefits while reducing



**Figure 3.** A proposed implementation model for scaling up Improved Fish Smoking Kilns across Western Africa.

post-harvest loss and ensuring local economic impact at scale.

This suggests that project proponents need to adequately consider the social, economic, and environmental issues relating to IFKs more holistically. Currently, most of the interventions are “project-like” in nature, with minimal time for a new technology to mature (Salagrama and King, ND). Therefore, the upscaling and sustainability of an IFK requires a radical shift from the current piecemeal and disorganized way development agencies deploy IFKs across the region to take advantage of the opportunities that come with it. Currently, there are no national policies governing the development and operationalization of IFKs in most counties across the region. Likewise, the promotion of IFKs by the United Nations Food and Agriculture Organization (FAO) has produced mixed results (FAO, 1995), leading to the persistence of policy challenges associated with developing the fish-smoking sector and addressing health risks (indoor pollution, health, food safety standards) to user groups. Essentially, scaling up offers an opportunity to effectively address these challenges, including increasing exposure to foreign markets and enhancing profitability (Bruce et al., 2000; Ward, 2004).

Figure 3 is a proposed conceptual model for scaling up IFKs to deliver sustainable development goals across Western and Central Africa. Upscaling would also require improving coordination at the institutional level within and outside the country. This is crucial for success because in most countries, for example, Sierra Leone and Ghana,

there are generally few or no institutional and organizational arrangements for effective collaboration on issues like deploying IFKs. A recent survey in Ghana highlighted the limited coordination between the Ministries of Fisheries and Health (Bilecki et al., 2018), which is needed to effectively regulate processes and outcomes resulting from the use of IFKs. To avoid duplication of efforts and ensure continuity between projects by development agencies operating in the same locality, governments must develop best practice protocols for operationalizing IFKs in each country and potentially in the region. Considering the links between biomass combustion, ecosystem degradation and human health (Barnes and Floor, 1996; World Bank, 2011), this process needs to be inclusive and participatory, involving all the relevant government agencies, scientific and technical institutions, local authorities, local communities, NGOs, and the private sector. This group would define the responsibilities of each institution and work collectively on aspects such as legislation, environmental, health, and social safeguards; ecosystems conservation; and fisheries policy coordination.

With an institutional framework at the national level, academia and other research institutes need to generate date-to-implementation protocols by ensuring that proposed guidelines are context-specific and consider socio-cultural norms in IFK development protocols (Sharma and Dasappa, 2017). This is a successfully tested approach in some East African and Asian countries where context-driven activities ensure the delivery of the

gains associated with the use of IFKs without making expensive compromises by users (Inayat, 2011; Sharma and Dasappa, 2017; Hailu et al., 2020).

The government agencies that make up the National Working Committee (MWC) could initiate their activities by seeking political buy-in from a cross-section of stakeholders (Figure 3). A similar approach has been proposed and tried in South-East Asia (Roy et al., 2018). To increase the chances of IFK proliferation, the awareness of politicians on the socio-economic impacts of scaling up IFKs to meet specific national development goals is essential. In the private sector, awareness messaging should focus on the business opportunities for scaling up IFK at household and community levels. Mainstreaming IFKs into national development programs and industries, such as Health, Poverty Reduction, Climate Change, and Biodiversity Conservation, amongst others, is a critical step that guarantees prioritization, funding, and sustainability of IFKs within country development programs.

Given the importance of the smoked-fish industry and biomass cooking system to ecosystem degradation and economic development in the region (Anderson and Fishwick, 1984; Ward, 2004), the integration of IFKs into country development processes should be considered an overlay to current initiatives and governance frameworks. Existing institutions such as councils, districts, and NGOs should lead the implementation of the IFKs proposed in national development programs. Integrating IFKs into local (subnational) initiatives and governance frameworks focused on biodiversity conservation, health, climate change, and economic growth will ensure their prioritization for national development planning and financing.

Capturing local experiences and knowledge from such pilot projects will build practical experiences in the scaling-up phase, deepening a sense of ownership and motivating local community members to adopt and utilize the technology. The experience can be shared amongst different actors at the national and regional levels to shape cross-border learning and collaboration and build capacity for policy planning and delivery. Connecting rural and peri-urban communities and government agencies at the national level will significantly raise community voices in national development planning.

For this and other objectives, the government and development agencies need to work closely with the private sector to encourage the adoption and scale-up of IFKs at various levels. The government and development agencies could jointly or independently promote community business enterprises as tools for expanding IFKs. For instance, in Sierra Leone, some community elites build semi-improved fish-smoking kilns and rent them out to women processors, who pay monthly fees for their use (Massaquoi, 2017). Organizing fish smokers into associations or cooperatives and providing such groups

with IFK construction subsidies could be a promising avenue for development agencies to facilitate the proliferation of improved cooking systems. In this co-funding approach, entrepreneurs could request the fish smokers to pay a fraction of the IFK construction cost while the development agencies or government provide the remainder. Small sustainable community financing schemes such as village savings and loans associations, which could enable community processors to access loans and micro-credit from standard banks to invest in IFKs, are also an opportunity with great potential. Innovative financing mechanisms, such as carbon credits, could also be a source of funding for community mobilization and capacity building. Furthermore, linking community fish smokers to European markets that can pay premium prices for high-quality smoked fish and provision of market information systems are all conditions that could enable and sustain the development of IFKs.

## Conclusion

High dependency on biomass as a source of energy for cooking across rural and peri-urban areas in Western Africa is threatening ecosystems and driving the emission of GHGs and particulate matter into the atmosphere. This review reveals that efforts to develop improved fish smoking systems to reduce the excessive consumption of fuelwood and abate serious environmental issues have failed because of a series of interconnected factors. These issues range from the poor fit of solutions to the socio-economic and market context and the inadequacy and misalignment of investment incentives.

Elsewhere, evidence shows that improved cooking/smoking systems contribute to tackling issues of wood scarcity, reducing emissions, conserving forests and generating jobs (Sahan et al., 2018; Roy et al., 2018; Nwa et al., 2021). For the region to consistently benefit from the opportunities that improve cooking systems offer, government agencies must lead efforts to coordinate the implementation of these initiatives in their countries.

We suggest a coordinated and phased approach that encompasses research, awareness-raising and education, targeted policy reforms, and mainstreaming these systems into national development programs. These recommendations must be aligned to the local and national circumstances, giving significant attention to stakeholders' participation in the implementation processes and ensuring full integration into the broader energy, ecosystems, and health management sectors. The full implementation of this approach could position IFKs or improved cooking systems high on the development agenda of countries in the region. Hence, enabling sustainable funding (including climate finance from carbon credits) to scale up IFKs in the area. Such an outcome would enhance the willingness of rural

entrepreneurs and poor communities to pay for improved cooking systems that ordinarily would be impossible to acquire. In this regard, anticipated results would be the conservation of ecosystems (avoided deforestation) and improved human health through indoor and outdoor pollution reduction (primarily for women and children).

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