

A Data-driven Circular Economy Roadmap For Ghana's Fish Value Chain

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A DATA-DRIVEN CIRCULAR ECONOMY ROADMAP
FOR GHANA'S **FISH VALUE CHAIN**

(2025-2030)



Executive Summary

This roadmap outlines a practical strategy to make Ghana's fish value chain more circular, efficient, and resilient by **2030**. It draws on the Circular Opportunity Mapping (OM) report, which demonstrates how circular economy principles can improve production, processing, distribution, and trade. The OM provides the evidence base, identifying value loss, resource inefficiency, and opportunities for recovery, cleaner production, and enterprise growth.

The OM was conducted in four districts in the Ashanti and Eastern Regions: Bosomtwe, Atwima Nwabiagya North, Kumasi Metropolis, and Asuogyaman. The study used a mixed-methods approach, desk research, interviews, focus group discussions, field observation, and structured surveys, to engage **252** value chain actors: **88** producers, **63** processors, and **101** traders. Analysis combined descriptive statistics, Material Flow Analysis (MFA), and a quasi-Life Cycle Assessment (quasi-LCA) to track resource inputs, outputs, waste streams, and value

leakages, ensuring the roadmap is data-driven and actionable.

The OM confirms that Ghana's fish value chain is essential for food security, local commerce, and livelihoods, supplying about **60%** of the country's animal protein requirements and supporting an estimated **three million** people. However, the system remains inefficient, with high post-harvest losses, limited access to cold storage infrastructure, underdeveloped circular practices, and traditional processing methods that strain resources, incomes, and working conditions.

The greatest inefficiencies are found in the post-harvest system, especially during processing. Processors handled about **19,454 kg** of fresh fish per cycle, producing **14,772 kg** of edible product and generating **4,864 kg** of by-products such as heads, guts, and bones. Spoilage was minimal at **55.5 kg**, indicating that the main challenge is the disposal of potentially valuable



material. Smoking also relies heavily on fuelwood, averaging **1.31 kg** of wood per **1 kg** of fish processed, making processing the primary hotspot for resource inefficiency and circular intervention.

In contrast, the trading stage is physically efficient: traders sell **98.4%** of the fish they procure (**56,624 kg** out of **57,529 kg**) with minimal spoilage. However, about **442 kg (0.8%)** is sold at reduced prices due to quality deterioration. This shows that losses can appear as lower prices and reduced margins, not just as waste. Strengthening cold-chain services and handling is essential to reduce spoilage and protect income.

The OM shows that gender and enterprise scale significantly shape the value chain. Production is predominantly male, while **90.5%** of processors and **97.0%** of traders are female. Most processors and traders run microenterprises, often relying on family labor. Education levels are generally modest, especially in post-harvest roles, highlighting the need for practical, visual, and accessible training. The roadmap's success depends on supporting women-led microenterprises with improved equipment, safer practices, better handling systems,

and reliable business support.

Accordingly, the roadmap focuses on practical priorities: cleaner, more efficient smoking systems; recovery and use of fish by-products; enhanced cold-chain and handling services; shared infrastructure for small operators; and targeted support for women- and youth-owned enterprises. Implementation will be phased, starting with key hotspots, piloting solutions in the four study districts, and scaling up successful models. Circularity is positioned as a practical strategy to retain value, improve livelihoods, reduce reliance on woodfuel and waste, and strengthen sector competitiveness and resilience.

In summary, the OM shows that Ghana's fish value chain has a strong economic foundation but loses significant value due to inefficient processing, unmanaged by-products, inadequate cold handling, and limited adoption of improved practices. This roadmap addresses these issues by translating OM findings into a **structured action plan** for cleaner production, stronger enterprises, improved market performance, and more inclusive circular growth.

Step 1: Vision and Strategic Intent

1.1 Vision

By 2030, Ghana's fish value chain will be a more circular, low-waste, low-emission, women-centred and market-resilient system in which fish losses, fuelwood dependence and unmanaged by-products are substantially reduced; value is retained locally through reuse, recovery, clean processing and cold-chain innovation; and circular upgrading creates decent livelihoods for producers, processors, traders and youth-led enterprises.

This vision starts from the simple fact that fish is too important to Ghana's food system and rural economy to remain trapped in a largely linear model. The OM report shows that fish supplies about 60% of the animal protein consumed in Ghana and supports an estimated three million people across fishing, aquaculture, processing, trading and distribution. In other words, this is not a marginal sector. It is central to food security, household income and local enterprise development. A circular transition in fish is therefore not only an environmental agenda. It is also a practical development agenda.

The vision also responds to a clear pattern of loss and inefficiency. The report identifies post-harvest losses of 20-30% in artisanal fisheries, limited cold-chain capacity, inefficient processing technologies and significant volumes of underused organic waste. At the processing stage alone, around 19,454 kg of fresh fish are handled per cycle across the surveyed processors. Of that, about 14,772 kg becomes edible product, while about 4,864 kg, roughly one quarter of the raw input, ends up as by-products such as heads, bones and guts. Spoilage at this stage is low at 55.5 kg, which means the bigger problem is not spoilage alone; it is the routine disposal of potentially valuable material.

A credible vision for the fish value chain

must therefore go beyond the familiar language of "reducing waste". It must speak to a more practical shift: from disposal to recovery; from heavy reliance on firewood to cleaner, more efficient processing; from weak handling systems to stronger cold-chain performance; and from survivalist enterprise conditions to more resilient local businesses. The OM is especially clear that traditional smoking remains the dominant processing pathway and that it carries the heaviest resource burden. Fuelwood use averages 1,313 kg for every 1,000 kg of fish processed, or about 1.31 kg of wood for every 1 kg of fish. Put plainly, the average processing system burns more wood by weight than the fish it processes. That is a serious problem in terms of efficiency, costs, and the environment.

The vision is deliberately women-centred because the OM shows that women overwhelmingly carry the post-harvest economy. While production is dominated by men (95.5%), processing is 90.5% female and trading is 97.0% female. Many of these women operate micro-enterprises with few or no employees, modest capital, and limited access to cold storage, finance and upgraded equipment. A circular fish economy that fails to improve the conditions of women processors and traders would miss the chain's real structure.

The vision is also intentionally market-resilient, as the trading node is already materially efficient: traders sell about 98.4% of the fish they procure, and physical spoilage at trade is very low. Yet this efficiency masks a persistent value problem. About 442 kg, or roughly 0.8% of the traded fish in the sample, is sold at a reduced price because quality declines before sale. That tells us the chain is not collapsing at market level, but it is leaking value through weak cold handling and rushed sales. A resilient circular system must therefore preserve both physical product and commercial value.

Finally, the vision is not about importing a perfect model from elsewhere. It is about building a Ghanaian pathway that fits the reality described in the OM: a chain that is socially important, labour-intensive, highly gendered, technically uneven, and rich in underused material streams. Circularity

here should mean practical improvements that local actors can recognise and use: cleaner kilns, lower fuel bills, more reliable fish quality, new uses for offal and scales, better storage, safer working conditions, and stronger local enterprise.

Figure 1. What the 2030 vision is trying to change

The comparison below translates the vision into plain operational terms.

Current pattern identified in the OM		2030 direction of travel
 A food-security-critical value chain still operating with high post-harvest losses, weak cold-chain performance and traditional processing systems	→	 A more efficient, better coordinated chain that keeps more fish, value and income in the system
 Around 25% of fish entering processing becomes by-products that are largely unmanaged	→	 By-products routinely collected, separated and converted into useful commercial or agricultural products
 Smoking depends heavily on firewood, at roughly 1.31 kg wood per 1 kg fish processed	→	 Cleaner and more efficient smoking systems with substantially lower wood intensity
 Women dominate processing and trading but often do so through small, under-capitalised enterprises	→	 Women-led businesses with better equipment, safer working conditions, stronger market access and improved finance
 Trading is physically efficient but still loses value through quality decline and discounted sales	→	 Stronger cold handling and storage so that more fish is sold at full value



1.2 Strategic Goals

The strategic goals below are designed to convert the vision into a manageable set of measurable outcomes. Each one is anchored in the OM baseline. Together, they focus on the points where the evidence shows the greatest pressure, the clearest opportunities and the most immediate prospects for impact.

Table 1. Strategic goals and 2030 targets

Strategic goal	Proposed 2030 target	Baseline evidence from the OM	Significance
Goal 1: Recover fish by-products instead of dumping them	Recover, reuse or commercialise at least 60% of currently unmanaged processing by-products in participating clusters	Processing generates around 4,864 kg of by-products per cycle across 63 processors , equal to roughly 25% of raw fish input; reported use of these by-products for animal feed was 0%	This is the clearest material leakage in the chain. It is also a direct opportunity for new products, added income and lower waste burdens
Goal 2: Cut fuelwood intensity in fish smoking	Reduce average fuelwood use from ~1.31 kg wood/kg fish to 0.80 kg/kg or less in upgraded smoking clusters	Processing uses about 1,313 kg of fuelwood per 1,000 kg of fish processed ; fuelwood use exceeds fish weight on average	This would represent a reduction of just under 40% in wood intensity, easing pressure on woodfuel demand, reducing emissions and improving operating efficiency
Goal 3: Reduce value leakage from quality loss and weak cold chains	Cut fish sold at reduced price because of quality decline from ~0.8% of traded fish to 0.3% or less in targeted markets	Traders sell 98.4% of procured fish, but around 442 kg per cycle is sold at a reduced price because quality drops before sale	The trading node is already efficient by volume. The next gain is to protect value, not only prevent spoilage
Goal 4: Make circular upgrading inclusive	Ensure at least 70% of direct beneficiaries are women and at least 30% are youth; support 25 women-led and 10 youth-led circular ventures	Processing is 90.5% female and trading 97.0% female ; youth involvement is present in only 29% of processing businesses and 27% of trading businesses	The chain cannot become more circular in practice unless the people who do most of the work can access the benefits of upgrading

First, Goal 1 recognises that by-products matter more than spoilage at the processing node. The report shows that spoilage during processing accounts for only 0.3% of the input, while by-products account for about

25%. This is significant because it shifts the policy conversation. The main issue is not simply how to stop fish from going bad; it is how to stop potentially valuable biomass from being treated as waste.

Second, Goal 2 addresses the dominant environmental and operational hotspot in the chain. The OM explicitly states that processing is the most resource-intensive stage and that smoking is the main reason. A reduction from 1.31 kg of wood per kilogram of fish to 0.80 kg would not solve the energy challenge entirely, but it would mark a clear improvement that processors, local authorities and support programmes could actually measure and verify.

Third, Goal 3 is designed around a more subtle problem: hidden value loss. The data show that the trading node is not failing in terms of crude physical performance. Fish is moving. Stocks are being sold. Spoilage is low. But commercial value is still being eroded because quality drops before sale. That is why cold-chain investment is significant even where waste appears small. Better handling, better ice access and better cold storage can improve incomes without requiring a complete redesign of the market system.

Fourth, Goal 4 ensures that the roadmap does not treat inclusion as a side issue. The OM shows a strongly gendered chain in which women dominate the stages where circular upgrading is most urgent, while many businesses remain very small. The average workforce size is only 2.7 persons per processing business and 1.4 persons per trading business, with a median of zero employees in both cases. That means many businesses are run solely by owners and family labour. If the roadmap expects these actors to adopt cleaner technologies, handle recovered by-products or improve storage, then support must be designed around their realities rather than around assumptions of larger firms.

A further implication follows from this. Since 64% of processors and 66% of traders are recorded as having basic education as their most common level and significant minorities have no formal education, circular upgrading will only work at scale if training, demonstration and finance are accessible in practice. This is why the strategic intent needs to connect material

efficiency with inclusion, enterprise support and public communication from the outset.

1.3 Alignment with Policy and Global Frameworks

This roadmap sits comfortably within Ghana's current development and sector planning landscape. At national level, the Medium-Term National Development Policy Framework 2026-2029 sets the wider planning context under the banner of "Resetting Ghana Agenda: Creating Jobs, Ensuring Accountability and Promoting Shared Prosperity." That framing is highly relevant to the fish value chain. A circular fish roadmap is, at its core, a jobs-and-productivity agenda as much as an environmental one: it seeks to retain value locally, reduce losses, support enterprise growth, and strengthen resilience in communities that already depend heavily on fisheries and aquaculture.

The roadmap also aligns closely with Ghana's National Fisheries and Aquaculture Policy 2022. That policy was revised to address current and emerging sector challenges, including high post-harvest losses, inadequate human, technological and infrastructural capacity, high aquaculture input costs, and limited access to quality production inputs. It sets out a strategic direction for sustainable sector growth and identifies policy focus areas that include fisheries infrastructure development, post-harvest management and trade, and environment and climate change. Those priorities map directly onto the OM's main findings on by-products, smoking energy, cold-chain gaps and enterprise upgrading.

Institutionally, the fit is equally strong. The Ministry of Fisheries and Aquaculture Development states that its mandate is to formulate and implement sector policies and strategies to transform the fisheries and aquaculture sector and contribute more effectively to national development. The Fisheries Commission, established

under the Fisheries Act, is mandated to regulate and manage fisheries, promote the development of the fishing industry, and address related matters. In practice, this gives the roadmap a clear policy home and an obvious implementation anchor.

The roadmap is also consistent with Ghana's Local Economic Development (LED) Policy and Implementation Plan 2024-2029, which official government reporting describes as promoting a conducive environment at district level for sustained local business growth, decent employment opportunities and economic empowerment. That is important because many of the interventions envisaged by the roadmap, such as shared smoking infrastructure, small-scale recovery hubs, cooling services, and enterprise support, are best delivered through district- and market-level systems rather than solely through national policy.

From a climate perspective, the roadmap aligns with Ghana's Updated Nationally Determined Contribution (2020-2030), which the government presents as a blueprint for transition to a climate-resilient, low-carbon economy. The ruling government links climate action with jobs, resilience and improved wellbeing, and it is explicitly framed as part of the national development agenda. A fish value chain strategy that reduces woodfuel intensity, strengthens

recovery of organic residues and improves low-carbon cold handling is therefore aligned with Ghana's broader climate direction.

The roadmap contributes directly to the Sustainable Development Goals, especially SDG 1 (No Poverty), SDG 2 (Zero Hunger), SDG 5 (Gender Equality), SDG 8 (Decent Work and Economic Growth), SDG 9 (Industry, Innovation and Infrastructure), SDG 12 (Responsible Consumption and Production), SDG 13 (Climate Action), and SDG 14 (Life Below Water). It also reflects the ILO Guidelines for a Just Transition, which frame the low-carbon transition as a practical policy process that should create decent work and support sustainable development, rather than shift costs onto already vulnerable workers and small enterprises. That principle is highly relevant in a chain where women dominate processing and trading and where many businesses are informal or micro-scale.

In effect, Step 1 places the fish value chain within a coherent policy story. It shows that circularity is not an isolated environmental theme. It is a way of delivering on national goals for jobs, food security, local enterprise development, resilience, cleaner growth and social inclusion, while responding to the real material losses and structural weaknesses identified in the OM.



Summary table

Element	Roadmap position
Development logic	Circular upgrading of a food-security-critical value chain that already supports livelihoods at scale and has clear, measurable leakages
Core problem addressed	A socially important chain with high post-harvest losses, fuelwood-heavy processing, underused by-products, weak cold handling and low uptake of reuse practices
Time horizon	A four-year implementation pathway nested within a 2030 transition vision
Primary transition levers	Clean processing, by-product valorisation, stronger cold-chain performance, women-centred enterprise support and practical circular business development
Main beneficiary logic	Producers, processors and traders benefit through lower losses, lower operating costs, stronger quality retention and new income streams; women and youth are intentionally prioritised
Institutional fit	Strong alignment with Ghana's 2026-2029 national policy framework, the National Fisheries and Aquaculture Policy 2022, Ministry and Fisheries Commission mandates, and district LED delivery systems
Global fit	Strong alignment with the SDGs, Ghana's updated NDC, and just transition principles centred on decent work, inclusion and managed change



Step 2: Baseline and OM

This step draws on the Circular OM exercise undertaken across four districts in the Ashanti and Eastern Regions - Bosomtwe District, Atwima Nwabiagya North District, Kumasi Metropolis and Asuogyaman District - and is based on evidence from 252 actors, comprising 88 producers, 63 processors and 101 traders. The baseline is therefore grounded in the realities of production, processing, and trade across a fish system spanning inland capture fisheries, aquaculture, urban distribution, and market sales.

Ghana's fish value chain is economically and socially important, but it is also marked by recurring inefficiencies: high post-harvest losses in parts of the chain, heavy reliance on traditional smoking, limited cold-chain capacity, weak recovery of by-products, and low levels of organised reuse and recycling. At the same time, the OM shows that not all parts of the chain perform badly. In fact, some parts perform relatively well. The real issue is that the greatest inefficiencies are concentrated in specific stages, especially processing, where the largest material leakage and the heaviest resource use occur.

2.1 Material Flow and Loss Patterns (MFA Insights)

The material flow analysis shows a fish value chain with two very different performance profiles. At the processing stage, most fish is successfully converted into food, but a substantial share exits the system as unmanaged by-products. At the trading stage, by contrast, physical losses are very low and most fish reaches consumers, although some value is still lost through quality deterioration and discounted sales.

At the processing node, the surveyed processors handle around 19,454 kg of fresh fish per cycle. From that inflow, about 14,772

kg of edible processed fish is produced. This means that roughly 75.9% of the material entering processing remains in the food system. That is a respectable product yield. However, the same data show that around 4,864 kg, or roughly one quarter of the raw input, leaves processing as by-products such as heads, guts and bones. Reported spoilage during processing is only 55.5 kg, which is around 0.3% of the input. The implication is important: the main material problem at this stage is not spoilage, but unrecovered by-products.

At the trading node, the picture is different. Traders procure around 57,529 kg of fish per cycle and sell about 56,624 kg, equivalent to 98.4% of what they buy. Cleaning waste is only 9.6 kg, and unsold spoilage is reported at 5.6 kg, which is less than 0.03% of input. This is an efficient distribution system in terms of physical logistics. Even so, the analysis identifies an important hidden loss: around 442 kg, or 0.8% of fish handled by traders, is sold at a reduced price because quality has deteriorated before sale. This means the trading system is materially efficient, but not fully value-efficient.

In practical terms, the material flow analysis suggests that the fish value chain does not need the same type of intervention everywhere. Processing needs systems that recover value from what is currently discarded. Trade needs systems that preserve quality and price. These are different problems, and Step 2 shows why they should not be treated as the same.

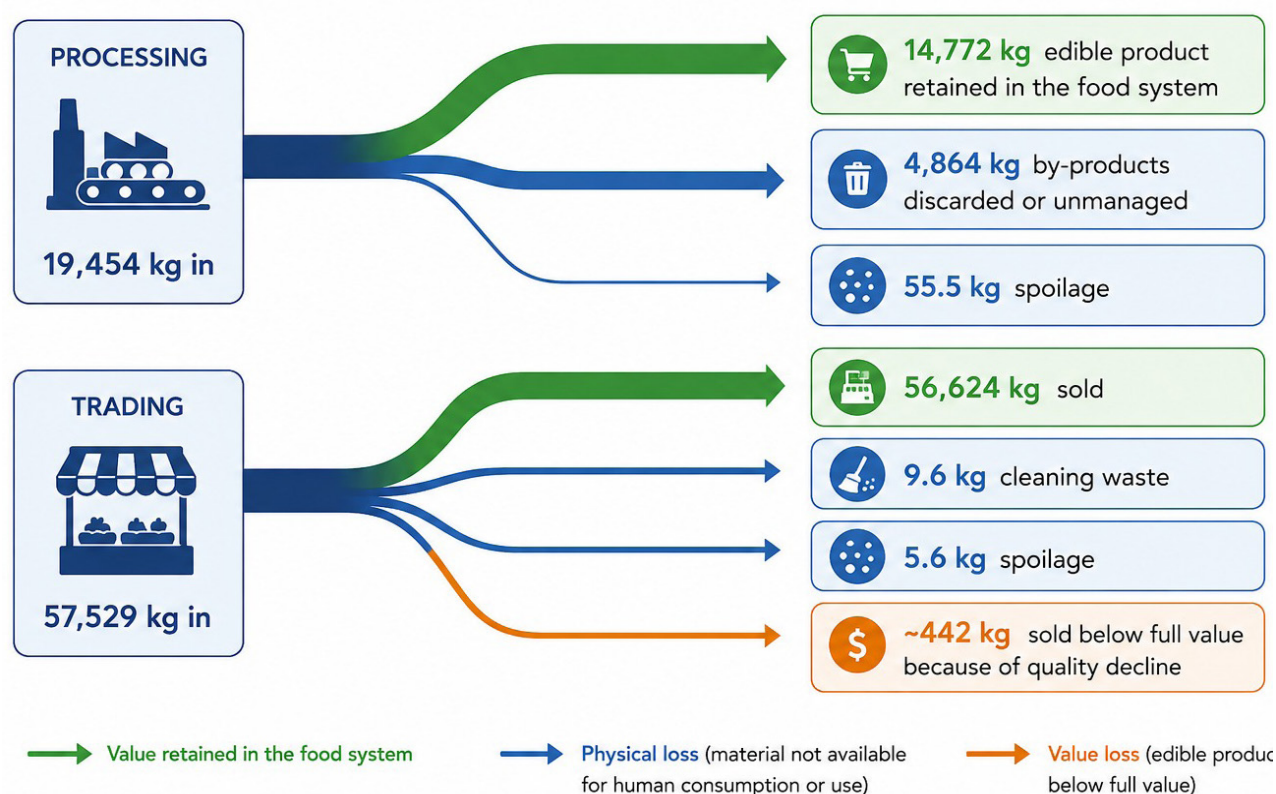


Table 2.1: Material flow and loss patterns across the fish value chain

Node	Inflow	Useful out-put	Loss/leakage	What this tells us
Processing	~19,454 kg raw fish per cycle	~14,772 kg edible processed fish (75.9%)	~4,864 kg by-products (~ 25%); 55.5 kg spoilage (~ 0.3%)	The main leakage is not spoilage but by-products that are not yet recovered or commercialised
Trading	~57,529 kg fish procured per cycle	~56,624 kg sold (98.4%)	9.6 kg cleaning waste; 5.6 kg spoilage; ~442 kg sold at reduced price (~ 0.8%)	Physical turnover is strong, but quality decline still leads to avoidable economic loss

Figure 2.1: Baseline reading of material flow performance

This simplified placeholder diagram helps distinguish between physical loss and value loss.



The baseline conclusion is straightforward: processing is the main point of material leakage, while trading is the main point of hidden value leakage.

2.2 Life Cycle Emissions and Environmental Burdens (Quasi-LCA Insights)

The OM does not provide a full cradle-to-grave life-cycle inventory with quantified greenhouse gas totals, toxicity scores, or full environmental footprints by product type. Instead, it presents a quasi-LCA based on resource-use intensity at the processing stage. That is an important limitation, and it should be stated clearly. Even so, the evidence is still strong enough to identify the main environmental burdens and the stages where intervention is most urgent.

The strongest signal comes from the use of fuelwood in fish smoking. The report shows an average fuelwood consumption of 1,313 kg per 1,000 kg of fish processed, or about 1.31 kg of wood per 1 kg of fish. In simple terms, processors on average burn slightly more wood by weight than the fish they process. This makes smoking the most resource-intensive and environmentally burdensome stage captured in the baseline.

By comparison, water use is much lower, at around 1,100 litres per 1,000 kg of fish, or 1.1 litres per kg. This suggests that water is not the largest physical burden in the processing system, although it remains important for hygiene and can become more significant where access is constrained. The report also notes that many processors do not

use water in all cases, especially when dry smoking practices are used.

Electricity use is similarly low, at around 92 kWh per 1,000 kg of fish, which points more to limited modernisation than to technical efficiency. Only a small number of processors reported any electricity use at all. This means that low electricity demand should not be read as a sign of an advanced low-energy system. In practice, it indicates limited refrigeration, limited mechanisation and continued reliance on manual methods and biomass fuel.

Diesel use is reported at about 48 litres per 1,000 kg for transporting raw material and 19 litres per 1,000 kg for transporting processed products, for a combined total of 67 litres per 1,000 kg. This is not the dominant burden by mass, but it still matters for operating costs and emissions, especially where market links are stretched and cold handling is weak.

The baseline also records labour intensity of around 12.6 man-days per 1,000 kg of fish processed. It shows that the sector is labour-intensive and livelihood-generating; while also signalling manual, physically demanding work concentrated in small enterprises, often led by women. In a circular economy context, this means the aim should not simply be to mechanise for its own sake, but to reduce drudgery, improve safety and raise productivity without undermining livelihoods.

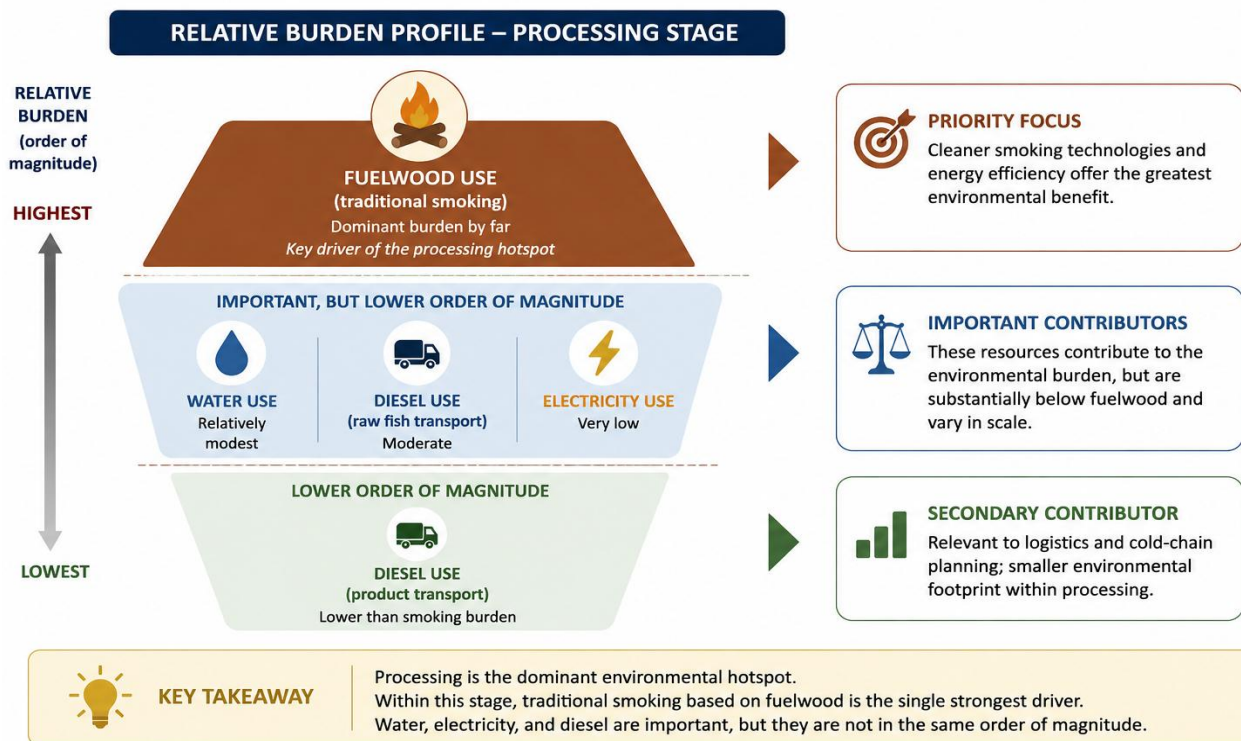
Table 2.2: Resource-use baseline at the processing stage

Indicator	Baseline	Comparative reading	Significance for the roadmap
Water use	~1,100 L/1,000 kg fish (1.1 L/kg)	Relatively modest	Worth improving, but not the principal hotspot
Fuelwood use	~1,313 kg/1,000 kg fish (1.31 kg/kg)	Highest burden by far	Clear priority for cleaner smoking and energy efficiency
Electricity	~92 kWh/1,000 kg fish	Very low	Suggests limited refrigeration and low mechanisation
Diesel for raw fish transport	~48 L/1,000 kg fish	Moderate	Routing, aggregation and shorter transport chains can improve efficiency

Indicator	Baseline	Comparative reading	Significance for the roadmap
Diesel for product transport	~19 L/1,000 kg fish	Lower than smoking burden	Secondary target linked to better logistics and cold-chain planning
Labour	~12.6 man-days/1,000 kg fish	High labour intensity	Important for livelihoods, but also points to drudgery and informality

Figure 2.2: Relative burden profile at the processing stage

A figure to show the clear dominance of fuelwood as the key resource burden identified in the OM.



Taken together, the quasi-LCA shows that processing is the dominant environmental hotspot, and that the single strongest driver within that stage is traditional smoking based on fuelwood. Water, electricity, and diesel are important, but they are not in the same order of magnitude.

2.3 Social Baseline and Inclusion Gaps

The OM makes clear that the fish value chain is not only a material system. It is also a social system, and a highly gendered one. The most significant inclusion issue is the sharp divide between male-dominated production and female-dominated post-harvest activities. This is significant because the main circular economy opportunities identified in the baseline are concentrated precisely where women are most active: processing and trading.

Among producers, 95.5% are male and only 4.5% are female. Producers are relatively youthful: 29.5% are under 36, and a further 21.6% are aged 36-39. Educational attainment is relatively stronger at this node than at lower nodes, with 55.7% reporting basic education, 22.7% secondary education, and 18.2% tertiary education. This suggests a production base with some capacity to absorb training, formal recordkeeping and improved technical guidance.

Among processors, the pattern is reversed. 90.5% are women. The largest age group is 40-49 years at 31.7%, and 22.2% report no formal education, while 63.5% have only basic education. This means that the part of the chain with the heaviest resource burden and the strongest need for technical upgrading is also the part where education levels are more limited and the labour burden falls mainly on women.

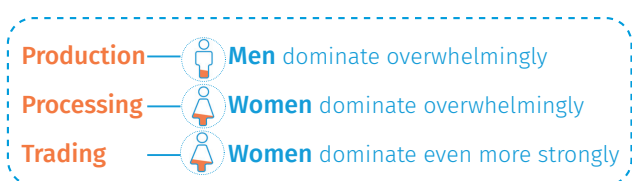
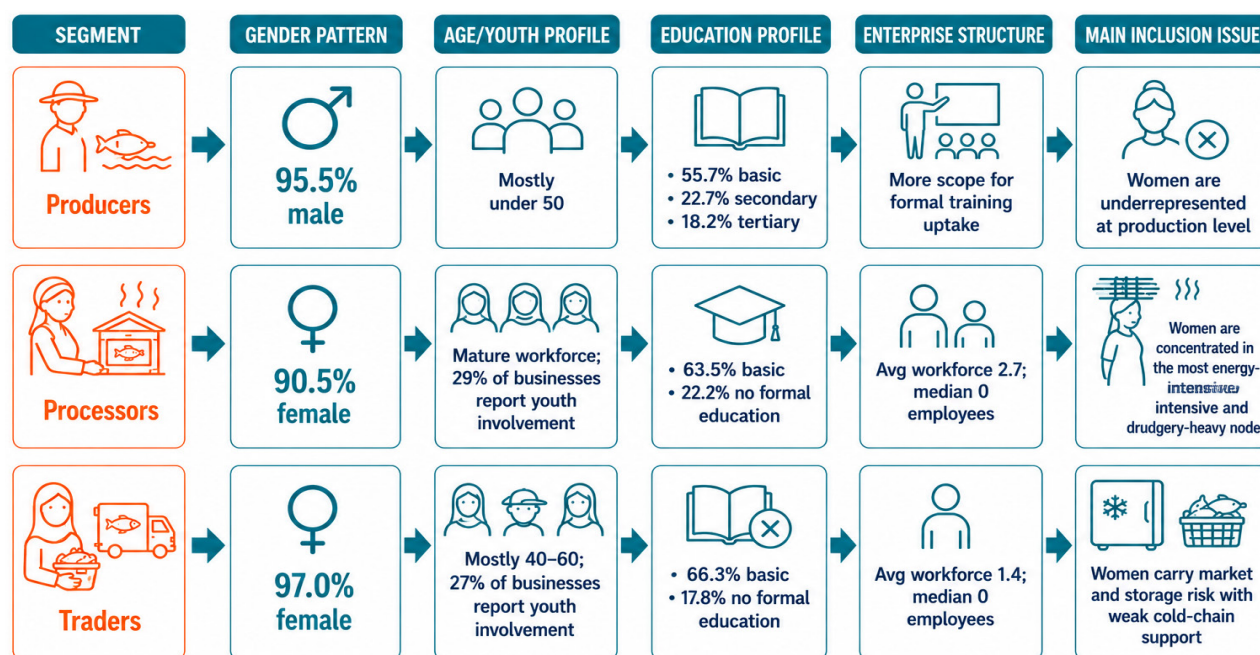
Among traders, the gender pattern is even more pronounced: 97.0% are women. The business base is mature rather than youthful, with 34.7% aged 40-49 and 30.7% aged 50-60. Education levels are again modest, with 66.3% reporting basic education and 17.8% reporting no formal education. This is important for the roadmap because trading is where cold-chain and quality-preservation measures will need to be implemented in practice. Those measures will succeed only if they are designed for small-scale, women-led enterprises rather than for large, formal firms.

The OM also shows that micro-enterprises dominate both processing and trading. The average workforce size is only 2.7 persons per processing business and 1.4 per trading business, while the median is 0 employees in both cases. In other words, more than half of these businesses have no hired labour beyond the owner and family members. This has major implications. Small businesses at this scale often struggle to invest in improved kilns, shared cold rooms, offal-handling systems, or better packaging without collective mechanisms or external support.

A further point concerns youth involvement. Around 29% of processing businesses and 27% of trading businesses reported at least one youth worker. Youth are therefore present, but not strongly embedded. The sector is clearly not drawing in younger participants at scale. That should be treated as a strategic concern, especially where new circular enterprises could create more attractive roles in collection, cooling, aggregation, repair, digital services or waste-to-value processing.

The baseline also identifies a practical information gap. While the questionnaire includes cooperative and association variables, the summary results presented in the OM do not clearly report cooperative membership levels to serve as a robust baseline figure for the roadmap. That should therefore be treated as a Year 1 data gap, not as a confirmed absence of organisation.

Figure 2.3: Gender structure of the fish value chain



The social baseline therefore points to a simple but important conclusion: circular upgrading in this value chain will stand or fall with women-led micro-enterprises. If the roadmap does not work for them, it will not work for the chain as a whole.

2.4 Current Circular Practices and Systemic Gaps

The OM does not portray a value chain with no adaptive behaviour. Some useful practices are already in place. For example, spoilage during processing is low, suggesting that processors are moving fish through the system quickly. Traders also achieve strong turnover, selling almost all the fish they buy. These are strengths and should be recognised. However, the report is equally clear that these strengths do not

yet amount to a circular system. Material recovery remains weak, reuse practices are limited, and supporting infrastructure is inadequate.

One current strength is rapid processing to limit spoilage. With spoilage at only 0.3% of processing input, fish is evidently being processed quickly enough to prevent large-scale loss at that stage. This is a useful operational practice. However, it should not be confused with circularity. The same system still discards large quantities of by-products, meaning material efficiency remains incomplete.

A second strength is fast market turnover, where traders sell 98.4% of the fish they procure. Again, this is a real efficiency, but it coexists with quality discounting and weak cold handling. It is therefore a strong linear market response rather than a fully circular one.

The main systemic gaps are more serious. The OM records no reported use of processing by-products for animal feed, despite the large volume of waste generated. It also finds that 87% of processors and 93% of

traders report no reuse of waste. Traditional smoking remains dominant, improved kilns and clean energy options remain limited, and cold-chain infrastructure is still insufficient. These are not isolated

technical problems. Together, they describe a chain in which value is still lost because the supporting conditions for circularity are weak: low awareness, low capital, low scale and weak infrastructure.

Table 2.4: Current circular practices and systemic gaps

Practice	Status	Observations
Rapid processing to reduce spoilage	Partially functional	Processing spoilage is low (~0.3%), which shows operational efficiency, but by-product recovery remains absent
Fast market turnover	Strong	Traders sell 98.4% of procured fish, yet value still leaks through discounted sales caused by quality decline
By-product reuse	Very weak/absent	No reported use of fish by-products for animal feed despite substantial quantities of offal, heads and bones
Waste reuse and recycling culture	Weak	87% of processors and 93% of traders reported no reuse of waste
Improved kilns and cleaner energy use	Limited	Traditional smoking remains dominant and fuelwood intensity is very high
Shared cold infrastructure	Insufficient	Weak cold-chain capacity continues to shape quality deterioration and forced quick sales
Cooperative-scale service delivery	Underdeveloped in the evidence base	Businesses are small and fragmented, but the baseline does not yet provide a strong reported cooperative benchmark

The baseline message here is not that actors are unwilling to improve. It is that most actors are working within systems that do not yet make circular practice easy, affordable or visible.

2.5 Circular Hotspots Identified

The OM identifies a set of hotspots where material loss, environmental pressures, or structural weaknesses create clear circular-economy opportunities. These hotspots are not all of the same kind. Some are physical waste streams. Some are energy burdens. Some are social or organisational constraints. All of them are significant, because each one blocks the chain from retaining more value locally.

The first and most obvious hotspot is processing by-products. Around 25% of raw fish input becomes heads, bones, guts and scales. Since processors reported no structured reuse of these materials for animal feed, this is the clearest single material leakage identified in the baseline. It is also the strongest candidate for waste-to-value activity, including fishmeal, soil amendments, fish oil, collagen-linked products or other bio-based uses.

The second hotspot is fuelwood-intensive smoking. A wood-to-fish ratio of around 1.3:1 is a strong signal of technical inefficiency. It also brings linked burdens: pressure on woodfuel supply, smoke exposure, emissions and avoidable operating costs. This is the clearest clean-production priority in the roadmap.

The third hotspot is trade-related quality loss. Although physical spoilage is low, around 0.8% of traded fish is sold below full value. This is a classic circular economy issue: not a complete loss of product, but a loss of quality, income and resource efficiency. Cold-chain interventions, better handling and service-based cooling solutions are therefore justified even in a system with low measured spoilage.

The fourth hotspot is the weak culture of reuse and recycling. With most processors and traders reporting no reuse of waste, the challenge is cultural, organisational, and technical. New infrastructure alone will not be enough if there is no practical demonstration of value.

The fifth hotspot is micro-scale fragmentation and weak investment capacity. The report repeatedly shows that businesses are small, often family-run and under-capitalised.

Table 2.5: Circular hotspots identified in the OM

Hotspot	Description	Opportunity
Processing by-products	Around 25% of raw fish input exits as heads, bones, guts and scales	Fishmeal, soil amendments, fish oil, pet feed ingredients, collagen and other bio-inputs
Fuelwood-intensive smoking	Around 1.31 kg of wood per kg of fish processed	Efficient kilns, cleaner fuel systems, briquettes, hybrid drying and smoking technologies
Quality loss in trade	Around 0.8% of traded fish is sold at reduced price despite very low spoilage	Solar ice, cold rooms, improved handling, crate systems and quality-preservation services
Weak reuse culture	Most processors and traders report no structured reuse or recycling of waste	Demonstration projects, practical training and visible business cases for reuse
Micro-scale fragmentation	Many businesses have no employees and limited capital	Cooperative models, shared infrastructure, cluster finance and leasing arrangements
Value chain-wide circularity gaps	Weaknesses also appear in feed, packaging, cold transport, retail waste and final disposal	Local feed production, reusable crates, biodegradable packaging, composting, biogas and circular enterprises

A further strength of the OM is that it widens the view beyond processing and trade alone. It identifies circularity gaps across the wider system, including inefficient input supply; plastic waste, wastewater, and sludge at production; post-harvest loss at landing; single-use packaging; cold-chain breaks in distribution; market waste at retail and consumption; and dumping at final disposal. This wider view is significant because it shows that the roadmap should not stop at one or two technical fixes. It should move towards a more connected system in which waste streams, energy systems, logistics and market services reinforce each other.

Summary table

Baseline conclusion	What it means for the roadmap
Processing is the main circularity hotspot	Priority should be given to clean smoking, by-product recovery and safer, more efficient processing systems
Trading is physically efficient but still loses value	Priority should be given to cold-chain services, handling standards and quality preservation
Women dominate the post-harvest economy	Inclusion must be built into the core design of interventions, not added later
Most businesses are micro-scale and under-capitalised	Shared infrastructure, cluster models and accessible finance will be essential
Reuse and recycling practices remain weak	Demonstration, behaviour change and practical waste-to-value models are needed
Circularity gaps extend across the wider chain	The roadmap should link processing upgrades with packaging, cooling, logistics, recovery and waste management



Overall, the baseline shows a working but inefficient value chain, with strong turnover, socially important, and capable of supporting livelihoods, yet still losing too much value through unmanaged by-products, fuelwood-heavy processing, weak reuse systems and inadequate cold-chain support. That is precisely why the opportunity is so significant. The chain already has a functioning economic base. What it now needs is a more circular operating model that allows it to keep more value, reduce pressure on resources and improve the conditions under which people work.

Step 3: Prioritisation and Scope Definition

Step 3 turns the baseline into a practical delivery focus. The OM does not suggest that every part of the fish value chain requires the same level of intervention at the same time. Instead, it points to a smaller set of locations, value-chain functions, and opportunity areas where circular-economy action is most likely to produce visible results within a reasonable period. The purpose of this step is therefore to define where the roadmap starts, what it concentrates on first, and why certain opportunities should be treated as immediate priorities while others are better approached as second- or third-order actions.

A central message from the OM is that prioritisation should follow the evidence. Processing is the most resource-intensive and waste-generating stage. Trading is materially efficient but still loses value through quality decline. The post-harvest system is also where women are most heavily concentrated and where micro-enterprise constraints are strongest. For that reason, the roadmap prioritises interventions that can reduce fuelwood use, recover by-products, protect fish quality, and make circular upgrading workable for small operators.

3.1 Geographic Scope

The primary roadmap geography comprises four districts and metropolitan areas in the **Ashanti and Eastern Regions**:

- **Bosomtwe District** - artisanal inland capture fisheries around Lake Bosomtwe
- **Atwima Nwabiagya North District** - smallholder aquaculture clusters and fish trading
- **Kumasi Metropolis** - a major urban hub for processing, cold storage, trade and wider distribution
- **Asuogyaman District** - capture fisheries and aquaculture activities along the Volta Lake

These four areas are not arbitrary. They were the field sites used in the OM exercise itself, which covered 252 actors: 88 producers, 63 processors and 101 traders. Taken together, they provide a workable pilot geography that captures different parts of the fish economy rather than focusing on a single production system or market type. Bosomtwe and Asuogyaman bring in inland capture fisheries and lake-based livelihoods; Atwima Nwabiagya North brings in aquaculture and trading functions; and Kumasi provides the main urban market, processing and distribution interface. That mix is important because the roadmap is not only about reducing waste at source. It is also about understanding how fish, by-products and value move across places.

The geographic logic is therefore one of functional coverage, not simply administrative spread. Between them, the four locations cover:

- production from inland capture fisheries and aquaculture
- post-harvest handling and processing
- local aggregation and transport
- cold storage and urban distribution
- market-facing trade and retail circulation.

This gives the roadmap a strong pilot base. It allows early action to be tested across the chain rather than at a single isolated node. It also reflects the report's own evidence that circularity problems are interconnected. For example, by-product recovery depends on what happens at processing sites, but its commercial viability may depend on aggregation, transport and local demand from other users. Likewise, better cold handling is important at both landing and market. A geography that combines lake communities with an urban distribution centre is therefore more useful than one focused solely on production.

That said, the roadmap should be clear about what this scope encompasses and what it does not. These four districts are the initial implementation geography, not the limit of future relevance. The wider OM makes clear that the fish value chain in Ghana includes marine, inland and aquaculture systems

and spans input supply, harvesting, landing, processing, distribution, retail and waste handling. The chosen geography should therefore be seen as a practical entry point for demonstration and learning, with scope for later replication in similar conditions.

Table 3.1: Geographic scope and rationale

Location	Principal fish-system role	Significance for the roadmap
Bosomtwe District	Inland capture fisheries and local processing	Brings in lake-based production, local processing and primary handling conditions
Atwima Nwabiagya North District	Smallholder aquaculture and fish trading	Brings in farmed fish systems and local trading functions
Kumasi Metropolis	Processing, storage, trade and urban distribution	Critical market and logistics node; important for cold-chain and quality issues
Asuogyaman District	Capture fisheries and aquaculture along the Volta Lake	Brings in a second major inland waterbody and mixed production systems

Figure 3.1: Why these four areas were prioritised



3.2 Value Chain Focus

The roadmap covers the full fish value chain, but it does not treat every node equally. The OM is clear that the most serious circular losses and environmental burdens sit in the post-harvest system, especially at processing. For that reason, the roadmap prioritises the parts of the chain where value is currently leaking most visibly and where intervention can yield the clearest combined economic, environmental, and social gains.

This means the core focus falls on:

- fresh fish from inland capture fisheries and aquaculture
- smoked fish
- dried and salted fish
- fish offal, heads, scales, bones, sludge and related residues as secondary resource streams
- reusable logistics and cold-chain services, including ice, storage and transport support.

This focus reflects the way the value chain is described in the OM. The report identifies a chain that begins with input supply and production, moves through harvest and landing, and then flows into gutting, smoking, drying, salting, frying, packaging, storage, trade and retail. Traditional smoking remains the dominant processing pathway and is explicitly associated with high fuelwood use, product inconsistency and waste generation. At the same time, the chain produces by-products and residual streams that are still underused, including

offal, scales, wastewater and wood residues. These are not side issues. They are part of the core circularity problem in the value chain.

The data also justify the decision to prioritise post-harvest functions. At processing, about 19,454 kg of fresh fish are handled per cycle across the surveyed processors. Of that, around 14,772 kg becomes edible product, while about 4,864 kg exits as by-products. Trading handles even larger volumes, with around 57,529 kg procured and 56,624 kg sold, but its main weakness is not physical waste; rather, it is quality deterioration, which reduces sale prices. In short, post-harvest nodes combine the strongest material leakage, the heaviest resource burden, and some of the clearest opportunities for better value retention.

The wider OM identifies circularity gaps in production too, particularly around wastewater, sludge and bycatch, and links these to opportunities such as aquaponics and sludge composting. However, production-side opportunities are more site-specific and technically variable.

Table 3.2: Value-chain scope and immediate focus

Value-chain area	Included in roadmap?	Degree of priority	Reason for position
Input supply	Yes	Moderate	Relevant for feed and plastics, but less immediate than post-harvest hotspots
Production	Yes	Moderate	Important for sludge, wastewater and bycatch, but more site-specific
Landing and handling	Yes	High	Important for post-harvest loss prevention and early cold support
Processing	Yes	Very high	Main hotspot for by-products, fuelwood use and women's labour burden
Storage and distribution	Yes	High	Important for quality preservation and market resilience
Trade and retail	Yes	High	Materially efficient, but still loses value through quality decline
Waste recovery and reuse	Yes	Very high	Central to circular transition and new business development

3.3 Prioritised Opportunities

The OM identifies a wide range of possible circular economy entry points. Step 3 narrows these into a smaller set of prioritised opportunities for the first phase of the roadmap. These are the areas where the report points to both a clear problem and a practical opening for action. Some are direct responses to measured hotspots. Others are enabling measures that make those responses viable for micro-enterprises.

1. Efficient smoking and clean-processing upgrades

Fuelwood use averages 1,313 kg per 1,000 kg of fish processed, or about 1.31 kg of wood per kg of fish. The OM identifies smoking as the most resource-intensive and environmentally impactful activity in the processing system. Cleaner kilns, more efficient smoking technologies and alternative or hybrid energy options therefore represent the clearest immediate route to reducing resource pressure, lowering operating costs, improving working conditions and strengthening product quality.

2. By-product valorisation enterprises

Processing generates around 4,864 kg of by-products per cycle across the processors surveyed, roughly 25% of raw fish input, yet the report records no structured reuse of these materials for animal feed. This is the largest measured material leakage in the chain. Fishmeal, compost, fish oil, pet feed ingredients, collagen-linked products and related bio-based uses all fall within this opportunity space. The case for prioritising this area is strong because it addresses both waste reduction and income diversification at the same time.

3. Solar cold-chain and ice access for traders and processors

Trade is already efficient in physical terms, but the OM shows that around 0.8% of traded fish, about 442 kg, is sold at reduced price because quality has deteriorated. The

report also repeatedly highlights weak cold-chain infrastructure and storage constraints. This makes low-cost cooling, solar cold rooms, ice hubs and related services a clear priority. The aim is not simply to prevent spoilage, which is already low, but to retain value, reduce distressed sales and allow more flexible market timing.

4. Reusable crate and low-waste packaging systems

The OM identifies spoilage and packaging waste during transport, single-use plastics at storage and packaging stages, and wider opportunities for reusable or biodegradable alternatives. Compared with kilns or processing hubs, crate systems are often simpler to introduce and less capital-intensive. They may not transform the chain on their own, but they can improve handling, reduce damage, cut disposable packaging and support better hygiene and logistics. This makes them a sensible second-tier priority.

5. Aquaponics, sludge composting and wastewater reuse at production nodes

The OM points to wastewater, sludge and bycatch at production level as significant circularity gaps, with aquaponics and sludge composting highlighted as practical responses. These opportunities are important because they extend circularity beyond the post-harvest system. However, they are also more dependent on local production conditions, technical capacity and site-specific infrastructure. For that reason, they are prioritised, but not placed ahead of the more immediate post-harvest hotspots.

6. Cluster-based cooperative and leasing models for micro-enterprises

The OM makes clear that many businesses are too small to invest in cold storage, waste processing or upgraded equipment on their own. About 50% of businesses have no employees, and the report explicitly recommends cooperative models, shared infrastructure, and improved access to finance. Cluster-based leasing and shared-

service approaches are therefore essential if the other priorities are to be adopted by the actors who most need them.



Table 3.3: Prioritised opportunities for the first phase of the roadmap

Opportunity	Why it is prioritised now	Main value expected
Efficient smoking and clean-processing upgrades	Direct response to the biggest measured environmental hotspot	Lower wood use, lower cost, better quality, safer working conditions
By-product valorisation enterprises	Direct response to the biggest measured material leakage	New income streams, reduced waste, stronger local circularity
Solar cold-chain and ice access	Direct response to hidden value loss in trade and weak storage systems	Better quality retention, reduced discounting, stronger market resilience
Reusable crates and low-waste packaging	Practical logistics improvement with moderate cost and visible benefits	Less damage, less disposable packaging, better handling
Aquaponics/sludge composting/wastewater reuse	Extends circularity to production and supports local nutrient recovery	Better resource use, reduced pollution, new local applications
Cluster-based cooperative and leasing models	Makes adoption possible for small and under-capitalised operators	Shared access, lower entry barriers, stronger inclusion

3.4 Feasibility and Impact Assessment

The OM states that one of the objectives of the exercise was to rank and prioritise circular solutions based on feasibility and impact. However, the report does not present a single formal scoring matrix with weighted criteria. The assessment below therefore translates the report's findings into a practical planning judgement. In other words, these ratings are roadmap judgements derived from the OM evidence, not a claimed verbatim ranking table from the report itself. That distinction is important and should be maintained.

Efficient kilns and clean smoking - Feasibility: High | Impact: Very High

This scores highest overall because the problem is clearly measured, the intervention is well understood, and the gains are likely to be multi-dimensional. The OM identifies smoking as the heaviest resource burden in the chain, with fuelwood use at around 1.31 kg per kg of fish processed. It also links traditional smoking to deforestation, air pollution, inconsistent quality and difficult working conditions. Improved kilns and cleaner energy systems therefore offer strong environmental, economic and social returns. Feasibility is rated high because the technology pathway is relatively clear, even if uptake will still require finance and demonstration.

By-product valorisation - Feasibility: Medium | Impact: Very High

The potential impact is very high because the volume of currently unmanaged by-products is large and the business case is potentially strong. However, feasibility is rated slightly lower than clean smoking because successful valorisation depends on multiple changes occurring simultaneously: segregation, collection, storage, quality control, product testing, market linkage, and, sometimes, basic processing equipment. It is highly promising, but it is more system-dependent than kiln upgrading.

Solar cold chain and ice hubs - Feasibility: Medium-High | Impact: High

The OM makes a strong case for cold-chain support because it addresses hidden economic loss and improves resilience in trading and storage. The impact is rated high rather than very high because the measured physical spoilage at trade is already low; the main benefits lie in value retention, timing flexibility, and market stability. Feasibility is medium-high because there are workable service models, but operation, maintenance and financing remain significant practical considerations.

Reusable crates and packaging redesign - Feasibility: High | Impact: Medium

This is comparatively easy to implement and does not necessarily require major infrastructure. It can be introduced through market associations, cluster arrangements or leasing systems. For that reason, feasibility is high. Impact is rated medium because this is a useful enabling measure, but it does not address the largest hotspot on its own. It is best understood as a practical supporting intervention rather than the main engine of change.

Aquaponics and sludge composting - Feasibility: Medium | Impact: Medium-High

These opportunities have strong circular logic and could be particularly useful in aquaculture-linked settings. They are rated below the post-harvest priorities because they are more technically specific and less universally applicable across the initial pilot geography. Their impact can still be meaningful, especially where nutrient recovery and wastewater management are pressing local issues.

Local feed and plastic recovery - Feasibility: Medium | Impact: Medium

The OM identifies inefficient material use and plastic waste at input supply as real issues, and local feed production has value

in reducing dependence on external inputs. Even so, these opportunities feel one step further from the most acute measured hotspots in the baseline. They are worth

developing, but they are better treated as later-phase or complementary actions rather than first-wave priorities.

Table 3.4: Feasibility and impact assessment

Opportunity	Feasibility	Impact	Justification
Efficient kilns/clean smoking	High	Very High	Strongest measured hotspot; clear gains on wood use, cost, quality and health
By-product valorisation	Medium	Very High	Large biomass stream and strong circular case, but depends on aggregation and quality control
Solar cold chain/ice hubs	Medium-High	High	Tackles hidden value loss and market resilience, though service delivery must be sustained
Reusable crates/packaging redesign	High	Medium	Easier to introduce and less capital-intensive, but not sufficient on its own
Aquaponics/sludge composting	Medium	Medium-High	Good production-side circularity opportunity, but more site-specific and technical
Local feed and plastic recovery	Medium	Medium	Valuable for system strengthening, but less immediate than post-harvest priorities

Summary table

Priority tier	Opportunities	What this means in practice
Tier 1	Clean smoking; by-product valorisation; cold chain	Start here first, because these areas match the strongest evidence of loss, cost and unrealised value
Tier 2	Reusable crates/packaging; cooperative and leasing service models	Use these to support adoption, improve logistics and lower barriers for small operators
Tier 3	Aquaponics; sludge composting; local feed and plastic recovery	Develop as complementary or second-wave actions, especially where local conditions are suitable

Overall, the case for prioritisation is strong and consistent. The roadmap should start where the evidence is clearest: processing, by-product recovery and cold-chain support. Those areas combine measurable inefficiency, practical circular opportunity and strong relevance for the women-led micro-enterprises that dominate the post-harvest economy. The wider set of opportunities remains important, but the first phase should focus on interventions that can demonstrate clear results, build confidence and create the conditions for broader replication across Ghana's fish value chain.

Step 4: Stakeholder Mapping and Engagement Design

The OM shows that the fish value chain is not driven by one group alone. It links producers, processors, traders, aggregators, cold stores, wholesalers and retailers, and it is supported by feed production, boat and gear supply, transport, ice production, credit services, and regulatory oversight from agencies such as MoFAD and the Fisheries Commission. The same report also shows that the main circular economy pressures lie in the post-harvest system, particularly in processing and trade. That means stakeholder engagement must centre on the people and institutions that shape processing, storage, quality, transport, waste handling and finance.

The actor profile in the OM also gives this section a clear social focus. Production is male-dominated, but processing and trading are overwhelmingly female: 90.5% of processors and 97.0% of traders in the sample were women. Most of these businesses are very small, with an average workforce of 2.7 persons for processors and 1.4 persons for traders, and a median of zero employees in both cases. The report

also notes that processors cited access to finance and market access as major challenges, while traders pointed to storage, cold chain and finance. These findings point to a stakeholder design that is practical, local and strongly focused on the post-harvest economy.

4.1 Key Stakeholders and Institutional Roles

The OM describes a value chain that begins with input supply and production, moves through post-harvest handling and processing, and then into distribution and marketing through aggregators, cold stores, wholesalers and retailers. It also identifies the supporting services around that chain, including transport, ice production, credit and regulatory oversight. On that basis, the roadmap should organise stakeholders around four functions: production and supply, post-harvest handling and trade, support services, and oversight and coordination.

Figure 4.1: Stakeholder structure across the fish value chain



Processors and traders hold the most significant operational roles in this roadmap. That

is because the OM identifies processing as the main hotspot for waste generation and fuelwood use, while trade is where hidden value loss appears through quality deterioration. Since women dominate both of these segments, they are not simply one stakeholder group among many. They are the core user group for any circular intervention in this value chain.

Table 4.1: Key stakeholders and institutional roles

Stakeholder	Role in the value chain	Relevance to the roadmap
Fishers and aquaculture producers	Supply raw fish into the chain	Important for handling quality at source, raw material flow, and management of early-stage residues and losses
Processors	Smoke, dry, salt, fry, gut, wash, package and store fish	Central actors for efficient kilns, by-product segregation, improved hygiene, and cleaner processing
Traders	Purchase, handle and sell fish to consumers	Central actors for cold-chain use, quality preservation, reduced discounting and better handling
Aggregators, cold stores, wholesalers and retailers	Move fish through distribution and marketing channels	Important for storage, distribution, quality maintenance and market access
Feed suppliers, boat and gear suppliers	Provide essential inputs and equipment to production systems	Part of the wider support structure identified in the OM
Transport providers	Move raw and processed fish between nodes	Relevant because transport affects spoilage, quality and cost
Ice providers	Support cooling and product preservation	Relevant because the OM identifies cold-chain weakness and storage constraints
Credit services	Provide finance to actors in the chain	Relevant because finance is repeatedly identified as a constraint, especially for processors and traders
MoFAD	Regulatory and sector oversight	Identified in the OM as part of the value chain's regulatory support structure
Fisheries Commission	Regulatory and sector oversight	Identified in the OM alongside MoFAD as part of the chain's oversight framework

The OM also points to the need to recognise stakeholders not only by formal position, but by where they sit in the chain's main pressure points. Processors are the main actors at the point where fish offal, bones, scales and fuelwood use become major circularity issues. Traders are the main actors at the point where storage and cold-chain limitations affect quality and price. Credit services are important because lack of finance limits the ability of small operators to invest in better equipment, storage or waste recovery. MoFAD and the Fisheries Commission are important because the OM places them within the chain's regulatory support system.

4.2 Stakeholder Engagement Platforms

The OM's own methodology provides the best guide for engagement design. The study used a mixed-methods approach combining desk research, key informant interviews, face-to-face interviews, focus group discussions and field observation across four districts. That is a useful model for the roadmap itself. It suggests that stakeholder engagement should be continuous, local and practical, rather than limited to formal meetings alone.

For this roadmap, three engagement platforms are appropriate:

Regional Design Labs

These should bring together the main categories of actors identified in the OM across the Ashanti and Eastern Regions: producers, processors, traders, support service providers, and relevant sector institutions. Their purpose should be to review evidence, agree on district priorities, and refine the pilot design based on the actual conditions in Bosomtwe, Atwima Nwabiagya North, Kumasi, and Asuogyaman. This follows directly from the OM's district-

based approach and its emphasis on context-specific entry points.

Value Chain Forums

These should create a wider space for the chain actors already named in the OM - including producers, processors, traders, aggregators, cold stores, wholesalers, retailers, transport providers, ice providers, credit services and sector institutions - to address cross-cutting issues such as quality, cold storage, waste handling and market linkages. This is justified by the OM's description of the chain as an interconnected system rather than a set of isolated actors.

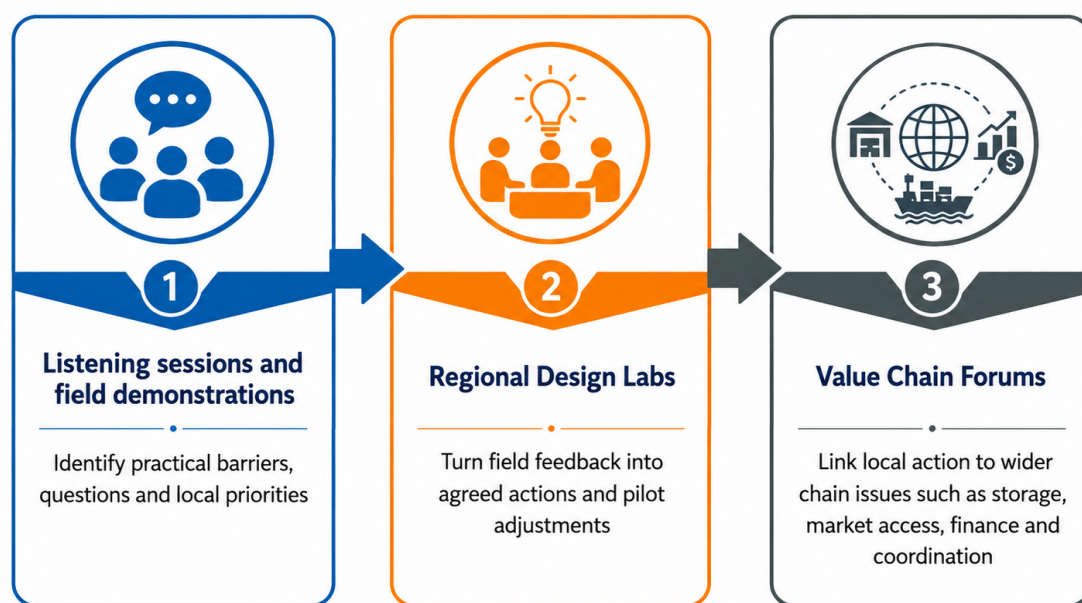
Listening Sessions and Demonstrations

These should be held close to the main constraints: processing sites, trading points, landing areas, and storage locations. The OM shows that many of the businesses involved are small, informal and often run by women with basic or no formal education. It also notes the need for practical, visual and hands-on approaches to support uptake. For that reason, listening sessions and demonstrations should be used to test improved practices in ways that are easy to understand and directly linked to daily work.

Table 4.2: Stakeholder engagement platforms

Platform	Main purpose	Main participants	Use in the roadmap
Regional Design Labs	Co-design and adaptation of interventions by region and district	Producers, processors, traders, support-service actors, MoFAD, Fisheries Commission	To shape pilots and respond to district-specific conditions
Value Chain Forums	Joint discussion of market, storage, quality and circularity issues across the chain	Producers, processors, traders, aggregators, cold stores, wholesalers, retailers, transporters, ice providers, credit services, sector agencies	To align action across the chain and address bottlenecks that no single actor can solve alone
Listening Sessions and Demonstrations	Practical engagement, trust-building and testing of new practices	Processors, traders, producers and local support actors	To support uptake through direct demonstration and feedback

Figure 4.2: Practical engagement flow



Stage	Purpose
Listening sessions and field demonstrations	Identify practical barriers, questions and local priorities
Regional Design Labs	Turn field feedback into agreed actions and pilot adjustments
Value Chain Forums	Link local action to wider chain issues such as storage, market access, finance and coordination

Summary table

Element	Roadmap position
Core stakeholder focus	Processors and traders, because the OM shows that the main circularity pressures sit in processing and trade
Key production-side actors	Fishers and aquaculture producers as suppliers of raw material and entry points for better handling
Key market actors	Aggregators, cold stores, wholesalers and retailers as the main distribution and market channels
Key support actors	Transport, ice production and credit services, because the OM links them to quality, storage and finance constraints
Key institutions	MoFAD and the Fisheries Commission, as the regulatory oversight bodies named in the OM
Preferred engagement style	Mixed-method, district-based and practical, reflecting the approach used in the OM itself

Step 5: Pillars, Levers and Enablers

Step 5 translates the OM into a practical architecture for action. The evidence points to a fish value chain with three clear pressure points: first, heavy fuelwood use and weak processing efficiency; second, the loss of value through unmanaged by-products and weak recovery systems; and third, the vulnerability of small, women-led enterprises that operate with limited capital, weak infrastructure and low access to modern equipment. The roadmap pillars therefore need to do three things at once: reduce avoidable waste, improve productivity and product quality, and strengthen the conditions under which small operators can adopt change. The OM is especially clear that the strongest circular economy opportunities are concentrated in and around the post-harvest system. Processing remains the most resource-intensive stage, fuelwood use is exceptionally high, by-products are largely unmanaged, and cold-chain weakness continues to affect quality and market value. At the same time, processing and trading are overwhelmingly female, mostly small-scale, and often constrained by limited financial resources, storage, and formal support. These findings shape the pillars below.

5.1 Strategic Pillars

1. Low-Emission Processing and Cold-Chain Modernisation

The first pillar responds to the clearest environmental and operational hotspot identified in the OM: traditional fish smoking. The report shows that fuelwood use averages about 1,313 kg per 1,000 kg of fish processed, or roughly 1.31 kg of wood for every 1 kg of fish. This is the heaviest resource burden recorded in the quasi-LCA, and it is directly linked to deforestation, smoke exposure, emissions, and avoidable production costs. The same section of the OM also points to the need for renewable energy for cold storage and lighting, and the recommendations call

for improved smoking technologies, clean energy alternatives, solar-powered storage, community cold hubs and off-grid solutions.

This pillar is therefore about more than replacing one type of kiln with another. It is about improving the whole post-harvest operating environment: cleaner smoking, more reliable cooling, stronger handling, and better logistics. The expected results are lower wood use, more stable product quality, reduced smoke-related risks, and less pressure to sell quickly at reduced prices.

2. By-product Valorisation and Resource Recovery

The second pillar follows directly from the material flow analysis. At the processing stage, across the processors surveyed, about 4,864 kg of by-products are generated per cycle, equivalent to about 25% of the raw fish input. The OM notes that none of the surveyed processors reported using these materials for animal feed, and presents this as the strongest material leakage in the chain. It also identifies clear opportunity streams for fishmeal, compost, collagen and other value-added products.

This pillar therefore focuses on turning what is now discarded into something useful and marketable. In practical terms, that means better segregation of offal, heads, scales and bones; simple collection and handling systems; and small-scale equipment or partnerships that can support conversion into useful products. The OM extends this recovery logic beyond processing alone. Its circularity gap table points to wastewater, sludge, and bycatch in production; offal recovery at landing; market waste at retail and consumption; and wider opportunities, such as composting, biogas, and circular enterprises, at the disposal stage. This means resource recovery should be understood as a value-chain-wide pillar, even though it begins most urgently at the processing stage.

3. Women-Centred Enterprise Strengthening

The third pillar is grounded in the chain's social profile. The OM shows that 90.5% of processors and 97.0% of traders are women, and that most operations are micro-enterprises with average workforces of 2.7 and 1.4 respectively, and a median of zero employees in both groups. It also identifies access to finance, storage, cold chain, market access and limited formal support as key barriers.

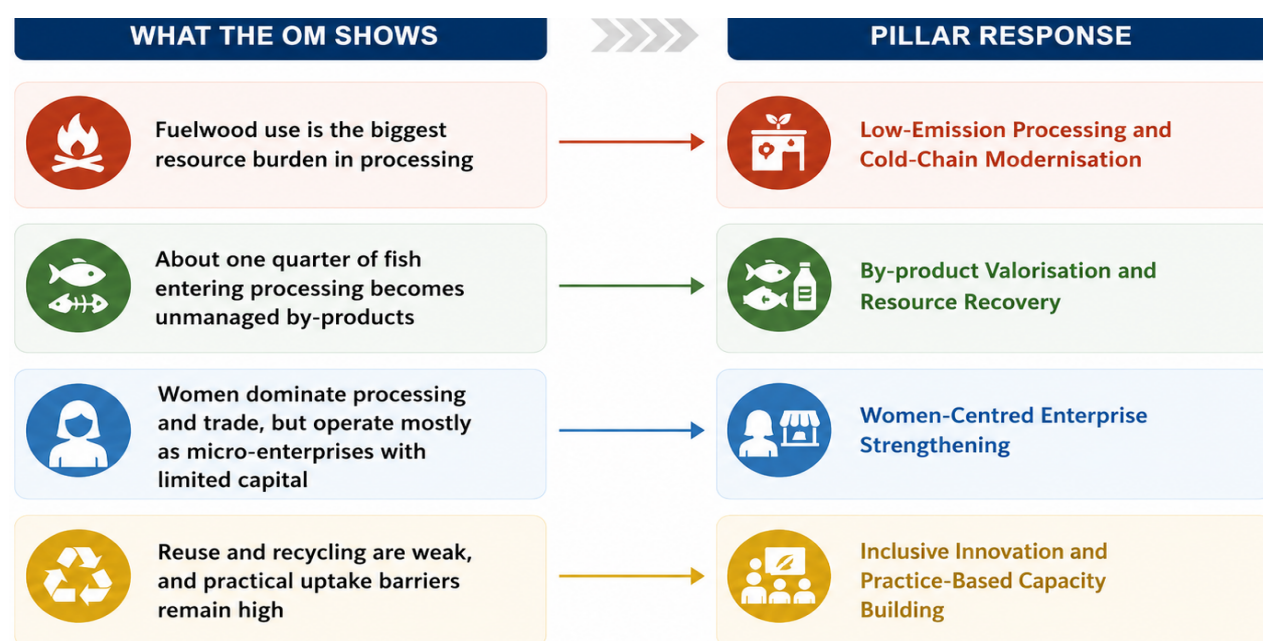
This pillar recognises that circular upgrading will only work if it works for the women who already carry most of the labour and commercial risk in the post-harvest economy. The OM recommends gender-sensitive financial products and credit schemes, women-focused cooperatives and producer groups, support for enterprise upgrading, health and safety training, and social protection mechanisms. It also stresses that training must be practical, visual and accessible to people with basic or no formal education. Together, these findings justify a pillar centred on enterprise resilience, safety, organisation and inclusion.

4. Inclusive Innovation and Practice-Based Capacity Building

The fourth pillar brings together the OM's repeated emphasis on awareness, training, demonstration and practical uptake. The report shows that 87% of processors and 93% of traders report no reuse of waste, and only a small minority expressed interest in reuse. It also notes that limited education, low awareness of circular options, and weak access to infrastructure can slow adoption. For this reason, the OM recommends awareness campaigns, demonstration projects, practical hands-on training, and literacy-inclusive materials. It also points to youth skills development and entrepreneurship support as part of broader efforts to broaden participation in the sector.

This pillar is therefore about making circular change visible, understandable and workable. It is not mainly about advanced technology. It is about building confidence through practical learning, showing the business case for reuse and recovery, and making new practices easier to adopt in small enterprises with limited capital and limited formal training.

Figure 5.1: How the four pillars respond to the OM



5.2 Policy Instruments and Delivery Levers

The OM identifies a set of practical levers that can move these pillars from principles to action. These are not abstract policy ideas. They come directly from the report's recommendations, the hotspot analysis, and the discussion of current circularity gaps.

a. Subsidies and financing schemes for improved smoking and clean energy alternatives

The OM explicitly recommends prioritising subsidies, financing schemes, and community-based demonstrations to accelerate the adoption of improved smoking technologies and clean energy alternatives. This is a direct response to the high fuelwood-to-fish ratio and the low ability of small processors to finance upgrades on their own.

b. Microcredit and green finance for shared infrastructure

The hotspot analysis states that many operators cannot afford cold storage, solar drying, or waste-processing equipment independently and recommends improved access to microcredit and government-backed green financing schemes. It also points to the value of communal cold rooms and shared processing hubs. This makes

finance not just a support measure, but a central delivery lever.

c. Community cold hubs, solar-powered storage and off-grid cooling

The recommendations section calls for stronger cold-chain and market infrastructure, including solar-powered systems, community cold hubs and off-grid solutions. These are practical levers for reducing quality deterioration in trade and easing pressure on traders to sell quickly at reduced prices.

d. Training, demonstrations and awareness campaigns

The OM repeatedly recommends training, awareness and demonstration. It calls for practical, visual and hands-on training for women and low-education groups; community-based demonstrations for smoking technologies; and awareness

campaigns and demonstration projects on reuse and recycling tailored for informal businesses. These are not secondary measures. They are central to uptake in a chain where formal education levels are modest and reuse practices remain weak.

e. Women-focused cooperatives and producer groups

The OM recommends that women-focused cooperatives and producer groups serve as platforms for scaling training and improving access to finance. The hotspot analysis also recommends cooperative models

and shared infrastructure, especially where businesses are too small to invest individually. This makes group organisation an important practical lever for scale.

f. Private-sector partnerships and small-scale processing equipment

For by-product recovery, the OM recommends training, small-scale processing equipment and private-sector partnerships. These are important delivery levers because valorisation depends not only on recovering waste, but on converting it into products that can be used or sold.

Table 5.1: Policy instruments and delivery levers drawn from the OM

Policy instrument/lever	What it supports	OM basis
Subsidies and financing schemes	Faster uptake of improved smoking technologies and clean energy alternatives	Recommendations on improved smoking technologies
Community-based demonstrations	Practical adoption of improved kilns and cleaner processing systems	Recommendations on smoking technology uptake
Microcredit and green finance	Access to cold storage, solar drying, waste processing equipment and business upgrading	Hotspot analysis on financial constraints
Community cold hubs/off-grid cooling	Better storage, reduced quality loss, improved market resilience	Cold-chain recommendations
Practical, visual and hands-on training	Better uptake among women and low-education groups	Social profile and recommendations
Awareness campaigns and demonstration projects	Stronger reuse and recycling culture	Hotspot analysis on limited reuse and recycling
Women-focused cooperatives and producer groups	Shared learning, shared services and stronger finance access	Recommendations on capacity building and inclusion
Small-scale equipment and private-sector partnerships	Conversion of by-products into viable products	By-product valorisation recommendation

5.3 System Enablers

The OM also makes clear that the transition will depend on a set of enabling conditions. Without these, even well-targeted interventions are likely to remain isolated.

Practical, literacy-inclusive training systems

Processors and traders are mostly women, and most have only basic education, with significant minorities having no formal education. The OM therefore stresses the need for practical, visual, hands-on and literacy-inclusive training materials. This is a basic system enabler for every pillar in the roadmap.

Shared infrastructure for small operators

The report repeatedly points to the micro-scale nature of the businesses involved and the need for communal cold rooms, shared processing hubs, and other forms of collective access to equipment. This is especially important because around half of businesses have no employees and limited ability to invest alone. Shared infrastructure is therefore an enabling condition for both resource recovery and cold-chain improvement.

Access to finance and business resilience tools

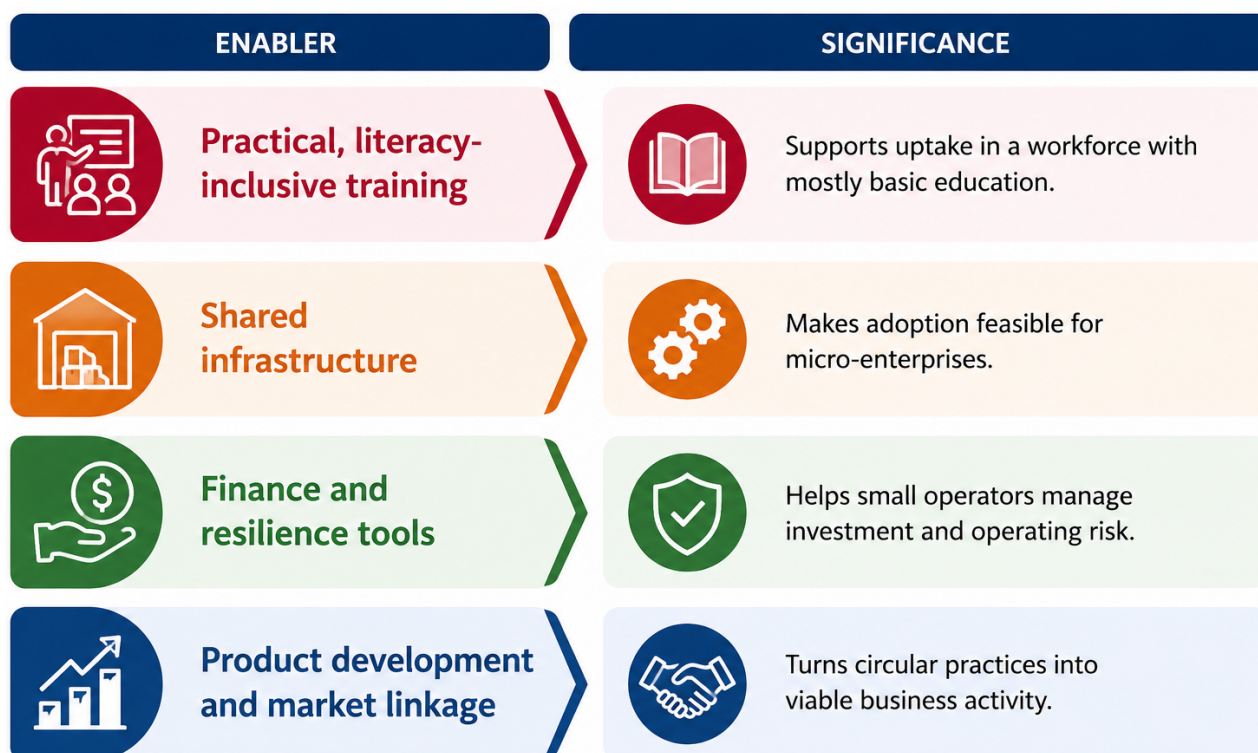
The recommendations section extends beyond equipment finance and includes group savings, digital payment systems, health and safety training, and social protection mechanisms for micro-businesses. These are enabling conditions because they make it more likely that small firms can absorb risk, manage cash flow, and sustain improvements over time.

Partnerships for product development and market linkage

The OM recommends private-sector partnerships for by-product valorisation and links better processing, cold storage and transport to improved market access and higher-value sales. That makes market linkage an enabler, not just an outcome. New circular practices will spread more easily where there is a clear route from recovered material to usable product and from improved quality to better prices.



Figure 5.2: Core enabling conditions



Summary table

Pillar	Main lever	Expected shift
Low-Emission Processing and Cold-Chain Modernisation	Improved smoking technologies, clean energy alternatives, solar-powered storage, better logistics	Lower fuelwood dependence, stronger product quality, reduced value loss
By-product Valorisation and Resource Recovery	By-product collection, small-scale processing equipment, private-sector partnerships	Less waste, more value retained, new commercial uses for residues
Women-Centred Enterprise Strengthening	Gender-sensitive finance, cooperatives, safety training, business upgrading support	Stronger women-led enterprises and better resilience in the post-harvest economy
Inclusive Innovation and Practice-Based Capacity Building	Practical training, demonstrations, awareness campaigns, literacy-inclusive materials	Higher adoption of circular practices and wider uptake across small operators

Step 6: Pilot Design and Execution

The OM points to three practical areas where early action is most likely to show visible results: cleaner processing, recovery of fish by-products, and better cold handling in trade. This is a sensible sequence. Processing is the point where the chain uses the most fuelwood and where the largest material leakage occurs. Trade, by contrast, is physically efficient but still loses value due to quality deterioration. The report's recommendations also converge around these same themes: improved smoking technologies, clean energy alternatives, by-product valorisation, stronger cold-chain infrastructure, and tailored support for women and low-literacy groups.

The three pilots below are therefore designed as demonstration pilots, not as full national programmes. Each one responds directly to a hotspot identified in the OM. Together, they test whether circular economy interventions can reduce waste, improve product quality, lower pressure on natural resources, and strengthen the economic position of small operators in the fish value chain.

6.1 Pilot 1: Clean Smoking and Safer Processing Cluster

Context and rationale

The OM identifies fish processing as the clearest hotspot in the value chain. Across the surveyed processors, around 19,454 kg of fresh fish are handled in a typical processing cycle. About 14,772 kg becomes an edible product, while about 4,864 kg exists as by-products. At the same time, the processing stage has the highest resource burden, with an average fuelwood use of about 1,313 kg per 1,000 kg of fish processed, or roughly 1.31 kg of wood per 1 kg of fish. The report is explicit that traditional smoking remains dominant and is associated with high fuelwood consumption, air pollution from

smoke, inconsistent product quality, and difficult working conditions. It also notes that processing is overwhelmingly female, with 90.5% of processors being women.

The purpose of this pilot is to test whether a cluster-based approach to cleaner smoking can reduce wood use, improve processing conditions, and support more consistent product quality in a setting that reflects the realities of women-led micro-enterprises. The pilot also responds to the OM's recommendation to promote improved smoking technologies and clean energy alternatives through financing and community-based demonstrations.

Proposed pilot objective

To demonstrate that improved smoking systems, combined with practical training and simple monitoring, can reduce fuelwood dependence and improve working conditions and product quality in selected processing clusters.

Key activities

- install and test improved kilns or more efficient smoking systems in selected processing clusters
- introduce simple monitoring of wood use, batch size and output quality
- train processors in hygiene, grading, offal sorting, safe handling, recordkeeping and basic cost tracking
- compare traditional and improved smoking systems on fuel use, throughput, product consistency and ease of use
- document user experience, especially among women processors, to understand what supports or limits uptake.

Justification for this pilot

This pilot is justified on three grounds from the OM. First, processing is the biggest measured environmental hotspot in the chain. Second, the report explicitly recommends improved smoking technologies and clean energy alternatives. Third, the main users are women working in small enterprises, so demonstration-led upgrading at cluster level is more realistic than expecting isolated individual uptake.

include fewer complaints about product inconsistency, a visible reduction in smoke exposure at pilot sites, and simpler batch records that show better control over inputs and outputs. The exact product-quality metrics should be finalised during pilot preparation, but the case for tracking them is justified by the OM's repeated concern with inconsistent quality and the need for practical training.

Proposed success criteria

The first success test is whether fuelwood intensity falls materially from the current baseline. A practical pilot target is to reduce average wood intensity in participating sites to 0.90 kg of wood per kg of fish or below within 12-18 months. This target is derived from the OM baseline of 1.31 kg/kg and gives a clear threshold for judging whether upgraded smoking systems are performing better. A second success test is whether processors actually use the systems and adopt the associated practices; a working benchmark is at least 30 processors trained and applying the improved methods. Additional signs of success would

Stakeholders and roles

Processors should be the lead adopters, since they operate the smoking systems and handle the fish directly. District-level actors are important because processing conditions, market siting and shared infrastructure often depend on local arrangements. The Fisheries Commission is relevant because the OM places it within the chain's support and oversight system. Equipment suppliers and fabricators are needed to install and maintain smoking technologies. Research and technical partners are needed for performance comparison and training support. Finance actors are relevant because the OM identifies finance as a major constraint to technology uptake.

Table 6.1: Pilot 1 design summary

Element	Pilot design
Pilot title	Clean Smoking and Safer Processing Cluster
Core problem	Fuelwood-heavy processing, smoke exposure, inconsistent product quality
Baseline evidence	~1.31 kg wood per kg fish processed; processing is women-led and resource-intensive
Primary objective	Show that improved smoking systems can reduce wood use and improve processing conditions
Main activities	Install improved kilns; monitor wood use; train processors; compare old and improved methods
Suggested pilot users	Women processors in selected cluster sites
Proposed success markers	Lower wood intensity; trained users applying improved practice; reduced smoke burden; more consistent product quality

6.2 Pilot 2: Fish By-product Recovery and Valorisation Micro-Hub

Context and rationale

The second pilot responds to the clearest material leakage identified in the OM. Across the surveyed processors, about 4,864 kg of by-products are generated per processing cycle. This is roughly 25% of raw fish input and consists mainly of heads, bones, guts and related residues. The OM states that these materials are typically discarded and that respondents reported 0% use for animal feed. The report identifies this as a key circularity hotspot and recommends developing by-product valorisation pathways, supported by training, small-scale equipment, and private-sector partnerships. It also notes the broader opportunity to convert fish waste into fishmeal, organic fertiliser, collagen and other useful products.

This pilot is designed to move that opportunity from theory to a manageable test. It proposes a small recovery hub linked to participating processors. The focus is on whether a basic system of separation, collection, handling, and first-stage conversion can recover value from materials currently treated as waste.

Proposed pilot objective

To test whether fish by-products from selected processors can be collected, handled safely and converted into saleable or usable secondary products at micro-hub scale.

Key activities

- organise source segregation of heads, bones, guts and scales at participating processing sites
- establish a micro-hub for basic drying, grinding, compost blending or similar first-stage processing
- test small product streams that reflect the opportunities named in the OM, such as feed ingredients, soil amendments or other simple bio-inputs
- put in place basic hygiene, sorting and handling procedures to improve product consistency
- link the hub to potential users or buyers, including livestock keepers, crop producers or small commercial buyers where appropriate.

Justification for this pilot

The justification is straightforward. The OM identifies by-products as the largest measured material loss in the chain. It also notes that these materials have recognised value potential, but that this potential remains largely untapped. Since the report recommends small-scale equipment and private-sector partnerships rather than large central facilities alone, a micro-hub model is a direct and proportionate response to the evidence.



Proposed success criteria

A credible first success criterion is whether the pilot can recover a meaningful share of the by-products generated by participating processors. A reasonable pilot benchmark is to recover at least 50% of the by-products from those participating sites. This does not claim that half of all by-products in the wider value chain will be recovered immediately; it is a pilot-level target derived from a baseline where recovery is currently close to zero. A second success criterion is whether the pilot can produce two or three usable secondary products that meet a standard that users or buyers are willing to test. A third criterion is whether the hub creates a small number of direct jobs or paid roles in sorting, handling, or processing, particularly for women and youth, consistent with the OM's wider emphasis on employment and enterprise upgrading. Finally, a visible reduction in uncontrolled dumping, odour or

unmanaged residues around participating sites would be an important operational indicator of success.

Stakeholders and roles

Processors are central because they generate the material and must sort it at source. Traders may support coordination where mixed handling or market-side recovery is relevant. Livestock and crop producers are likely users of the feed or soil-input products suggested in the OM. Research institutions and technical partners are important because product quality and basic process design will need testing and refinement. Private buyers and enterprise partners are important because valorisation only works if there is some route to use or sale. Finance actors are relevant because even a micro-hub will require working capital and basic equipment.

Table 6.2: Pilot 2 design summary

Element	Pilot design
Pilot title	Fish By-product Recovery and Valorisation Micro-Hub
Core problem	Large volumes of by-products are discarded with little or no structured reuse
Baseline evidence	~4,864 kg by-products per processing cycle; roughly 25% of raw fish input; 0% reported use for animal feed
Primary objective	Test whether basic recovery and conversion can turn discarded by-products into usable outputs
Main activities	Source segregation; collection; basic drying and grinding; product testing; simple hygiene procedures
Suggested pilot users	Participating processors plus potential users or buyers of recovered materials
Proposed success markers	Meaningful recovery rate; 2-3 usable products tested; reduced dumping; small job creation

6.3 Pilot 3: Solar Ice, Cold Storage and Reusable Crate Service

Context and rationale

The OM shows that trade performs well in physical terms but still experiences hidden value loss. Traders procure around 57,529 kg of fish per cycle and sell about 56,624 kg, equivalent to 98.4% of what they buy. Spoilage is very low. However, around 442 kg, or about 0.8% of traded fish, is sold at reduced price because quality has deteriorated before sale. The report also identifies weak cold-chain infrastructure, inadequate storage, and pressure to make quick sales as important constraints. It recommends stronger cold-chain and market infrastructure, including solar-powered systems, community cold hubs and off-grid solutions.

This pilot responds to that specific problem. It does not treat trade as a waste-heavy stage. Instead, it treats it as a stage where better cooling and handling can protect value that is already close to market. The reusable crate component addresses the OM's concerns about better handling, packaging, and logistics, while the cold-room or ice-point component addresses the storage gap more directly.

Key activities

- establish mini solar cold rooms, ice points or similar low-scale cooling services in selected trading or landing locations
- test reusable crates or similar handling systems in place of packaging or handling methods that contribute to damage or poor quality retention
- train traders in icing, handling, sorting, grading and simple stock or quality logging
- test basic service-fee arrangements and group management options to understand whether the service can be used consistently.

Proposed pilot objective

To test whether small-scale cold-chain services and improved handling systems can reduce quality-related discounting and improve price realisation in selected market and landing-site locations.

Justification for this pilot

This pilot is justified because the OM shows a clear gap between high physical turnover and avoidable value loss. Fish is still reaching buyers, but some of it is no longer reaching them at full value. Since traders themselves identified storage and cold-chain limitations as key challenges, and the recommendations call for stronger cold-chain infrastructure, a service-oriented pilot is well supported by the evidence.

Proposed success criteria

The main success test is whether the share of fish sold at reduced value falls in participating markets. A practical pilot benchmark is to reduce the discounted fish volume to 0.4% or lower in those sites. This target is grounded in the OM's baseline. It reflects the fact that the pilot is trying to improve value retention rather than eliminate spoilage entirely. A second test is whether traders use the service regularly; the draft benchmark of at least 50 regular users is appropriate for a market-facing pilot of this kind, provided the specific site can support that scale. A third test is whether reusable crates replace a measurable share of current handling materials. A fourth is whether traders report improvement in shelf-life, product condition or price realisation. Those outcome areas are directly justified by the OM's evidence on cold-chain weakness, handling constraints and discounted sales.

Stakeholders and roles

Trader groups and market leaders are central because they control the day-to-day use of the service. Cold-chain providers and solar equipment suppliers are important because the OM specifically highlights the need for renewable energy and off-grid cooling. District-level actors are relevant

where siting, market management or local infrastructure is involved. Finance actors are important because service models still require upfront capital or working finance.

Table 6.3: Pilot 3 design summary

Element	Pilot design
Pilot title	Solar Ice, Cold Storage and Reusable Crate Service
Core problem	Fish is sold efficiently, but some value is lost because quality declines before sale
Baseline evidence	~442 kg per cycle sold at reduced price; ~0.8% discounted due to quality loss; cold-chain gaps persist
Primary objective	Test whether cooling and better handling can improve price realisation and product quality
Main activities	Install mini cold-chain services; test reusable crates; train traders; trial service management
Suggested pilot users	Traders in selected markets and landing sites
Proposed success markers	Lower discounting; regular user uptake; measurable crate use; improved shelf-life or pricing

6.4 How the three pilots fit together

The three pilots are distinct, but they are intended to work as a connected set. The first addresses the energy and processing efficiency problem. The second addresses the material leakage problem. The third addresses the quality and market-value problem. Together, they reflect the OM's broader conclusion that Ghana's fish value chain is economically vibrant, but constrained by structural inefficiencies, heavy dependence on traditional practices, underused waste streams, and limited adoption of improved technologies.

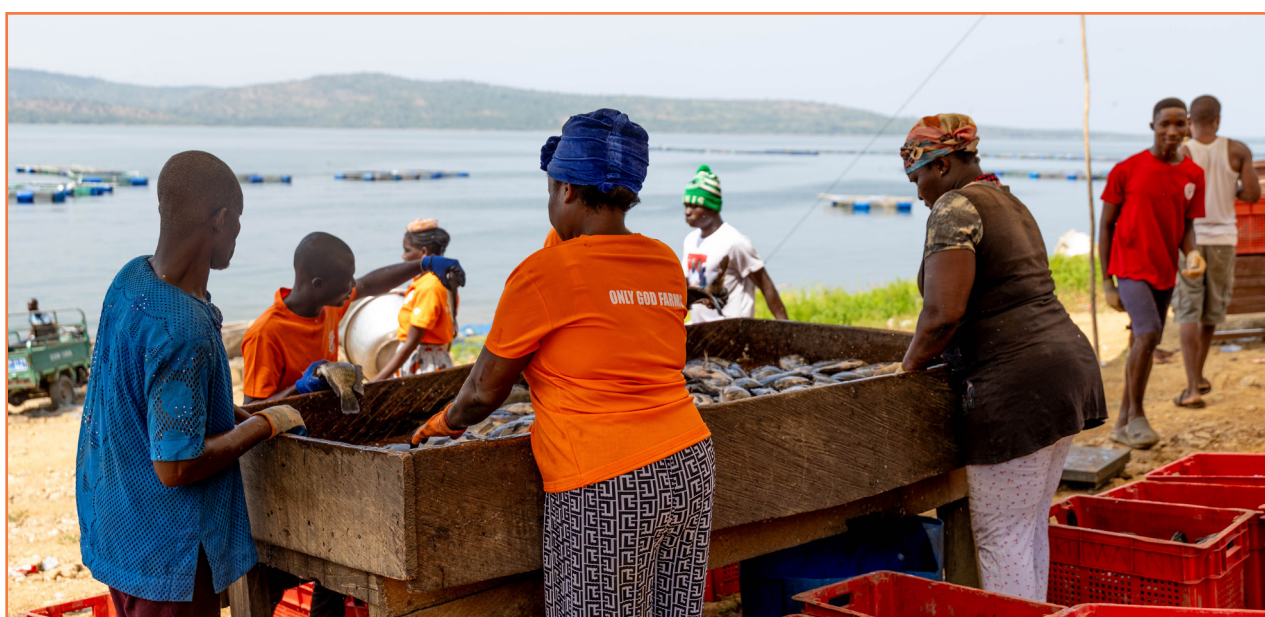
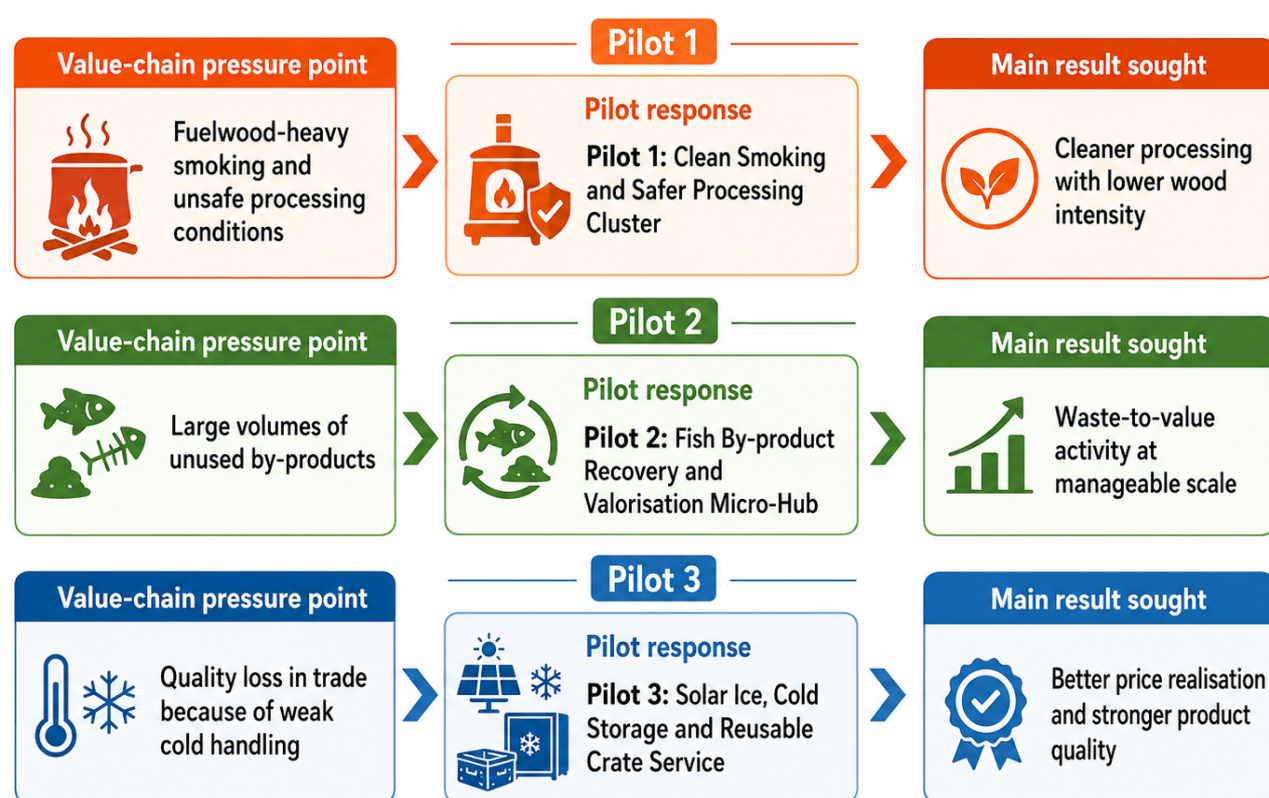


Figure 6.1: Pilot logic across the value chain



Summary table

Pilot	Core problem	Main result sought
Pilot 1	Fuelwood-heavy, smoke-intensive and inconsistent processing	Lower wood intensity, safer processing and more consistent product quality
Pilot 2	Unused by-products and unmanaged fish waste	Recovery of useful material and development of secondary products
Pilot 3	Quality deterioration in trade and weak cold-chain support	Better value retention through cooling and improved handling

These pilots are intentionally practical. They stay close to the evidence in the OM and focus on the points where the report itself sees the clearest opportunities: improved smoking systems, by-product valorisation, stronger cold-chain infrastructure, and support for the women-led enterprises that sit at the centre of the post-harvest fish economy.

Step 7: Action Plan and Implementation Pathways

The OM does not present a formal phased implementation plan, but it does provide a clear basis for one. Its findings and recommendations point consistently to the same sequence: start where the losses and burdens are greatest, test workable solutions in the four study districts, strengthen the conditions for adoption, and then expand what proves effective. The evidence in the report justifies that sequence: processing is the main hotspot for fuelwood use and by-product leakage; trade is physically efficient but still loses value through quality deterioration; and most of the actors who need to adopt change are women-led micro-enterprises facing finance, storage and infrastructure constraints.

7.1 Short-term actions (Years 1-2)

The first phase should focus on foundation and demonstration. The immediate task is not to scale everything at once. It is to organise implementation around the clearest priorities already identified by the OM, namely improved smoking technologies, by-product valorisation, stronger cold-chain support, practical training for women and low-literacy groups, and enterprise support for small operators.

The first action should be to establish implementation platforms in the four districts covered by the OM exercise: Bosomtwe, Atwima Nwabiagya North, Kumasi and Asuogyaman. This aligns with the OM's geography and provides a practical delivery framework across production, processing, trade, storage, and distribution. These district-level arrangements should bring together the main actor groups identified in the report: producers, processors, traders, support-service actors and the relevant oversight institutions.

The second short-term action should be to confirm the operational baseline needed for implementation. The OM

already provides a strong evidence base on material flows, fuelwood use, by-product generation, gender participation and business structure. What matters now is translating that evidence into site-level pilot preparation: identifying participating processors and traders, confirming current processing practices, documenting existing storage arrangements, and assessing the cluster-level infrastructure already in place. This is especially important because the OM shows that businesses are small and informal, and that practical constraints vary across actors and locations.

The third short-term action should be to launch the three priority pilot areas identified from the OM:

- cleaner smoking and safer processing
- fish by-product recovery and valorisation
- solar-supported cold-chain and handling improvements for trade. These pilots are directly supported by the report's recommendations on improved smoking technologies, by-product utilisation, cold-chain strengthening and enterprise upgrading.

The fourth action should be to develop practical training and demonstration packages. The OM is explicit that many processors and traders have only basic education, and that training must therefore be hands-on, visual and accessible. This means early implementation should not begin with technical manuals alone. It should begin with demonstration, peer learning, simple recordkeeping tools and local-language delivery.

The fifth action should be to open practical finance and support channels for small operators. The report repeatedly identifies finance as a major barrier, and recommends subsidies, financing schemes, microcredit, government-backed green finance, and stronger business support for women-led micro-enterprises. In the short term,

this means putting in place workable mechanisms that help processors and traders access improved kilns, cold storage services, small recovery equipment or shared infrastructure.

The sixth short-term action should be to put in place simple monitoring arrangements for pilots and early adopters. This is justified by the OM's own analytical approach,

which relied on material flow analysis and resource-use assessment to identify hotspots. At the implementation stage, simple records of fish input and output, wood use, by-product recovery, storage use, and product quality will be needed to compare results and guide later decisions. That is a practical inference from the OM's evidence base and from the need to test the pilots properly.

Table 7.1: Short-term actions (Years 1-2)

Action area	What should happen in Years 1-2	Why this comes first
District implementation setup	Organise implementation in Bosomtwe, Atwima Nwabiagya North, Kumasi and Asuogyaman	These are the four OM districts and cover production, processing, trade and distribution
Baseline confirmation for pilots	Identify sites, participating actors and existing operating conditions	The OM provides the strategic baseline, but pilots need site-level preparation
Pilot launch	Start action on clean smoking, by-product recovery and cold-chain support	These are the clearest priorities in the OM
Training and demonstrations	Develop visual, practical and locally accessible training packages	The OM shows that most actors are low-literacy, small-scale operators
Finance access	Introduce practical support for equipment, services and small enterprise upgrading	Finance is repeatedly identified in the OM as a major barrier
Simple monitoring	Track wood use, fish flows, product quality and recovery results	Needed to compare pilot performance and support scale-up

7.2 Medium-term actions (Years 2-3)

The second phase should focus on consolidation and selective expansion. By this stage, the initial pilots should have generated enough operational evidence to show what is working, what is not, and what needs refinement. The OM already indicates the direction of travel; the task in Years 2-3 is to turn early demonstration into more stable operating models.

The first medium-term action should be to

consolidate and compare pilot performance. Cleaner smoking sites should be assessed against traditional practice in terms of wood use, batch handling and product consistency. By-product pilots should be reviewed for recovery rates, handling practicality and product usefulness. Cold-chain pilots should be reviewed for use, quality retention and changes in price realisation. This phase is important because the OM is clear that interventions must suit micro- and small-scale actors, not just work in theory.

The second action should be to formalise supply and offtake linkages for recovered materials. The report identifies clear opportunities for fishmeal, compost, fertiliser, collagen-linked products and other value-added uses. Once basic recovery systems are functioning, the next step is to stabilise the connection between processors generating residues and the farmers, feed users or buyers who can absorb them. This gives resource recovery a practical route to market instead of leaving it as a demonstration exercise.

The third action should be to extend adoption to second-wave clusters. The OM strongly supports cluster-based and shared-service models because many businesses are too small to invest in improved equipment or storage on their own. Medium-term implementation should therefore expand from the initial pilot sites to additional groups of processors and traders in the study districts, especially where shared use of kilns, cold rooms, crate systems, or waste-handling arrangements is realistic.

The fourth action should be to embed circular actions into district-level planning and local economic development practice. This is a reasonable implementation step because the OM repeatedly links waste handling, market infrastructure, storage, cold-chain support and enterprise upgrading to place-based conditions. If successful action remains confined to isolated pilots, the wider system will not change. Integrating circular measures into district planning is therefore a justified pathway from pilot to routine local practice. This is an inference from the OM's district-based methodology and its emphasis on infrastructure, shared facilities and local constraints.

The fifth action should be to begin introducing basic quality and circularity standards around pilot activities. The OM emphasises hygienic handling, quality preservation, and cleaner processing and storage. Once pilot operations are stable, there is a clear case for simple operating standards for sorting, hygiene, storage, and handling, so that improved practices become more reliable and easier to replicate.

Table 7.2: Medium-term actions (Years 2-3)

Action area	What should happen in Years 2-3	Justification from the OM
Pilot consolidation	Compare performance and refine operating models	The OM stresses practical suitability for small actors
By-product market linkages	Connect recovered materials to users and buyers	The OM identifies clear secondary product opportunities
Second-wave cluster rollout	Expand improved kilns, cold handling and recovery systems to more groups	Shared infrastructure and cooperative approaches are recommended in the OM
District integration	Link circular actions to local planning and infrastructure decisions	The OM is district-based and highlights place-specific constraints
Basic standards and operating rules	Introduce simple quality, hygiene and handling protocols	The OM stresses product quality, hygiene and practical training

7.3 Long-term actions (Years 3-4)

The third phase should focus on scaling, institutionalisation and replication. By this stage, the roadmap should move from proving individual ideas to embedding successful approaches in the wider fish value chain. The OM provides a strong justification for this: it presents circularity not as a one-off project, but as a pathway to improve competitiveness, resilience, waste reduction, and livelihoods across the sector.

The first long-term action should be to scale the strongest models across additional fisheries and aquaculture clusters. The OM covers four districts, but its findings speak to broader patterns in the fish value chain: heavy reliance on traditional smoking, weak cold-chain support, underutilised by-products, and constraints on small enterprises. Where pilots have shown strong results, these models should be adapted and extended to other inland and, where relevant, coastal settings with similar conditions.

The second long-term action should be to make circular economy support more routine within sector and local support

systems. This includes maintaining finance pathways for small-scale equipment and shared infrastructure, continuing practical training and demonstration, and supporting local group organisation where it helps businesses access services. This step is justified by the OM's repeated concerns about weak finances, low technology uptake, and the need for ongoing capacity support.

The third action should be to connect successful business models to stronger market channels. The OM stresses that better processing, stronger cold-chain systems and improved quality can support market access and economic resilience. In the longer term, this means linking successful enterprises or clusters to larger buyers, more organised supply arrangements and, where feasible, stronger quality requirements. This is not a claim that export markets are already secured; it is a justified extension of the OM's repeated focus on quality, market access and enterprise upgrading.

The OM is careful and data-driven. The implementation pathway should be the same. Replication should follow demonstrated gains in wood use, handling, recovery, quality retention and enterprise viability, not assumption alone.

Table 7.3: Long-term actions (Years 3-4)

Action area	What should happen in Years 3-4	Why it follows from the OM
Wider rollout	Extend proven models to additional clusters beyond first pilot sites	The OM identifies sector-wide patterns, not only site-specific issues
Routine support systems	Maintain finance, training and shared-service support	Small operators need ongoing support to sustain change
Stronger market linkages	Connect improved products and services to more stable buyers and markets	The OM links quality improvement to market resilience and value retention
Evidence-led replication	Replicate only where results justify expansion	The OM itself is built on measured hotspots and practical OM

7.4 Phased implementation pathway

The phased pathway below brings the action plan together.

Figure 7.1: Phased implementation pathway

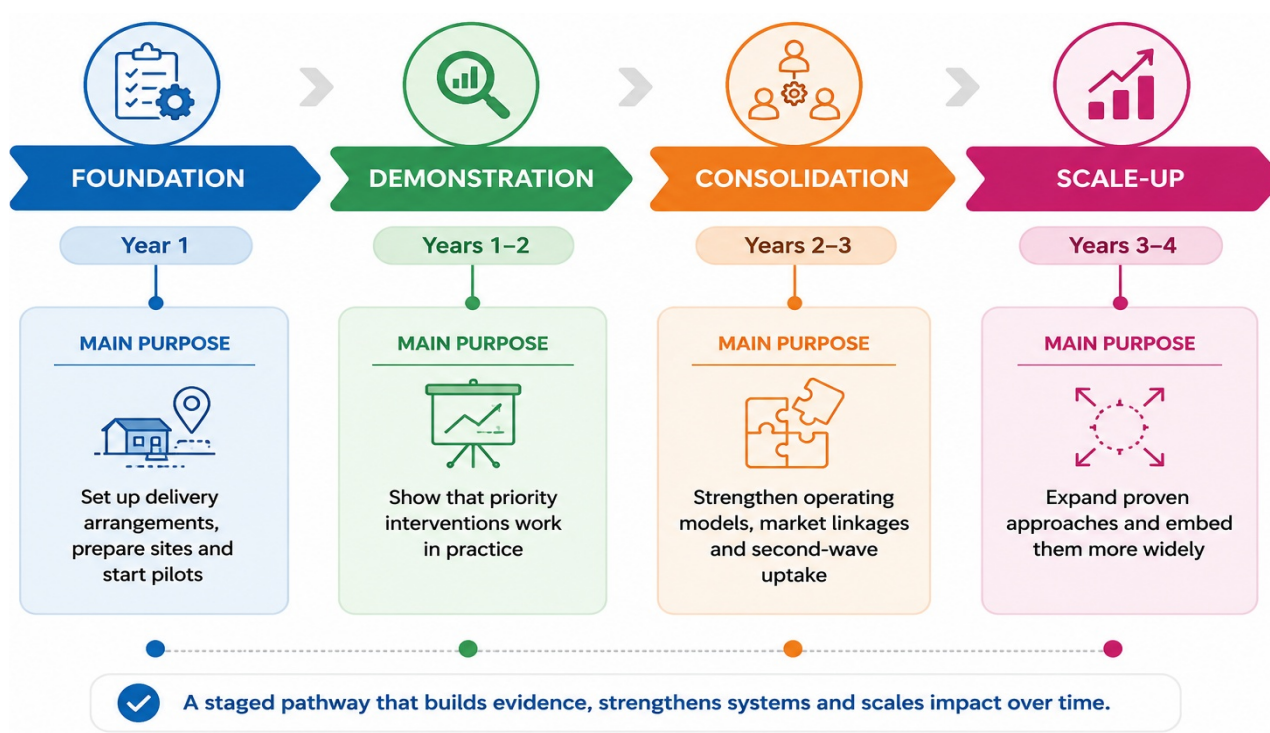


Table 7.4: Phased summary table

Phase	Timeline	Key outputs
Foundation	Year 1	District implementation arrangements, pilot preparation, training materials, first monitoring tools
Demonstration	Years 1-2	Three pilots operating, first users trained, early finance support in place
Consolidation	Years 2-3	Pilot comparison completed, second-wave clusters supported, by-product linkages established, local integration strengthened
Scale-up	Years 3-4	Replication package, wider uptake, more stable support systems, stronger market and service linkages

Summary table

Implementation logic	Description
Start with the clearest hotspots	Processing and post-harvest systems come first because that is where the OM identifies the heaviest losses and burdens
Use pilots to prove the case	Early action should test whether cleaner processing, recovery and cold handling work under real operating conditions
Expand through clusters and shared services	The OM shows that most businesses are too small to upgrade alone, so collective and shared approaches matter
Scale on evidence, not assumption	Replication should follow measured performance in wood use, recovery, quality and enterprise viability
Build from local conditions	The action pathway should remain grounded in the four study districts and the practical realities identified there



Step 8: Monitoring, Reporting, and Verification (MRV)

The OM measures material flows, resource use, value leakages and social conditions across the fish value chain, using a mixed-methods survey of 252 actors in four districts. That is important because the roadmap does not need to invent a monitoring system from scratch. It can build on the same logic the study used: track what goes into the system, what comes out, what is lost, what it costs, and who benefits.

The MRV framework should therefore do four things. It should track changes in mass and resource use; track changes in commercial value and enterprise performance; track changes in inclusion, labour conditions and access to support; and provide a simple, repeatable evidence base for deciding whether pilots should be improved, expanded or stopped. The

baselines below come from the OM. The proposed roadmap targets are for the pilot and scale-up phases.

8.1 Environmental KPIs

The environmental side of MRV should focus on the pressures the OM identifies most clearly: unmanaged by-products, heavy fuelwood use, transport fuel use, and quality losses linked to weak cold handling. The OM does not provide a full greenhouse gas inventory, but it does provide robust physical indicators that are practical to track over time. That makes the MRV approach both realistic and evidence-based.

Table 8.1: Environmental KPIs

Indicator	Baseline	Proposed target	Source/method
Processing by-products unmanaged	~4,864 kg per cycle across surveyed processors	Recover at least 60% in pilot zones by Year 4	Processor batch logs; recovery hub records
Fuelwood intensity in processing	~1.31 kg wood per kg fish	≤0.80 kg/kg by Year 4 in upgraded sites	Batch logs; wood weighing records
Water use intensity in processing	~1.1 L/kg fish	Maintain or reduce, while protecting hygiene standards	Process audits; water-use logs
Diesel use intensity	~67 L per 1,000 kg fish total (48 L raw fish transport; 19 L product transport)	15-20% reduction in pilot logistics where routing and handling improve	Transport logs; operator records
Trading spoilage	~5.6 kg per cycle	Keep spoilage low while reducing price discounting	Trader logs; market spot checks
Cleaning waste in trade	9.6 kg per cycle	Maintain tracking and improve reuse where practical	Trader logs; waste handling records

These indicators are useful because they reflect the OM's structure. Processing is the main environmental hotspot, so by-product recovery and fuelwood intensity should sit at the centre of environmental MRV.

Trade adds very little physical waste, but it still needs to be monitored because even small losses matter when product quality and value are being protected through cold-chain support.

Figure 8.1: What environmental MRV should capture



Processing	Trade	Cross-cutting
Fish input	Fish procured	Transport fuel use
Fish output	Fish sold	Water use
By-products recovered	Fish discounted or spoiled	Waste handling practice
Fuelwood used	Cleaning waste	Cold-chain uptime where relevant

This structure is justified by the OM's own analytical approach, which tracked resource inputs, outputs, waste streams and value leakages through Material Flow Analysis and resource-use assessment.

8.2 Economic KPIs

The economic side of MRV should measure whether circular action is actually retaining

value in the chain. The OM makes clear that some losses are hidden. Trade is physically efficient, but still loses value through discounted sales. Processing generates large by-product streams that currently have little or no structured use. Finance and weak infrastructure also limit small operators' ability to improve quality and productivity. Economic MRV should therefore track both income protection and new value creation.

Table 8.2: Economic KPIs

Indicator	Baseline	Proposed target	Source/method
Fish sold at reduced value because of quality loss	~442 kg per cycle (~0.8% of traded fish)	≤0.3% by Year 4 in participating markets	Trader sales records; market pricing checks
Formal by-product reuse among surveyed processors	0% reported for animal feed use	At least 3 viable secondary product lines tested and in use by Year 4	Recovery hub records; enterprise surveys
Processor fuel cost per kg fish	Not reported in the OM; establish in Year 1	25-35% reduction in upgraded sites, subject to confirmed baseline	Enterprise cost sheets; processor records
Sales or use of secondary products from recovered fish waste	Not established in the OM; establish at pilot start	Positive and sustained off-take in pilot zones by Year 4	Hub sales records; buyer records
Use of shared cold-chain or storage services	Not established in the OM; establish at pilot start	Regular use by participating traders and processors	Service logs; user registers

The most important near-term economic indicator is the share of fish sold below full value due to quality decline. The OM shows that this is already measurable and directly reflects the weaknesses of storage and cold-chain systems. By contrast, some business-performance indicators, such as processor fuel cost per kilogram or sales of secondary products, are useful but were not reported as numeric baselines in the OM. They should therefore be established in Year 1, not presented as if they already existed in the evidence base.

chain because the OM shows that the post-harvest economy is overwhelmingly female, mostly informal, and highly constrained by finance, storage and weak infrastructure. Processing is 90.5% female and trading 97.0% female. Youth involvement exists, but only in about 29% of processing businesses and 27% of trading businesses. The average workforce is also very small: 2.7 persons in processing and 1.4 persons in trading, with a median of zero employees in both cases. These are not background statistics. They determine who should benefit, who may be excluded, and what adoption will actually look like in practice.

8.3 Social KPIs

The social side of MRV is essential in this value

Table 8.3: Social KPIs

Indicator	Baseline	Proposed target	Source/method
Women in processing	90.5% of surveyed processors	Maintain women-centred access and ensure at least 70% of direct roadmap beneficiaries are women	Participation records; beneficiary lists
Women in trading	97.0% of surveyed traders	Same as above	Participation records; beneficiary lists
Youth involvement	29% of processing businesses; 27% of trading businesses have at least one youth worker	≥40% of supported enterprises involve youth labour, training or ownership by Year 4	Enterprise surveys; participation records
Average workforce scale	2.7 persons for processors; 1.4 for traders	Improve work quality and enterprise resilience without undermining viability of small firms	Annual business surveys
Businesses trained in OHS and circular practices	Not tracked in the OM ; establish in Year 1	More than 300 actors trained by Year 4	Training registers; attendance records
Use of practical, low-literacy training methods	Implied need in OM , not numerically tracked	All pilot training delivered in practical, visual and accessible formats	Training design review; participant feedback

The social indicators should show whether the roadmap is reaching the actors the OM identifies as central: women processors, women traders, youth entrants, and small enterprises that would otherwise struggle to adopt improved practices. The OM is particularly clear that training needs to be practical and accessible, given modest educational levels and the prevalence of informal businesses. That makes training reach and usability part of the MRV system, not an afterthought.

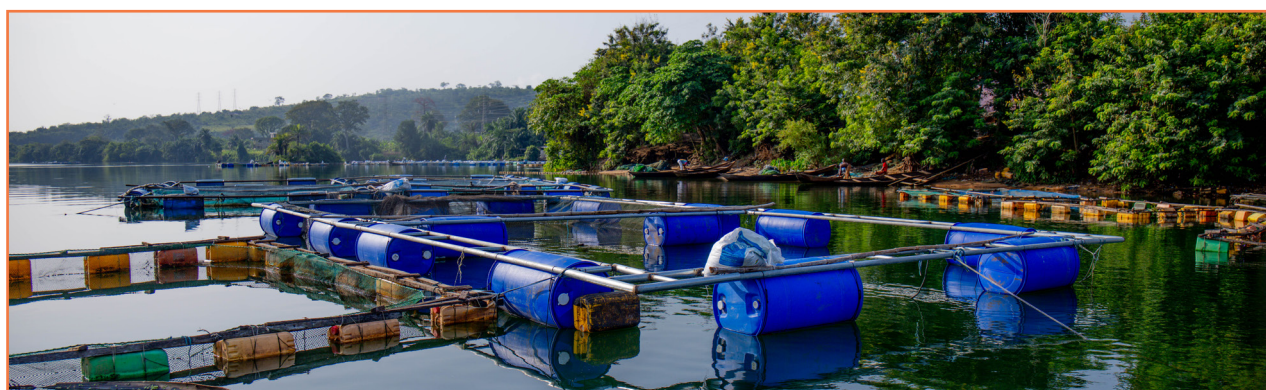


Figure 8.2: Social MRV should answer four questions



This structure follows directly from the social profile set out in the OM.

8.4 Data collection tools

The OM itself shows what a workable data system looks like. The study used electronic questionnaires on tablets, mixed-methods, material flow analysis, and resource-use assessment. It also relied on variables such as input use, product sold, waste generated, spoilage, transport, reuse and quality loss. For the roadmap, the data collection tools should stay equally practical. They should not be so heavy that small operators cannot use them, but they should be strong enough to show whether pilots are delivering real improvements.

The core data collection tools should include the following:

- mobile or paper batch logs for fish input, product output, by-product volumes,

wood use and water use at processing sites

- trader logs for fish procured, fish sold, discounted fish, spoilage, cleaning waste and use of ice or cold storage
- periodic site audits covering hygiene, smoke conditions, waste handling, storage and the condition or use of shared equipment
- enterprise and household surveys at agreed intervals to track labour, income effects, training uptake and constraints
- group or association records, where groups are active, to track shared equipment use, finance uptake or group-managed services
- market quality and pricing spot checks to verify whether cold-chain support is reducing discounting and protecting quality.

Table 8.4: Data collection tools and their use

Tool	Main use	Why it is suitable
Batch logs	Record fish input, output, by-products, wood and water use	Simple and aligned with the OM's material-flow logic
Trader logs	Record stock handled, spoilage, discounting and storage use	Tracks the hidden value loss the OM identifies in trade
Periodic site audits	Check hygiene, smoke exposure, waste handling and equipment use	Helps verify whether practices are changing, not only whether records exist
Enterprise and household surveys	Track labour, business change, finance access and social effects	Useful for following the small-enterprise realities highlighted in the OM
Group or association records	Track shared infrastructure or group-based support	Relevant where cooperative or shared-service models are introduced
Market pricing spot checks	Compare product quality and sale values over time	Necessary because trade losses are partly about price, not just weight

Summary table

MRV principle	Application in this roadmap
Keep it simple	Use short batch logs, trader logs and practical audit forms rather than complex reporting systems
Track both mass and value	Measure kilograms recovered or lost, but also track discounted sales and new product use
Make gender visible	Disaggregate beneficiaries, trainees, users and employment indicators by sex and, where possible, by age
Use pilots as evidence engines	Expand only what shows clear gains in recovery, quality, cost, or inclusion
Do not invent baselines	Where the OM did not report a numeric baseline, establish it in Year 1 before setting performance claims



Step 9: Financing Strategy and Investment Mobilisation

The fish value chain is economically important, but many of the actors who must adopt change are small, informal and under-capitalised. Processors cited access to finance and market access as major constraints. Traders highlighted storage, cold chain and financial barriers. The report also shows that most processing and trading businesses are micro-enterprises, often with no hired workers beyond the owner and family labour, which means they are rarely in a position to finance improved kilns, cold storage, waste recovery equipment or better handling systems on their own. This is why finance is not a separate issue in the roadmap. It is one of the conditions for implementation.

The OM also points to the kinds of investments that matter most. It recommends improved smoking technologies and clean energy alternatives; by-product valorisation pathways supported by training, small-scale equipment, and private-sector partnerships; solar-powered and community cold storage solutions; and enterprise upgrading measures such as

microcredit, group savings, digital payment systems, and women-focused cooperatives. It further notes that many circular solutions will be more realistic if they are organised through cooperative models or shared infrastructure, such as communal cold rooms or shared processing hubs. That is the core financing logic for this step.

9.1 Cost estimates for priority interventions

The figures below are indicative planning estimates for the roadmap, structured around the identified priority interventions, and should therefore be treated as a planning envelope for design, procurement, and fundraising, not as findings from the COM study. The ranges are intended to reflect the fact that implementation could vary by site, scale, equipment specification and whether infrastructure is individual, shared or cluster-based.

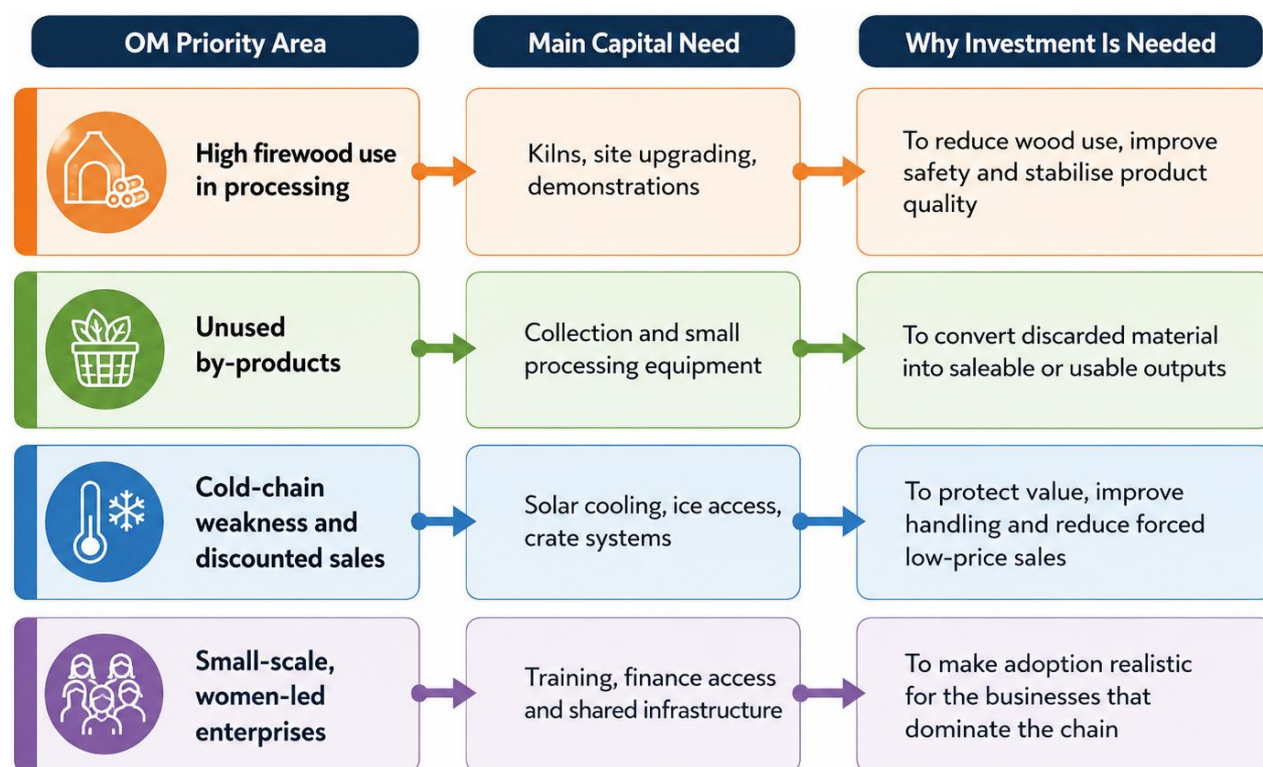
Table 9.1: Indicative cost estimates for priority interventions

Intervention	Estimated cost (USD)	Notes
Clean smoking cluster upgrades	180,000-300,000	Improved kilns, site adaptation, user training, demonstrations and basic monitoring
By-product recovery micro-hub	220,000-400,000	Collection, sorting, drying, grinding, storage, hygiene setup and early product testing
Solar cold rooms/ice and crate system	300,000-500,000	Solar-powered cold units, cooling equipment, reusable crates and basic service setup
Capacity-building and extension	120,000-220,000	Training materials, practical demonstrations, local-language delivery and field support
MRV, governance and enterprise support window	180,000-300,000	Coordination, simple data systems, market linkage support and small enterprise facilitation

Indicative four-year pilot package total: USD 1.0-1.72 million

The largest planned investments sit where the OM identifies the strongest pressure points: processing, cold-chain weakness and by-product recovery. The logic is simple. Where the value chain loses the most wood, value or material, it will also require the most careful investment response.

Figure 9.1: How the indicative financing envelope maps to OM priorities



OM priority area	Main capital need	Why investment is needed
High firewood use in processing	Kilns, site upgrading, demonstrations	To reduce wood use, improve safety and stabilise product quality
Unused by-products	Collection and small processing equipment	To convert discarded material into saleable or usable outputs
Cold-chain weakness and discounted sales	Solar cooling, ice access, crate systems	To protect value, improve handling and reduce forced low-price sales
Small-scale, women-led enterprises	Training, finance access and shared infrastructure	To make adoption realistic for the businesses that dominate the chain

9.2 Funding sources

The OM supports a mixed financing approach rather than a single funding route. Its own recommendations point to several practical sources of support: subsidies, financing schemes, microcredit, government-backed green financing schemes, group savings, private-sector partnerships and support from development programmes working on circular economy and enterprise upgrading. This suggests that the roadmap should combine public, partner-supported, private, and group-based finance rather than relying on a single channel.

The first source is public and programme-based funding. This is justified because the OM explicitly recommends subsidies and financing schemes for improved smoking technologies, and because the interventions proposed - such as community cold hubs, practical training and shared infrastructure - have public-good characteristics as well as commercial value. These are the kinds of activities that often require some form of public or programme support in the early stages.

The second source is development partner finance and technical support. The OM itself was produced within a UNIDO-supported circular economy project and is intended to guide policymakers, researchers, industry stakeholders and development partners. This makes development partner support

a natural financing source for pilot design, demonstration, enterprise upgrading and capacity-building.

The third source is microcredit and other small-enterprise finance channels. The OM explicitly recommends access to microcredit, gender-sensitive financial products and credit schemes, and stronger support for women-focused cooperatives and producer groups. This is especially important because processors and traders are mostly women, and many operate with limited capital and limited formal support.

The fourth source is private-sector co-investment and market partnerships. The OM recommends private-sector partnerships for by-product valorisation and highlights the need for stronger links with buyers, storage providers, and organised supply chains. This means that private buyers, equipment providers, recovery businesses and service operators can all play a role in co-financing viable parts of the circular economy transition.

The fifth source is group-based finance and shared-service arrangements. The OM recommends cooperative models, communal cold rooms, shared processing hubs, group savings and collective solutions for micro-operators who cannot afford equipment individually. This makes group-based finance a particularly relevant source for women-led processing and trading clusters.

Table 9.2: Funding sources aligned to OM findings

Funding source	Why it fits the OM	Most suitable uses
Public or programme funding	The OM recommends subsidies, financing schemes and support for shared infrastructure	Pilot setup, demonstrations, common infrastructure, training
Development partner support	The OM is positioned as a tool for policymakers and development partners	Early pilots, technical assistance, business support, learning
Microcredit and inclusive finance	The OM recommends microcredit and gender-sensitive financial products	Small equipment, working capital, enterprise upgrading

Funding source	Why it fits the OM	Most suitable uses
Private-sector co-investment	The OM recommends private-sector partnerships, especially for valorisation	Recovery hubs, product development, buyer linkages, service provision
Group savings and cooperative finance	The OM supports cooperatives, group support and shared infrastructure	Collective cold rooms, shared kilns, shared recovery equipment

9.3 De-risking mechanisms

The OM shows that many actors face low capital, weak market access, storage constraints, uncertain demand and limited formal support. For micro-enterprises, especially women-led businesses, the issue is not only whether a technology works. It is whether the risk of trying it is bearable. The de-risking strategy should therefore reduce upfront cost, lower adoption risk and improve confidence in new circular practices.

The most direct de-risking tool supported by the OM is subsidies and financing schemes for improved smoking technologies and clean energy alternatives. The report explicitly recommends these to accelerate adoption. This is especially important where processors are being asked to shift away from familiar but inefficient traditional smoking methods.

A second de-risking tool is microfinance and green financing for shared infrastructure. The OM states that many small operators cannot afford to purchase cold storage, solar drying, or waste-processing equipment on their own and explicitly recommends improving access to microcredit and government-backed green financing schemes. This makes finance and risk sharing central to adoption.

A third de-risking mechanism is group-based delivery through cooperatives and producer groups. The OM recommends women-focused cooperatives and producer groups as platforms for scaling training and improving access to finance. It also recommends cooperative models so processors and traders can share resources such as cold rooms or fishmeal grinders. Group-based organisation reduces the burden on individual firms and spreads risk across a cluster.

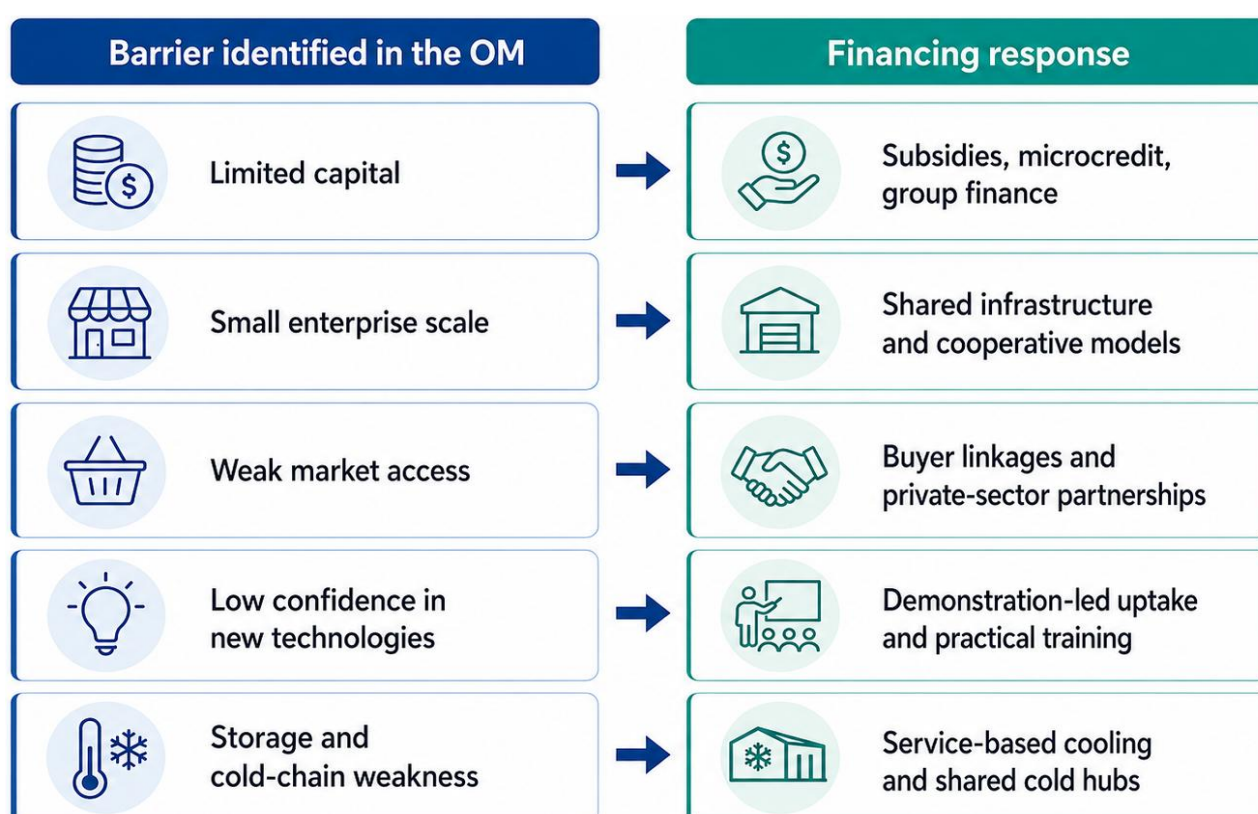
A fourth de-risking mechanism is market linkage and private-sector partnership. In particular, for by-product recovery, the OM does not stop at equipment. It recommends training, small-scale processing equipment and private-sector partnerships. That is important because a recovery business is less risky when there is some route to use or sale. In financing terms, buyer linkages and off-take relationships help reduce commercial uncertainty.

A fifth de-risking mechanism is community-based demonstration. The OM repeatedly recommends demonstrations and practical training, both to improve smoking technologies and to promote broader reuse and recycling practices. This is a form of adoption de-risking: it reduces uncertainty by showing what works under real conditions before individual actors commit scarce cash.

Table 9.3: De-risking mechanisms grounded in the OM

De-risking mechanism	What risk it reduces	OM basis
Subsidies and financing schemes	Upfront equipment cost for improved smoking and clean energy	Explicitly recommended for smoking technologies
Microcredit and green finance	Capital access for cold storage, solar drying and waste processing	Explicitly recommended for small operators
Cooperative and group-based finance	Individual investment burden and scale constraints	Explicitly recommended for communal infrastructure and shared equipment
Private-sector partnerships	Market uncertainty for recovered products	Explicitly recommended for by-product valorisation
Community demonstrations	Technology adoption risk and low confidence in new practices	Explicitly recommended in the OM

Figure 9.2: Financing risk pathway



Barrier identified in the OM	Financing response
Limited capital	Subsidies, microcredit, group finance
Small enterprise scale	Shared infrastructure and cooperative models
Weak market access	Buyer linkages and private-sector partnerships
Low confidence in new technologies	Demonstration-led uptake and practical training
Storage and cold-chain weakness	Service-based cooling and shared cold hubs

9.4 Investment instruments

The OM does not provide a named list of financial instruments, but it clearly supports a practical financing architecture built around small-enterprise access, shared infrastructure, group-based support and equipment plus training rather than finance alone. On that basis, the most suitable investment instruments for this roadmap are as follows.

The first is a small-equipment finance window for processors and traders. This follows directly from the OM's recommendations on improved kilns, solar-powered storage, low-cost cold-chain solutions and small-scale processing equipment. It would support individual or clustered access to priority technologies.

The second is a shared infrastructure investment window for communal or cluster-level assets. The OM repeatedly refers to communal cold rooms, shared processing hubs and cooperative models for small operators. This points to a need for investment instruments that can

support cluster-owned or jointly managed infrastructure rather than only individual loans.

The third is a working-capital and enterprise-resilience window. The OM recommends microcredit, group savings, digital payment systems and business support for micro-businesses. This suggests that some finance must help firms manage operating cash flow, not only buy equipment.

The fourth is a recovery and product-development support window for by-product valorisation. Since the OM recommends training, small-scale processing equipment, and private-sector partnerships, investment needs to cover early product development, handling systems, and market linkage, not just capital items.

The fifth is a women-centred group finance facility. The social profile in the OM strongly justifies this: women dominate processing and trading, face persistent financial barriers, and are specifically identified as needing gender-sensitive financial products and credit schemes.

Table 9.4: Suitable investment instruments for the roadmap

Investment instrument	Main purpose	Most suitable users
Small-equipment finance window	Support access to kilns, cooling units and small recovery equipment	Individual processors, traders and small firms
Shared infrastructure window	Finance communal cold rooms, shared hubs and cluster equipment	Cooperatives, associations and cluster groups
Working-capital and resilience finance	Support cash flow, storage use, stock handling and enterprise resilience	Micro-enterprises in processing and trade

Investment instrument	Main purpose	Most suitable users
Recovery and product-development support	Support early-stage valorisation activities and market linkage	By-product recovery ventures and processor groups
Women-centred group finance facility	Improve inclusive access to finance for the main post-harvest actors	Women-led cooperatives, groups and small businesses

Summary table

Finance priority	Instrument
Equipment access	Subsidies and financing schemes; small-equipment finance
Shared infrastructure	Cooperative finance; communal infrastructure investment windows
Enterprise upgrading	Microcredit, group savings and working-capital support
By-product recovery	Small-scale processing support and private-sector partnership finance
Inclusion	Gender-sensitive financial products and women-centred group finance



Step 10: Capacity Development and Institutional Strengthening

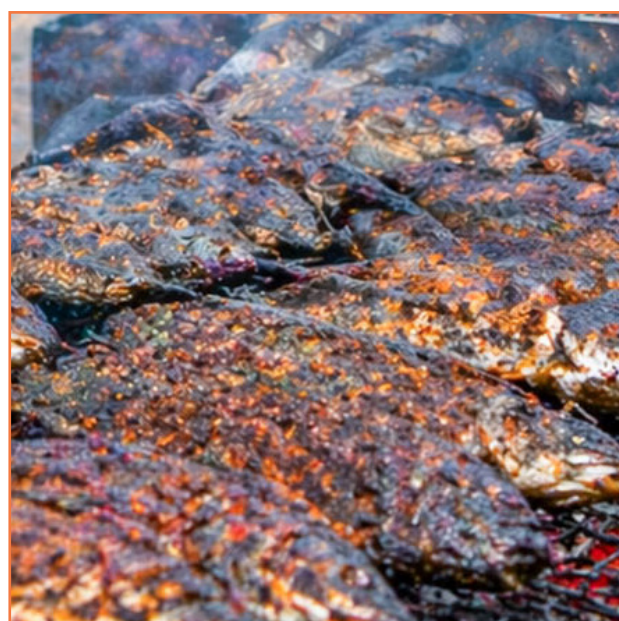
The OM makes the case for capacity development very clearly. The fish value chain is heavily dependent on small operators, especially women in processing and trading, yet most of these actors work with limited formal education, limited capital, weak infrastructure and low access to improved technologies. Among processors, 63.5% have basic education and 22.2% have no formal schooling. Among traders, 66.3% have basic education and 17.8% have no formal schooling. At the same time, processing is 90.5% female and trading 97.0% female, and most businesses are micro-enterprises. This means capacity-building cannot be generic. It has to be practical, visual, local and closely tied to the real bottlenecks the OM identifies: fuelwood-heavy smoking, weak cold handling, unmanaged by-products, low reuse, and weak business systems.

The report's recommendations point in the same direction. It calls for tailored capacity-building for women and low-literacy groups; practical support for hygienic handling, business management, recordkeeping, resource-efficient processing, and occupational health and safety; stronger cold-chain and market infrastructure; and support for enterprise upgrading, including microcredit, group savings, digital payment systems, and health and safety training. It also identifies clear technical opportunity areas at different stages of the chain, from local feed production, sludge composting and aquaponics to efficient kilns, fishmeal, collagen, reusable crates and cold-chain leasing. Step 10 should therefore translate those needs into a structured capacity package.

It should also be practical, as the report repeatedly states that many actors work best with visual, hands-on, and demonstrative approaches rather than formal classroom teaching. Training should be delivered in short, usable modules that fit around working time and focus on direct business and operational gains.

For producers

The OM shows that production remains the entry point for several circularity gaps. It identifies inefficient input use and plastic waste at the input-supply stage, and wastewater, sludge, and bycatch at the production stage, with corresponding opportunities such as local feed production, plastic recycling, aquaponics, and sludge composting. It also shows that producers generally have stronger formal education than post-harvest actors, with 55.7% having basic education, 22.7% having secondary education, and 18.2% having tertiary education. That profile supports a training package that combines practical resource management with more structured enterprise and recordkeeping content.



10.1 Modular CE Training Curriculum

The training curriculum should be modular because the OM shows that the needs of producers, processors, and traders differ.

Table 10.1: Proposed training modules for producers

Module area	What the training should cover	Significance
Feed efficiency and local feed sourcing	Better feed use, lower waste, local alternatives where feasible	The OM identifies inefficient materials at input-supply stage and points to local feed production as an opportunity
Sludge handling, wastewater management and composting	Safe collection, basic treatment, composting and reuse pathways	Production-stage gaps include wastewater and sludge, with aquaponics and sludge composting highlighted as opportunities
Post-harvest handling at landing sites	Basic quality protection, icing awareness, cleaner handling and offal separation	The OM identifies post-harvest loss at landing and handling, and points to ice hubs and offal recovery
Basic enterprise records and group organisation	Simple input/output records, cost tracking, group purchasing and shared service use	Producers' education profile suggests scope for stronger recordkeeping and organised uptake of improved practice

For processors

The strongest training need sits with processors. The OM shows that processing is the main hotspot for fuelwood use, by-product leakage and difficult working conditions. Smoking uses about 1.31 kg of wood per kg of fish processed, and around 4,864 kg of by-products are generated per cycle across the sampled processors.

The report explicitly states that training for processors should cover improved processing techniques, hygiene, safety standards and recordkeeping, and that it should be delivered in practical, visual and hands-on ways. It also recommends support for by-product valorisation and improved smoking technologies.



Table 10.2: Proposed training modules for processors

Module area	What the training should cover	Significance
Efficient smoking techniques	Improved kiln use, batch control, product consistency and cleaner processing practice	Traditional smoking is dominant and is associated with high wood use, emissions and inconsistent product quality
Fuelwood benchmarking and kiln maintenance	Measuring wood use, avoiding waste, simple maintenance and correct loading	Fuelwood is the largest measured resource burden in the OM
Waste sorting and by-product handling	Separation of heads, bones, guts and scales; safe storage; first steps in recovery	About one quarter of raw fish in processing becomes by-products and is largely discarded
Hygiene, food safety, OHS and smoke-risk reduction	Clean handling, safer workspaces, exposure reduction and product safety	The OM recommends practical training on hygienic handling and occupational health and safety
Pricing, costing and simple profit tracking	Basic enterprise costing, wood cost tracking, product grading and margin awareness	Processors face finance and market constraints and need stronger business management support

For traders

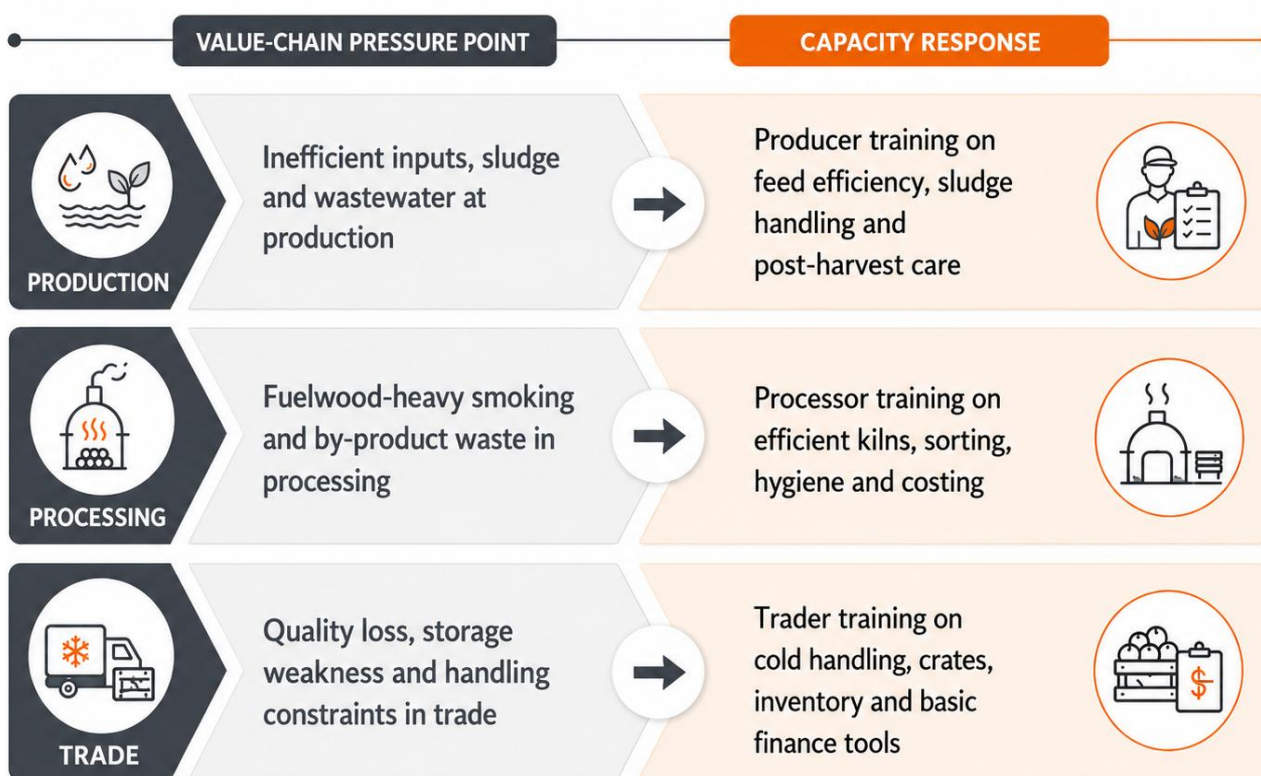
The OM shows that traders are physically efficient but still lose value through quality decline. About 98.4% of fish procured is sold, but around 442 kg per cycle, roughly 0.8%, is sold at reduced price because quality falls before sale. Traders also identify storage and cold-chain limitations, as well as financial barriers, as major constraints. The report recommends low-cost cold-chain solutions, hygienic handling, and stronger market infrastructure, and notes that trader training should be simple, practical, and demonstrative.

Table 10.3: Proposed training modules for traders

Module area	What the training should cover	Significance
Cold-chain handling and quality preservation	Icing, short-term storage, handling for freshness and basic hygiene	Quality deterioration, not high spoilage, is the main trading loss identified in the OM
Reusable crate use and return systems	Better handling, stackability, cleaning and reduced damage	The OM identifies reusable crates as a practical circular opportunity in transport and trade

Module area	What the training should cover	Significance
Basic inventory and loss tracking	Quantities procured, sold, discounted and spoiled	Traders need to see where value is lost, not only where fish is wasted
Group savings, digital payments and cooperative procurement	Simple financial tools that strengthen day-to-day trading resilience	The OM recommends microcredit, group savings and digital payment systems for enterprise upgrading
Customer trust, quality communication and traceability	Product condition, safer handling and confidence in improved storage	Better quality preservation is only useful if it strengthens market trust and price realisation

Figure 10.1: Training logic across the value chain



10.2 Extension officer upskilling

The OM notes that producers' educational levels are sufficient to support engagement with extension services, and it describes the value chain as already including regulatory oversight by agencies such as MoFAD and the Fisheries Commission. It also shows that practical adoption will depend on field-level

support, as the businesses involved are small, women-led, and often constrained by limited formal education and infrastructure. For that reason, the roadmap should include a focused upskilling package for Fisheries Commission field staff and district-level implementers so that they can translate circular economy opportunities into day-to-day advisory support.

That upskilling package should cover five areas. First, staff need to understand the OM's main circularity hotspots and how to identify them in the field. Second, they need facilitation methods suited to low-literacy and women-led groups, since the report explicitly states that training must be practical, visual, and accessible. Third, they need basic enterprise-coaching skills because many of the barriers are both commercial and technical. Fourth, they

need basic data-capture skills to support the material-flow and performance tracking that the roadmap depends on. Fifth, they need to deliver support in a way that is responsive to the chain's gender structure and to the different conditions faced by producers, processors and traders. These are reasonable delivery requirements drawn directly from the OM's evidence on the actor's profile, business structure, and recommended training content.

Table 10.4: Suggested upskilling areas for field delivery teams

Upskilling area	Why it is needed
Circular economy screening tools	To identify wood-use hotspots, by-product losses, cold-chain gaps and reuse opportunities in the same way the OM does
Low-literacy facilitation methods	Because processors and traders are mostly basic-educated and often need practical, visual support
Enterprise coaching	Because finance, market access and business resilience are major barriers in the OM
Simple monitoring and data capture	Because the roadmap needs reliable tracking of inputs, outputs, losses and improvements
Gender-responsive facilitation	Because processing and trading are overwhelmingly female and interventions must fit that reality

10.3 Vocational partnerships

The OM repeatedly points to the need for training, small-scale processing equipment, private-sector partnerships, improved technologies, youth skills development and entrepreneurship support. That makes a strong case for delivery partnerships with universities, technical institutes and business support organisations that can turn the report's recommendations into short, practical learning offers rather than one-off awareness sessions.

Four partnership areas stand out. The first is fish-by-product processing, because the OM identifies a large, unmanaged by-

product stream and recommends training, small-scale equipment, and private-sector partnerships. The second is the fabrication, use, and maintenance of efficient kilns, because improved smoking technologies are among the report's strongest recommendations. The third is solar and low-cost cold-chain operations, because the OM recommends solar-powered systems, community cold hubs and off-grid storage solutions. The fourth is youth-focused micro-enterprise incubation, because youth involvement is present but still limited, and the report explicitly recommends youth skills development and entrepreneurship support.

Table 10.5: Vocational and technical partnership priorities

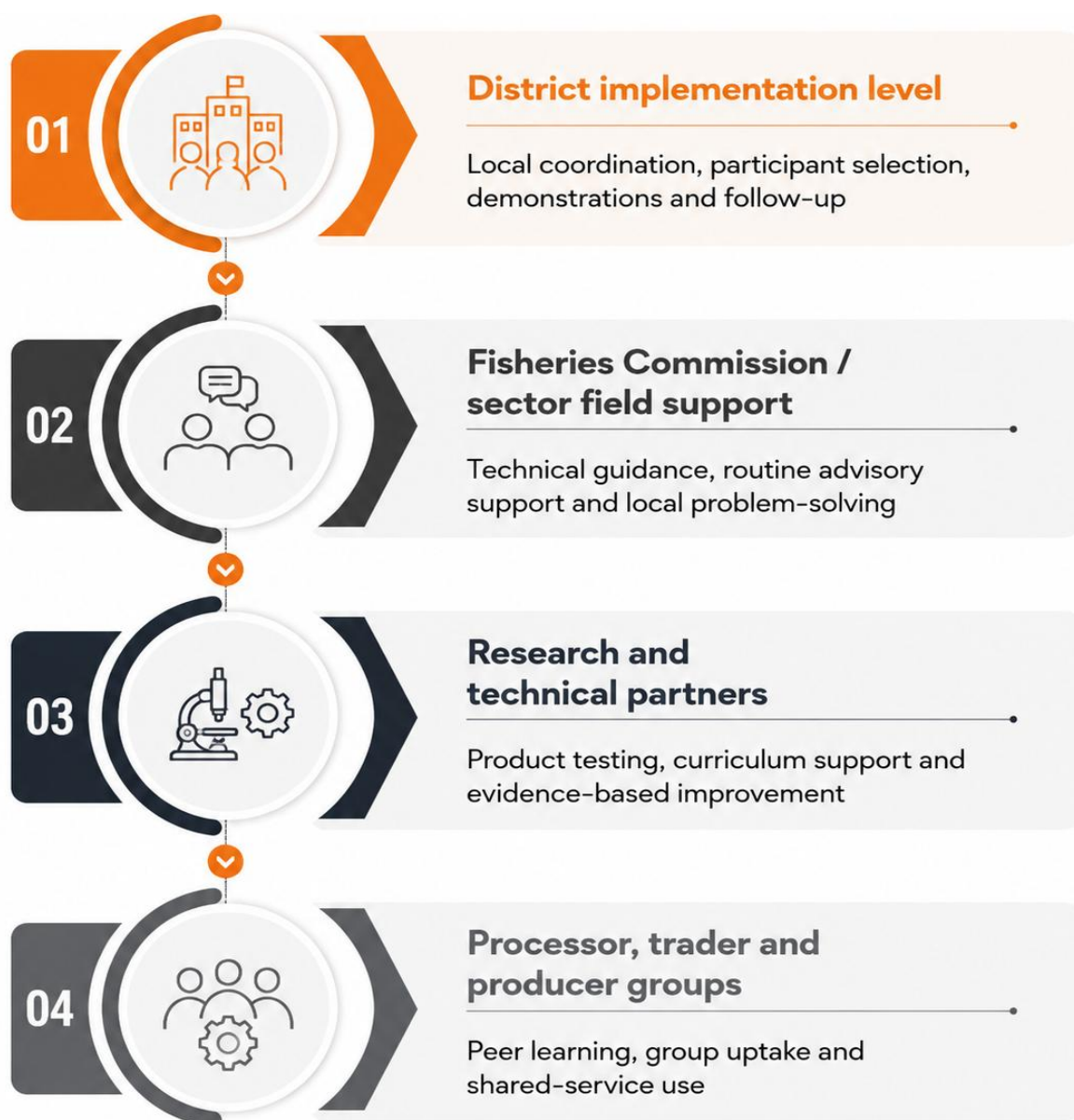
Partnership area	Practical focus
Fish by-product processing	Drying, grinding, basic product preparation, hygiene and quality control
Efficient kiln fabrication and maintenance	Construction, repair, operating practice and performance improvement
Solar and cold-chain operations	Basic cold-room use, solar-supported storage, ice handling and service management
Youth enterprise incubation	Small business models around recovery, cooling, handling, group services and value addition

10.4 Institutional integration

Capacity development will have limited effect if it stays outside routine implementation structures. The OM was carried out across four districts and is explicitly intended to provide a foundation for policymakers, industry stakeholders, researchers and development partners. It also describes a value chain that already depends on support services and regulatory oversight from MoFAD and the Fisheries Commission. The practical implication is that training and support modules should be integrated into the same delivery spaces where fish value chain decisions are already being made.

In practical terms, that means four points of integration. First, district implementation arrangements in the four OM locations should align with the training agenda, as the hotspots are place-specific and the study itself is district-based. Second, Fisheries Commission field support should incorporate the core modules on handling, processing efficiency, recovery and enterprise support. Third, any pilot or demonstration package on improved smoking, by-product recovery or cold-chain upgrading should carry a training component, not treat training as a separate activity. Fourth, partnerships with research and technical institutions should be embedded in delivery so that product testing, training and feedback loops continue beyond the first pilot stage. This is the most direct way to turn the OM from a diagnostic exercise into a working support system.

Figure 10.2: Institutional pathway for capacity support



Summary table

Capacity gap identified in the OM	Evidence from the OM	Roadmap response
Low literacy and limited formal education	Basic education is the most common level among processors and traders; many have no formal schooling	Visual, practical and local-language training modules
Weak technical adoption	Traditional smoking remains dominant; cold-chain and recovery practices are limited	Demonstrations, peer learning and targeted technical training
Weak business systems	Finance, market access, storage and small enterprise scale are recurring constraints	Simple costing, recordkeeping, group savings and inventory tools
Limited enterprise resilience	Most operators are micro-enterprises with few or no employees	Group organisation, cooperative-style support and enterprise coaching
Thin delivery follow-through	The chain depends on support services and field-level oversight	Integration into district delivery, Fisheries Commission support and technical partnerships



Step 11: Governance and Integration Framework

The OM shows that the fish value chain already operates across several linked layers. It covers production, processing, storage, distribution, and trade, and is supported by feed supply, transport, ice production, credit services, and regulatory oversight from MoFAD and the Fisheries Commission. It also spans four districts in two regions and is intended to inform action by policymakers, industry stakeholders, researchers and development partners. That is the right starting point for governance. The roadmap needs a structure that can steer action nationally, coordinate it regionally, and manage delivery at the district level, where the actual fish, infrastructure, and businesses are located.

The strongest circular economy pressures in the chain are not isolated technical issues. They cut across fuelwood use, by-product handling, cold-chain weakness, market access, finance and enterprise support. Processing is the main hotspot for waste and energy use. Trade is materially efficient, but it still loses value due to quality deterioration. Most of the businesses involved are small, informal and women-led. That means governance must do more than approve activity. It must connect technical action, local problem-solving, market support and institutional follow-through.

11.1 Multi-level governance structure

The governance structure should be organised at three levels: national, regional and district. The study was carried out across four districts in the Ashanti and Eastern Regions, and it also describes a national fish value chain shaped by sector agencies, market systems, and support services. A three-level structure is therefore the most practical way to connect strategic direction with field implementation.

National level

At the national level, the roadmap identifies MoFAD and the Fisheries Commission as part of the regulatory oversight around the fish value chain. It also presents the OM as a foundation for policymakers, industry stakeholders, researchers and development partners. On that basis, national governance should focus on overall direction, sector alignment, technical oversight and external coordination.

At this level, the main function is not day-to-day delivery. It is to provide a stable institutional home for the roadmap, ensure that the main circular economy priorities remain visible, and link implementation to the wider support system already surrounding the fish sector.

Proposed national roles

- set the overall direction of the roadmap
- align circular actions with fish value chain priorities already identified in the OM
- coordinate sector agencies and technical partners
- review performance evidence from the pilot districts
- support resource mobilisation and wider replication where pilots succeed.

Regional level

The OM's fieldwork was conducted in the Ashanti and Eastern Regions, and the selected districts span diverse fish production and post-harvest conditions. A regional layer is therefore useful as a coordination bridge. It allows pilot evidence to be reviewed across districts, supports performance comparisons, and helps

resolve issues that are too large for one district but too operational for national steering.

In practical terms, regional coordination should focus on reviewing pilot progress, comparing district results, identifying common bottlenecks and supporting consistency in implementation across the two regions.

Proposed regional roles

- coordinate roadmap activity across the four study districts
- review pilot performance and readiness for wider rollout
- identify operational bottlenecks shared across districts
- support cross-district learning on processing, recovery and cold-chain models.

District level

The OM is rooted in Bosomtwe District, Atwima Nwabiagya North District, Kumasi Metropolis and Asuogyaman District, and the strongest pressures it identifies are highly practical: smoking sites, storage constraints, transport links, market conditions, and the organisation of small enterprises. This makes district-level governance the most important delivery tier.

District-level structures should therefore focus on execution. They should be the point at which sites are selected, local actors are mobilised, demonstrations are organised, shared infrastructure is coordinated, and basic data are collected. They should also provide the day-to-day problem-solving needed in a value chain dominated by small operators.

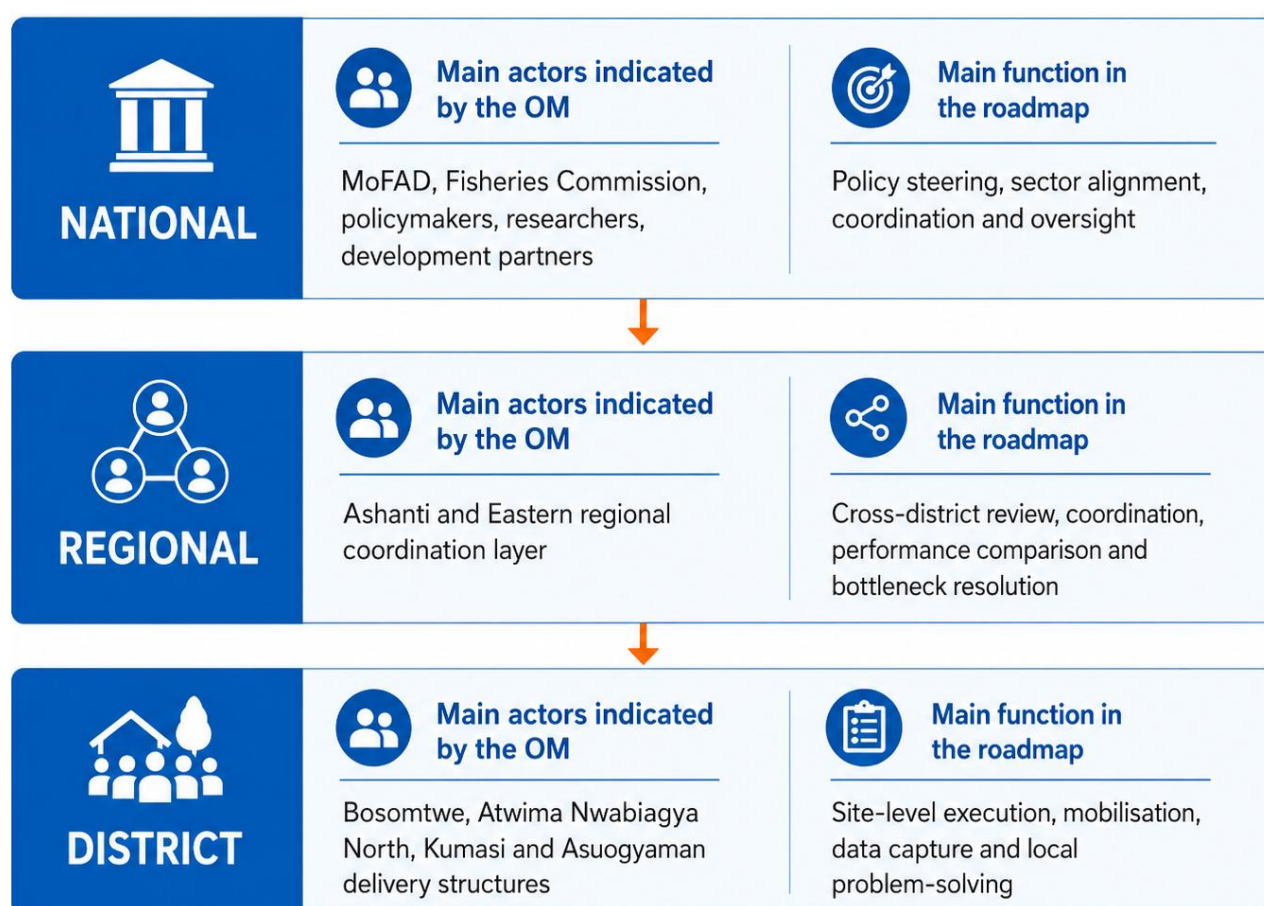
Proposed district roles

- select and support pilot sites
- convene processors, traders, producers and service providers locally
- coordinate market, storage and infrastructure-related actions
- support local conflict resolution and practical troubleshooting
- collect simple delivery and performance data
- sustain community engagement around the pilots.

Table 11.1: Proposed multi-level governance structure

Governance level	Main actors indicated by the OM	Main function in the roadmap
National	MoFAD, Fisheries Commission, policymakers, researchers, development partners	Policy steering, sector alignment, coordination and oversight
Regional	Ashanti and Eastern regional coordination layer	Cross-district review, coordination, performance comparison and bottleneck resolution
District	Bosomtwe, Atwima Nwabiagya North, Kumasi and Asuogyaman delivery structures	Site-level execution, mobilisation, data capture and local problem-solving

Figure 11.1: Governance flow



11.2 Integration into planning and policy systems

The OM is not written as a stand-alone academic exercise. It clearly states that it is intended to provide a foundation for policymakers, industry stakeholders, researchers, and development partners to design interventions that improve the fish value chain's environmental, social, and economic performance. That means the roadmap should be integrated into the systems that already shape decisions in the fish sector, rather than left as a separate project document.

The first point of integration is support for the fisheries and aquaculture sector. The OM identifies the Fisheries Commission and MoFAD as part of the chain's support and oversight environment. That makes them the most obvious institutional home for technical follow-up, especially on processing, post-harvest handling, quality and enterprise support.

The second point of integration is district-level implementation. This follows directly from the OM's methodology and

geography. The study is district-based. Its recommendations on improved smoking technologies, cold-chain support, by-product valorisation and practical training all depend on local implementation conditions. Integrating roadmap actions into district-level planning and service delivery is therefore a practical necessity.

The third point of integration is market and infrastructure support. The OM shows that the value chain includes cold stores, transport, ice production, credit services and urban distribution hubs. It also recommends stronger cold-chain infrastructure, solar-powered storage, community cold hubs and support for enterprise upgrading. For the roadmap to take hold, these market-facing support functions need to be treated as part of implementation, not as external factors.

The fourth point of integration is capacity and enterprise support. The OM repeatedly calls for tailored capacity-building, practical training, women-focused support, microcredit, group savings and enterprise upgrading. Governance must therefore link technical action with training and business support rather than treating them as separate strands.

Table 11.2: Main integration points

Integration point	Significance	OM basis
Sector support and oversight	The roadmap needs an institutional home within the fish value chain support system	MoFAD and Fisheries Commission are named as oversight actors
District implementation systems	The hotspots identified by the OM are place-based and need local execution	The study was conducted across four districts
Market and infrastructure systems	Cold storage, transport, ice and distribution affect value retention and adoption	The OM identifies these as part of the chain and highlights storage and cold-chain gaps
Capacity and enterprise support systems	Circular upgrading depends on training, finance and practical support for small operators	The OM repeatedly recommends tailored training and enterprise upgrading

11.3 Institutionalisation and oversight

The OM provides a strong baseline for what should be tracked: material flows, resource use, value leakage, social profile, and circularity hotspots. That makes it possible to design oversight that is evidence-led rather than impressionistic. Institutionalisation, in this context, means ensuring the roadmap is regularly reviewed, that performance is visible, and that decisions on expansion are based on real results.

A sensible oversight structure should therefore include four elements.

First, there should be an annual performance review of the roadmap. This is justified because the OM itself is built around baseline measurement and prioritisation. A yearly review allows the main actors to compare progress on the exact pressure points identified in the report: processing efficiency, by-product recovery, cold-chain performance, quality retention, and support for women-led micro-enterprises.

Second, there should be district and regional performance scorecards. This is a

practical extension of the study's district-based structure. Since implementation is starting in four distinct locations, a simple scorecard makes it easier to see where pilots are moving, where uptake is weak, and where adjustments are needed.

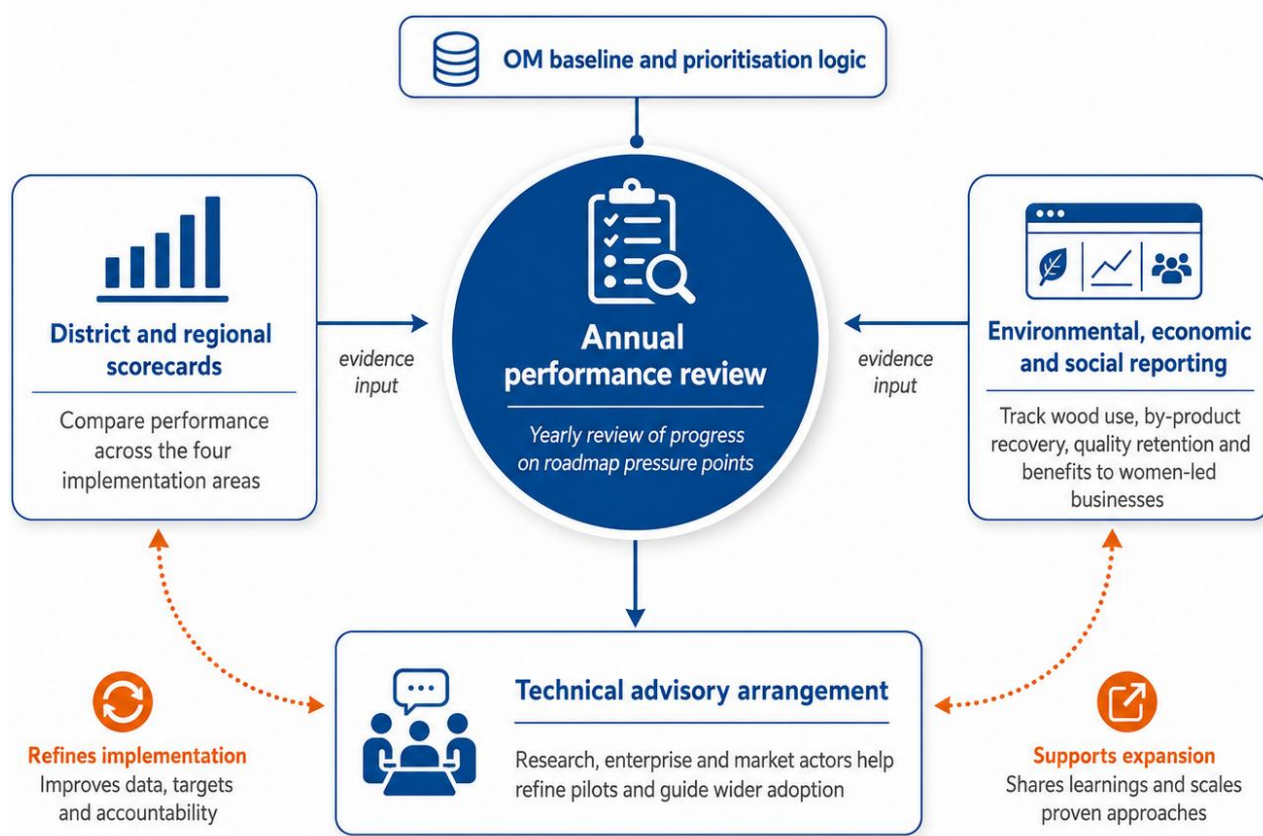
Third, there should be regular reporting on environmental, economic and social indicators. This follows directly from the OM's evidence base, which already combines material, economic and social analysis. Reporting should therefore not be limited to environmental gains alone. It should show whether wood use is falling, whether by-products are being recovered, whether quality loss is falling, and whether women-led businesses are actually benefiting.

Fourth, there should be a small technical advisory arrangement involving research, enterprise and market actors. This is justified by the OM's stated audience - policymakers, industry stakeholders, researchers and development partners - and by the fact that several of the proposed interventions, especially by-product valorisation and improved processing, will need technical refinement as they move from pilot to wider adoption.

Table 11.3: Oversight and institutionalisation measures

Oversight measure	Purpose	Why it is justified
Annual roadmap review	Check progress against priority hotspots and agreed actions	The OM provides a strong baseline and prioritisation logic
District and regional scorecards	Compare performance across implementation areas	The roadmap begins in four districts across two regions
Environmental, economic and social reporting	Keep performance visible across the full circular economy agenda	The OM combines these three dimensions in its analysis
Technical advisory support	Help refine pilots and guide scale-up	The OM is intended for policymakers, industry, researchers and partners

Figure 11.2: Oversight cycle



Summary table

Governance level	Main function
National	Policy steering, sector alignment and resource mobilisation
Regional	Coordination, technical review and performance comparison
District	Execution, data capture, local facilitation and problem-solving



Step 12: Communications, Behavioural Change and Cultural Shifts

The OM shows that communication is not a side activity in this roadmap. It is part of implementation. Three findings make that clear.

First, the report identifies a limited culture of reuse and recycling across the fish value chain. It states that 87% of processors and 93% of traders reported no material reuse or waste, and that only a small minority expressed interest in reuse. The report therefore recommends awareness campaigns and demonstration projects to show the economic value of circular practices.

Second, the actors who must adopt many of the new practices are mostly women with modest formal education. Processing is 90.5% female and trading is 97.0% female. Among processors, 63.5% have only a basic education, and 22.2% have no formal schooling. Among traders, 66.3% have basic education and 17.8% have no formal schooling. The report explicitly states that training and support should therefore be delivered through practical, visual, and hands-on methods.

Third, the fish value chain is shaped by a small number of very visible problems: heavy reliance on firewood for smoking, unmanaged by-products, weak reuse practices, and quality loss during trade. These are the kinds of issues that can be communicated clearly through demonstration, comparison and peer learning. The OM itself argues that behaviour change is needed alongside technical and financial solutions.

For that reason, Step 12 should focus on communication that shows, not simply communication that tells. The aim is to make circular practice visible, credible and socially acceptable within the daily realities of processors, traders and producers.

12.1 Storytelling and recognition

The report supports a communications approach built around visible proof of improvement. It recommends demonstration projects because interest in reuse is currently low and because many actors will need to see the practical and economic benefits of new approaches before changing established habits. In this roadmap, storytelling should therefore be grounded in real operational change: less wood used, fewer by-products dumped, better fish quality, safer working conditions and more stable prices.

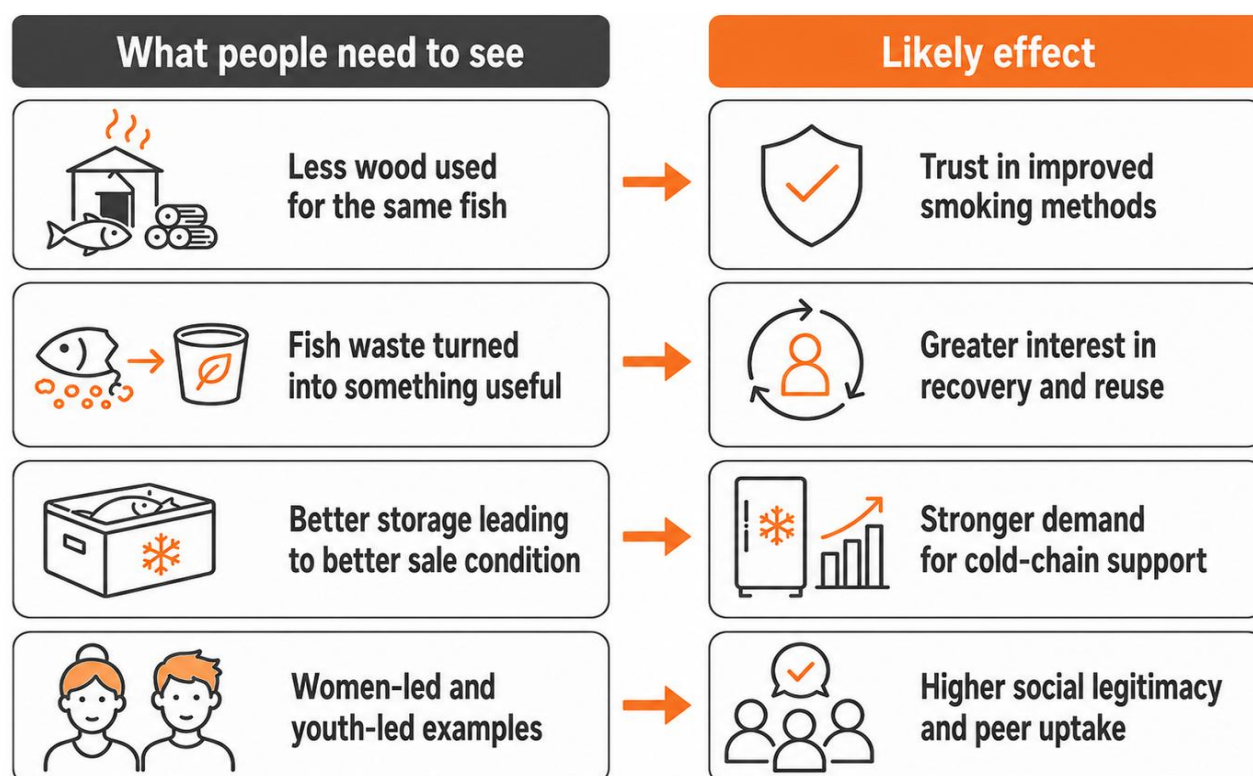
The most effective stories will be simple and comparative. For example, processors should be able to see the difference between traditional and improved smoking methods in terms of wood use, smoke exposure and product consistency. Traders should be able to see the difference between fish handled with and without better cooling or storage. These are not abstract messages. They follow directly from the report's evidence on fuelwood intensity, quality deterioration and low awareness of reuse opportunities.

Recognition also matters because the post-harvest economy is overwhelmingly female, communication should visibly recognise women-led uptake of better practices. The same applies to youth-focused entrepreneurship support, which the report recommends as part of widening participation in the sector. Recognition should not be treated as a ceremonial extra. Used well, it can help turn improved practice into something people want to be associated with.

Table 12.1: Storytelling and recognition priorities

Communication task	Significance in the OM	Practical form
Show the benefits of cleaner smoking	Fuelwood use is extremely high and improved technologies are recommended	Before-and-after comparisons at smoking sites; simple visual evidence on wood saved and product quality
Show the value of reuse and recovery	Most actors currently do not reuse waste and awareness is low	Demonstrations of fish by-product sorting, recovery and simple secondary uses
Show that better handling protects value	Trade loses value through quality deterioration even where spoilage is low	Market-side comparisons of better cooling, handling and sale condition
Recognise local adopters	Women dominate processing and trading; youth support is recommended	Public acknowledgement of processor groups, trader groups and youth-led ventures that adopt practical circular solutions

Figure 12.1: Communication logic for behavioural change



12.2 Local-language and low-literacy messaging

The report gives very strong evidence for a low-literacy communication approach. It states that training for processors and traders should be delivered using practical, visual and hands-on methods. It also recommends literacy-inclusive training materials and support tailored to women and low-education groups. This means the roadmap's communication methods should rely heavily on pictures, demonstrations, oral explanation and simple repetition.

In practice, that means messages should be delivered in the dominant local languages of the pilot districts and should avoid dense written content wherever possible. This is a direct operational inference from the OM's findings on education levels and training needs. Visual cues will be

especially useful in areas such as waste sorting, fish grading, crate handling and hygiene practice. Short oral reminders and field-based reinforcement are likely to work better than long written instructions for most post-harvest actors.

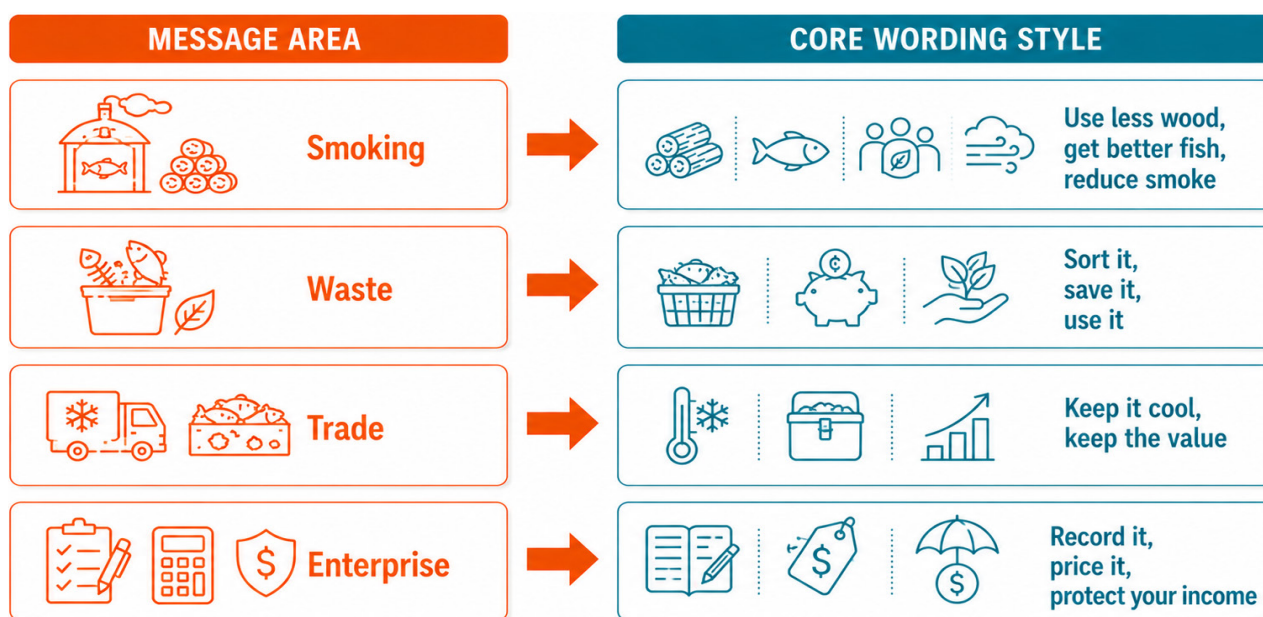
The content of the messages should also be narrow and practical. The OM suggests that behaviour change will be easier where communication focuses on a few immediate gains:

- lower fuelwood use
- cleaner and safer smoking
- less dumping of fish waste
- better handling and storage
- stronger product quality
- clearer business value from reuse and recovery.

Table 12.2: Low-literacy communication design

Need identified in the OM	Communication response
Many processors and traders have only basic or no formal education	Use pictures, demonstrations, oral explanation and short practical guidance
Training must be practical and hands-on	Deliver messages through live demonstrations, not only written materials
Reuse awareness is low	Use very simple “waste-to-value” examples grounded in local practice
Women are the main post-harvest actors	Design messages around women’s working realities, time constraints and existing group settings

Figure 12.2: Simple message architecture



12.3 Community-led channels

The OM itself was built through face-to-face interviews, focus group discussions, key informant interviews and field observation. That is important because it shows that the fish value chain is best understood, and therefore best influenced, through direct engagement in the places where people work. Communication should therefore move through the same kinds of channels: processor meetings, trader discussions, landing-site engagement and practical demonstrations at real working sites.

This is especially important because the businesses involved are small, informal and often built around trust and routine rather than formal systems. The report shows that many actors rely on practical experience and interpersonal networks. That means behaviour change is more likely when communication occurs in familiar peer settings than through distant, formal

campaigns alone.

For this reason, the strongest channels for Step 12 are likely to be:

- processor group meetings, especially where cleaner smoking or by-product sorting is being introduced
- trader association meetings and market discussions, especially where cold handling, storage or better quality practices are being tested
- landing-site discussions, where handling and early post-harvest losses can be addressed
- demonstration days at smoking sites and markets, where actors can compare old and new practices directly. These channels are all strongly supported by the OM's methodology, social profile and recommendations on demonstration-led uptake.

Table 12.3: Community-led communication channels

Channel	Why it fits the OM	Best use
Processor group meetings	Processing is the main hotspot and is strongly women-led	Cleaner smoking, waste sorting, hygiene and costing messages
Trader meetings and market discussions	Traders are overwhelmingly female and face storage and quality challenges	Cold handling, quality preservation and simple stock/loss tracking
Landing-site discussions	The OM identifies post-harvest losses and handling gaps at this stage	Early handling, icing awareness and offal recovery messages
Demonstration days	The OM explicitly recommends demonstration projects	Show the economic and practical benefits of new practices

Summary table

Communication objective	Channel or method
Shift norms on waste and reuse	Demonstrations, simple visuals, processor and trader group discussions
Increase trust in improved technology	Before-and-after comparisons, peer examples and field demonstrations
Keep women and low-literacy actors fully included	Local-language, visual and hands-on communication
Build social acceptance for circular practice	Public recognition of early adopters and visible local success stories



Step 13: Circular Business Model Incubation and Scaling

The OM points to a small number of business directions that are both commercially relevant and materially significant. They sit where the chain is currently losing the most value: at processing, where about 25% of raw fish input becomes by-products and is largely unmanaged; at smoking, where fuelwood use averages about 1.31 kg of wood per kg of fish processed; and at trade, where most fish is sold but about 0.8% is sold at a reduced price because quality has deteriorated before sale. The report also shows that most processors and traders are small-scale operators, many with no hired workers, and that these nodes are overwhelmingly female. That combination of waste, cost pressure, quality risk, and the small-enterprise structure is what makes business-model design so important.

Put simply, the strongest circular business models in this value chain are not abstract innovations. They are practical service

and recovery models built around the real bottlenecks identified in the OM: discarded by-products, expensive and inefficient smoking, weak cold handling, and the inability of micro-enterprises to invest in equipment on their own.

13.1 Circular business models identified

The OM does not present a formal venture catalogue, but it clearly identifies a set of opportunity areas that can be translated into three strong business model directions for incubation and scaling: by-product conversion, shared clean-smoking services, and cold-chain and crate services. These are the most commercially plausible because each responds to a measured hotspot and can be organised at the cluster or service level, which suits the micro-scale structure of the sector.

Table 13.1: Circular business models identified

Business model	Typology	Problem addressed	Core opportunity
Fish By-product Conversion Enterprise	Resource recovery/waste-to-value	About 25% of raw fish entering processing becomes by-products and surveyed processors reported 0% current use for animal feed	Convert offal, bones, heads and scales into fishmeal, compost, pet feed ingredients, fertiliser inputs or collagen-linked products
Kiln-as-a-Service/Clean Smoke Cluster	Product-service system	Small processors face high fuelwood use, smoke exposure and limited capital for better equipment	Shared efficient kilns, fee-for-use smoking, maintenance support, training and quality-assured processing services
Solar Ice, Cold Storage and Reusable Crate Leasing	Sharing platform/service model	Trade is physically efficient, but about 442 kg per cycle is sold at reduced price because quality falls before sale; cold-chain support remains weak	Pay-per-use cooling, ice supply, short-term storage and reusable crate circulation for traders and processors

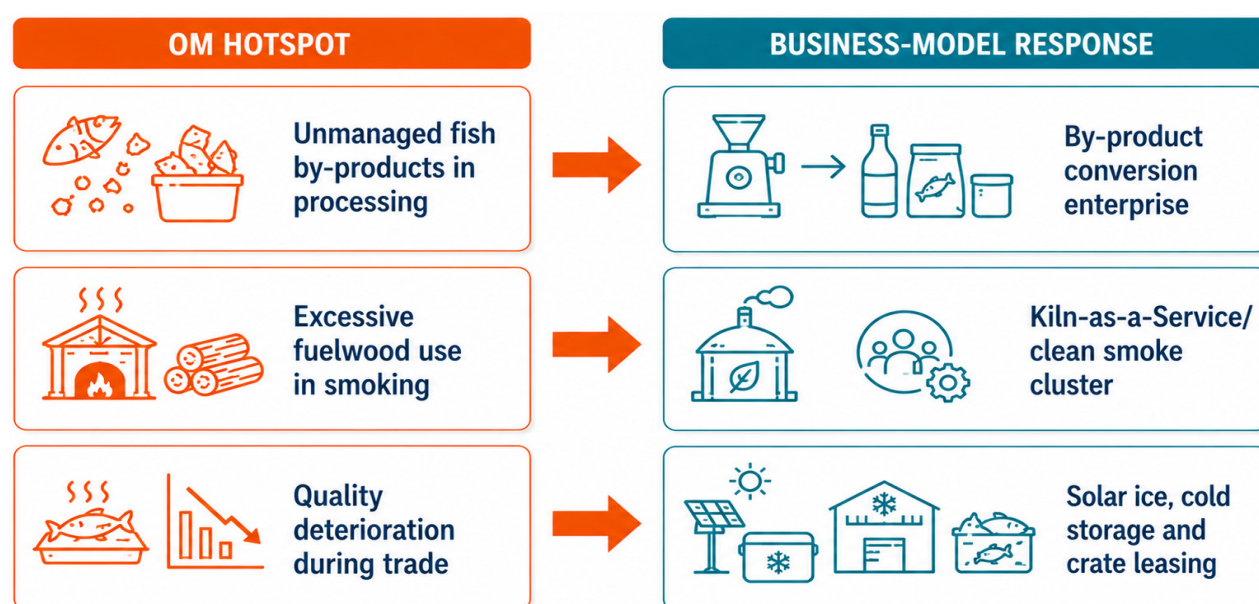
The first model, fish by-product conversion, is the most direct response to a material leakage already measured in the report. The OM shows that processors handle about 19,454 kg of fresh fish per cycle and generate about 4,864 kg of by-products, most of which are discarded. The report explicitly identifies fishmeal, compost, pet feed, fertiliser, collagen and other high-value products as plausible opportunity areas. This makes by-product conversion the clearest waste-to-value enterprise direction in the roadmap.

The second model, Kiln-as-a-Service, follows from the OM's finding that smoking is both energy-intensive and difficult for small processors to upgrade alone. The report recommends improved smoking technologies, cleaner energy alternatives, micro-financing and demonstration-based

adoption. It also notes that many operators are too small to invest independently in new infrastructure. A shared-service model therefore fits the evidence better than assuming each processor will buy and maintain her own upgraded system.

The third model, solar ice, cold storage, and reusable crate leasing, addresses hidden economic losses rather than large physical waste. The OM shows that traders sell nearly all the fish they procure, but still lose value because some fish is sold below full price after quality declines. It also highlights inadequate storage, weak cold-chain infrastructure and the case for low-cost cooling, solar-powered systems and reusable handling solutions. This supports a service model built around access rather than ownership.

Figure 13.1: Where the business opportunities sit



13.2 Projected returns by model

The table below presents directional returns inferred from the OM, not measured financial projections. Each return is tied to a problem the report actually documents.

Table 13.2: Projected returns by model

Model	Economic return	Environmental return	Social return
Fish By-product Conversion Enterprise	New revenue from material that is currently discarded; lower disposal burden around processing sites	Could divert a substantial share of the ~25% by-product stream away from dumping and unmanaged disposal	Creates work in collection, sorting and first-stage processing; the OM suggests this could be especially relevant for women and youth if linked to enterprise support
Kiln-as-a-Service/Clean Smoke Cluster	Lower unit fuel cost, more stable throughput and potentially better product consistency	The OM cites evidence that improved smoking technologies can reduce wood use by up to 50% while improving product quality	Reduced smoke exposure and drudgery in a node where 90.5% of processors are women
Solar Ice/Cold Storage/Crate Leasing	Better price realisation through reduced quality discounting; less loss from weak handling	Lower spoilage risk, less avoidable deterioration and less packaging waste where reusable crates are adopted	Strong practical benefit for women traders, who make up 97% of the surveyed trading sample

The strongest economic logic sits with value recovery. In processing, this means monetising material that is currently treated as waste. In smoking, it means reducing fuel cost and improving operational efficiency. In trade, it means protecting sale value rather than simply preventing spoilage. The OM supports all three directions.

13.3 Readiness pillars and support needs

The OM suggests that these business models are promising, but not yet fully market-ready. They need support in four areas: technical readiness, financial viability, policy and operational fit, and market development. This is a fair reading of the report, which repeatedly points to low technology uptake, limited capital, weak infrastructure, low reuse culture, and the need for training, demonstration and private-sector partnerships.



Table 13.3: Readiness pillars and support needs

Readiness pillar	Support needs	Basis in the OM
Technical readiness	Equipment testing, simple operating procedures, fabrication or maintenance support, basic product-quality protocols	The OM recommends improved smoking technologies, small-scale recovery equipment and practical training
Financial viability	Microfinance, shared-service models, cooperative finance, start-up working capital	The OM highlights finance as a major constraint and recommends microcredit, green finance and cooperative models
Policy and operational fit	Hygiene guidance, site-level permissions, quality handling rules and local implementation support	The OM links circular opportunities to practical handling, storage and post-harvest conditions rather than to stand-alone technologies
Market development	Buyer linkage, product demonstration, offtake arrangements and confidence-building for new outputs	The OM recommends private-sector partnerships and awareness-building to show the economic value of circular practices

Three points deserve emphasis here. First, technology alone is not enough. The OM is clear that low adoption is also about finance, awareness and small enterprise scale. Second, shared models are important because many businesses are too small to invest alone. Third, buyer confidence matters, especially for any model based on recovered materials or improved quality.

13.4 Incubation support mechanisms

The OM does not use the language of incubation in a formal enterprise development sense, but it supports a clear set of mechanisms that serve the same purpose. It repeatedly recommends training, community-based demonstrations, private-sector partnerships, microfinance, women-focused cooperatives, and support for youth entrepreneurship. Taken together, these amount to a practical incubation pathway for circular businesses in the fish value chain.

A workable incubation package for this roadmap should include four parts.

Demo Days

The OM strongly supports demonstration-led uptake. Demo Days should therefore be used to show working examples of secondary products, improved kilns, cleaner smoking, cold-chain services and better handling systems. The point is not only visibility. It is to give processors, traders, buyers and financiers something practical to judge.

Innovation Roundtables

The OM makes clear that circular opportunities cut across technology, finance, market access and support services. Innovation roundtables should therefore bring together entrepreneurs, processors, traders, buyers, suppliers, technical partners, and finance providers to address specific venture bottlenecks, such as input supply, handling standards, service pricing, or buyer confidence.

Pre-incubation training

The report repeatedly calls for practical, visual and hands-on training, especially for women and low-literacy groups. Pre-incubation support should therefore cover simple costing, product handling, quality control, recordkeeping, group organisation and basic customer development, all in a format suited to micro-enterprises.

Access to shared tooling

The OM's cooperative model logic is particularly important here. Because many businesses cannot afford equipment individually, incubation should include shared access to items such as grinders, drying capacity, simple storage, crate pools and fabrication support for smoking systems. This follows directly from the report's support for communal cold rooms, shared processing hubs and cooperative solutions.

Table 13.4: Incubation support mechanisms

Support mechanism	Purpose	OM justification
Demo Days	Show working ventures and real performance differences	The OM recommends demonstrations to build awareness and confidence
Innovation Roundtables	Solve finance, market and technical bottlenecks across actors	The OM shows that barriers are cross-cutting, not purely technical
Pre-incubation Training	Build enterprise basics in low-literacy, practical formats	The OM explicitly recommends practical, visual training
Access to Shared Tooling	Lower entry barriers for micro-enterprises	The OM recommends cooperative models and shared infrastructure

13.5 Scaling path

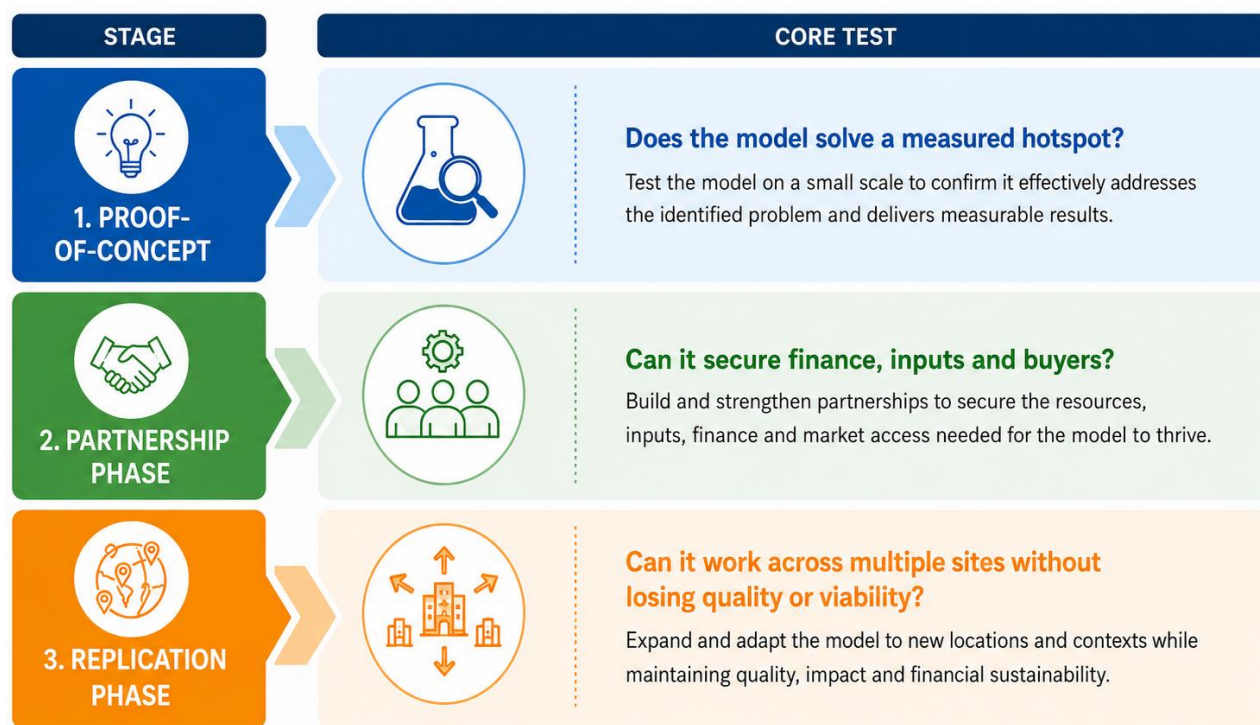
The scaling path should be disciplined and evidence-led. The OM itself is built around measured hotspots and practical recommendations, and the same principle should apply to business-model scaling. Early-stage business models should first prove they work in real operating conditions across the four study districts; then build partnerships and buyer confidence; and only then move into wider replication.

Table 13.5: Scaling path

Phase	Timeline	Key outputs
Proof-of-Concept	Years 1-2	Three priority pilot directions operating; first ventures tested in by-product recovery, clean smoking and cold-chain services
Institutional Partnerships	Years 2-3	Stronger finance links, district-level support, buyer relationships, product handling rules and operational refinement
Regional Replication	Years 3-4	Expansion to additional inland or similar market clusters, with a practical replication package based on what worked

The first phase is about proving that each model solves a real bottleneck. The second phase is about reducing business risk through partnerships, finance and user confidence. The third phase is about replication, but only where the evidence shows a workable fit. That is especially important in a chain where most enterprises are very small and cannot absorb repeated trial-and-error at their own cost.

Figure 13.2: Scaling logic



Summary table

Scaling principle	Roadmap approach
Start with services, not just hardware	Shared models reduce the entry barrier for micro-enterprises and reflect the OM's support for cooperative and cluster solutions
Build markets alongside technology	Recovery and cold-chain ventures only work if buyers, users and service demand are in place
Use women-led clusters as anchor users	Processing and trading are overwhelmingly female, so the strongest early business case sits there
Replicate only proven models	Scale should follow measured performance, not assumption, which is consistent with the OM's evidence-led approach



About Ghana Circular Economy Centre

The Ghana Circular Economy Centre (GCEC) project supports Ghana's transition to a resource-efficient and inclusive circular economy by promoting innovation, strengthening policy and institutional frameworks, and building capacity across key value chains, including plastics, agriculture and agro-processing (cassava, mango, pineapple and tilapia), and textiles.

The project is implemented by the United Nations Industrial Development Organization (UNIDO) in partnership with the Ministry of Environment, Science and Technology (MEST), with funding support from Global Affairs Canada.

The GCEC serves as a national hub for knowledge generation, stakeholder engagement, and the piloting of circular solutions to advance sustainable industrial development, improve resource efficiency, and create decent jobs.

Host Institution



Value Chain Leads



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