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# WOMEN SHELLFISHERS AND FOOD SECURITY

## Value Chain and Economic Analysis of the Shell By-Product of Bivalve Fisheries in Ghana and The Gambia: An Assessment of Oyster, Cockle, and Clam Shells

October 2024

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**Cover photo:** A truck load of clam shells (top left), fresh and milled clam shell (top right), oyster shell cultches for oyster culture (bottom left), and bagged lime (bottom right).
**Photo credit:** West Africa Shellfish Knowledge and Outreach Hub, University of Cape Coast

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# TABLE OF CONTENTS

Page

# LIST OF TABLES

Page

# LIST OF FIGURES

Page

# ACRONYMS

| | |
|---|---|
| CCM | Centre for Coastal Management |
| CRC | Coastal Resources Center |
| DAA | Development Action Association |
| DOPA | Densu Oyster Pickers Association |
| EB | Economic Benefit |
| EV | Economic Value |
| FAO | Food and Agriculture Organization of the United Nations |
| FGDs | Focus Group Discussions |
| FISH4ACP | Fish for African Caribbean and Pacific |
| GCC | Ground Calcium Carbonate |
| ICRAF | World Agroforestry (International Centre for Research in Agroforestry) |
| IRB | Institutional Review Board |
| KII | Key Informant Interview |
| MOFAD | Ministry of Fisheries and Aquaculture Development |
| NOHA | Narkwa Oyster Harvesters Association |
| PCC | Precipitated Calcium Carbonate |
| PVC | Polyvinyl Chloride |
| SWOT | Strength Weakness Opportunities and Threat |
| TRY | TRY Oyster Women's Association |
| UCC | University of Cape Coast |
| URI | The University of Rhode Island |
| USAID | United States Agency for International Development |
| WSFS | Women Shellfishers and Food Security |

# EXECUTIVE SUMMARY

This report examines the shell value chain and the economic potential of shell by-products from bivalve fisheries in Ghana and The Gambia. The study focuses on three key bivalve species: the West African mangrove oyster (*Crassostrea tulipa*), West African bloody cockle (*Senilia senilis*), and the Volta clam (*Galatea paradoxa*). It provides insights into the opportunities and challenges within the shell value chains of these species.

The study used a mixed methods approach to gather both quantitative and qualitative data from interviews and focus group discussions across four coastal locations in Ghana (Densu delta, Narkwa lagoon, Whin estuary, and Big Ada at the Lower Volta River) and four locations in The Gambia (Kamalo, Old Jeshwang, and Lamin within the Tanbi wetlands; and Kartong within the Allahein wetlands). The research involved ten key informant interviews and eight focus group discussions targeting four main actors: shell harvesters (primary producers), people who mine shells from old shell beds that are not based on recent shellfish harvesting activities (miners), people who buy shells in small quantities from primary producers and shell miners for onward sale to shell millers (aggregators), and processors (manufacturers of shell products).

Shells were primarily generated as a by-product of shellfish processing and were used for various purposes and products. But the key uses found by this study were milling into granular powder for animal feed formulation; lime production (for use as paint by the construction industry and pond fertilization in aquaculture); domestic use for controlling erosion and land reclamation. The Gambian shellfishers used the oyster shells for oyster culture while the Densu shellfishers used the shells for reef enhancement. Shells were mainly sold, with shells at the peri-urban areas (Densu, Ada, Lamin, and Old Jeshwang) costing about two to three times higher than shells in more rural areas (Narkwa and Kartong). Prices of shells in The Gambia (US$ 0.04-US$ 0.12 per kg) were also about four times higher than in Ghana (US$ 0.01-US$ 0.04 per kg). The study identified five main actors in the bivalve shell value chains across Ghana and The Gambia: shell generators (mainly women shellfish harvesters and a few men shell miners), shell aggregators, semi-finished shell product producers, end-product manufacturers, and end users. Along the milled shell value chain, three channels were observed in the transition of shells from primary producers to end users, with or without intermediaries. Findings indicated that shell processors in Ghana generated more income, especially due to the high demand from the poultry industry.

The results suggest that women shellfish harvesters are highly constrained in deriving the full benefits at the different nodes of the value chain beyond production and sale of the shells. Confounding factors, including production cost, equipment and other fixed costs, transport, low demand from local markets in The Gambia, and marginal profits in Ghana, seriously challenge the potential of women harvesters to effectively engage in the shell milling business for production of granular shell product. Transitioning to feed formulation would be even more difficult, as the average cost of procuring and installing a

feed formulation machine alone is US$ 5,867 in Ghana, and US$ 11,596 in The Gambia, which is unaffordable to the individual shellfishers and the shellfishers associations. An effort of the governments to support the women shellfish harvesters through national women economic empowerment policies and programs to fund start-up costs, particularly for establishing shell milling enterprises, could elevate them within the value chain. However, this must be gauged against the limiting factors of sufficient production of shells that ensures continuous availability of raw materials all-year round for a viable and sustainable gendered enterprise in the case of Ghana, and a viable model that minimizes the processing cost and offers milled shell products at prices competitive to the prices of the product imported from Senegal-including meeting the quality demand-in the case of The Gambia.

The results also highlight the need to promote re-use of bivalve shells (importantly oyster shells) for reef enhancement as this emerged as the most economically profitable option (yielding 716 percent to 2,350 percent gains per year over and above the profit made if shells were sold or milled). The Densu women shellfishers have been pioneers in using oyster shells for reef enhancement as a management measure based on a gendered rights-based shellfisheries co-management approach. For areas in The Gambia where there are stockpiles of oyster shells, options for supporting the women to establish shell processing enterprises need to be explored as only a limited proportion of shells produced could be used for reef enhancement or oyster culture.

The study provides recommendations to promote gender-focused business opportunities for women sellfishers to maximize the benefits from the bivalve shells they produce, including support strategies for the women to participate in the shell milling enterprise, research to optimize the cost-effective and environmentally friendly lime production, and promotion of shell utilization for reef enhancement and oyster culture.

# 1. INTRODUCTION

## 1.1 Background to the study

Shellfish fisheries, especially bivalve fisheries, have been recognized as a significant component of the livelihoods and economic empowerment of women and their households in the rural and peri-urban coast of West Africa. West African shellfisheries are now estimated to contribute over US$ 300 million to the region's economy (Chuku et al., 2022). Although the economic benefits from bivalves are of longstanding local knowledge, it has only recently become prominent in national discourses following evidence emerging from recent efforts at data gathering by individual marine/fisheries researchers and targeted donor-funded projects. In the past fifteen years, three projects, (i.e., the USAID Ba Nafaa Senegal-Gambia Sustainable Fisheries Project, the USAID Ghana Sustainable Fisheries Management Project, and the West Africa Women Shellfishers and Food Security Project) have particularly highlighted the significance of the sector and helped demonstrate sustainable exploitation and mangrove habitat stewardship through rights-based co-management arrangements. The FAO FISH4ACP project also supports the sector in The Gambia and Senegal since 2020.

A major interest and knowledge gap in the advancement of West Africa's shellfisheries and their sustainable management are the ecosystem services and the potential economic benefit to be derived from the copious volumes of shell by-products. This study, therefore, focuses only on the shell value chain and not the entirety of the bivalve. The common practice is that after harvesting and shucking the meat for subsistence and/or sale, the women harvesters pile up heaps of shells as waste (or by-products). In several instances, these shell piles have, after several years, become part of the geological formation along the banks of the estuaries. Meanwhile, there are accounts of the myriad uses of the shell by-product around the globe. Bivalve shells are reported to have use in agriculture (as soil amendment and animal feed inputs) (GOPA AFC, 2022; Blunk et al., 2024), building (Arkhurst & Andoh, 2016), and fashion industries (Tribord, 2018) as well as in traditional medicine (González & Vallejo, 2023). They are also useful for regenerating degraded shellfish populations and habitat restoration (Mahu et al., 2022; Smith et al., 2022).

To harness the full economic potential of the shell by-product requires a holistic analysis of the supply/value chain, which is currently unknown. Value chain analysis is the concept of analyzing the disaggregated phases of production, which has gained recognition over the years in economics and management (Abecassis-Moedas, 2006). Analyzing the shell value chain will reveal the chain of actors, activities, costs, and benefits related to the shell from production to end use. The importance of such analysis on the shell by-products of the West African bivalve fisheries is to provide valuable insights, guide decision-making, enhance sustainability, attract investments, and foster growth in the identified spectrum of uses of the shell. Several controlling factors must be considered, including the shell's originating species and market types, as they influence the activity chain. For instance, because bivalve shells are primarily deposits of calcium laid by the mantle epithelium (Louis et al., 2022), the physical and chemical processes associated with their varying habitats play critical roles in shell formation. Oysters inhabit a range of sandy mud to hard substrates in estuarine conditions of 5-30 ppt salinity. The Volta clam thrives in freshwater. Cockles colonize the muddy depths of the estuarine floor, with the capability of burrowing into the mud with a specialized foot. As a result, these clades have differential shell micro-structures within and between individual animals – this is accentuated between genera. The differential mechanical properties of bivalve shells may present varied economic opportunities, and specific potential challenges with processing and value addition.

There is ample evidence of some economic benefits of bivalve shells in coastal communities of West Africa. The post-harvest shell product is sold to various actors for onward utilization in a myriad of other products, including poultry feed, paint manufacture, etc. (Obirikorang et al., 2013). The shell powder production industry processes large volumes of bivalve shells due to the high demand for shell powder in industrial-scale manufacturing of paint, and agricultural uses as calcium and phosphorus for poultry, fish, and livestock feed, fertilizers, or as a soil pH buffer. In addition, in countries like Ghana where oyster spat settles and grows on the bottom substrate, shells have been returned to these habitats to maintain and enhance reefs or substrate, as in the Densu Delta Shellfish Co-Management Plan (Ghana MOFAD, 2020).

## 1.2 Literature review of global demand and utilization of bivalve shell by-products

The potential supply of bivalve shells is enormous as the global production of marine bivalves for human consumption exceeds 15 million tonnes annually, constituting approximately 14 percent of the world's total marine production (Wijsman et al., 2019). Oysters are the most produced molluscan species, followed by clams. Together, these two groups make up 71 percent of global production, with scallops and mussels accounting for 17 percent and 13 percent respectively (Wijsman et al., 2019). Asia, particularly China, dominates this sector, contributing 85 percent of global output and driving production growth with the majority coming from clams and oysters. The predominant bivalve species found in China are the *Crassostrea gigas* (oyster), *Perna viridis* (mussel), *Ruditapes phillippinarum* (clam), and *Siliqua patula* (clam) (Willer & Aldridge, 2020). Like China, Korea, Japan, and Thailand have been identified as major producers of bivalves in Asia. Other marine bivalve producing countries of importance worldwide, are the United States of America (oysters and clams), France (scallops), Canada (mussels), Spain (mussels), Chile (mussels and scallops) and Australia (oysters). In Africa, there is low production of bivalves due to limited market demand. With about 24 countries engaged in aquaculture, the production of bivalves in Africa accounts for less than one percent of the world production (Wijsman et al., 2019; Cai et al., 2023). Countries involved in bivalve production in Africa include Senegal, Nigeria, Cameroon, Ghana, Gambia, South Africa, Sierra Leone, Guinea Bissau, Guinea, Liberia, Cote d'Ivoire, Togo, Benin, Morocco, and Namibia (Akinjogunla & Moruf, 2019; Willer & Aldridge, 2020; Chuku et al. 2022; Cai et al., 2023). In West Africa, Chuku et al. (2022), identified the most harvested species of bivalves to be *Crassostrea tulipa* (oyster), *Senilia senilis* (cockle), and

*Galatea paradoxa* (clam), while Willer and Aldridge (2020) identified *Ruditapes decussatus* (clam), *Crassostrea gasar* (oyster), and *Mytilus edulis* (mussel) as the most dominant bivalves in Senegal and Sierra Leone.

The issue of shell waste disposal has become a barrier to shellfish production in many parts of the world due to its operational and financial burden. It is estimated that marine by-product wastes, including but not limited to shells and trimmings, amounts to 25 percent of the total marine production (Hou et al., 2016). These wastes are normally processed into poultry feed, used as fertilizers or end up in landfills. However, the dumping of oyster, clam and mussel shells in landfills leads to environmental pollution including damage to the marine ecosystem (Jung et al., 2007). The composition of calcium carbonate ($CaCO_3$) in shells makes them impossible to decompose without any prior treatment. It is thus necessary that shells are converted into raw materials to be used as a valuable resource. The sections below review a range of applications and uses of shell product.

### *1.2.1 Food and culinary*

Ground oyster shells are commonly included in animal feed, especially for poultry and livestock (Morris et al., 2019; GOPA AFC, 2022). They are a rich source of calcium, promoting bone development, shell formation in egg-laying hens, and overall animal health. Shells of bivalves have served as a calcium carbonate source for the poultry industry. The calcium carbonate provided to poultry farms is primarily removed from the system as it is deposited in eggshells.

### *1.2.2 Industrial applications*

Shells act as adsorbents in wastewater treatment. Phosphorus, nitrogen and other nutrients in water can result in oxygen depletion. Thus, shells have been utilized effectively to remove phosphate and nitrate from industrial and agricultural wastewater, particularly calcined shells (Popovic et al., 2023).

Use of oyster shell has been investigated as an alternative material for construction related applications such as a substitute for aggregates in building materials or cement clinker (Yang et al., 2005; Chiou et al., 2014; Paris et al., 2016). Crushed oyster shells can be used as aggregate in construction materials such as concrete and asphalt. Their hardness and durability make them a sustainable alternative to traditional aggregates, reducing environmental impact. This alternative to limestone has the added benefit of a lower carbon footprint because it does not require the use of equipment associated with mining limestone.

Calcium carbonate ($CaCO_3$) is commonly used as a filter in the manufacturing of polypropylene and polylactide to enhance molding productivity and elevate operating temperatures (Hamster et al., 2010; Cecchi et al., 2019). This additive, often in the form of a precipitated $CaCO_3$ (PCC), plays a vital role in optimizing the physical and chemical properties of plastic products to meet customer specifications while contributing to carbon sequestration (Boicko *et al.*, 2004). Additionally, the Decathlon sports gear brand sells equipment incorporating 15 percent oyster shell blended with thermoplastic elastomer (Tribord, 2018).

Bivalve shells can substitute ground calcium carbonate (GCC) or limestone in various applications, including glass manufacturing. The shells can also be utilized as pore forming agents for thermal insulation foams and in the production of houseware materials like sea plaster and opal marine glass (Teixeira et al., 2017).

In the paint manufacturing and coating industry, precipitated calcium carbonate (PCC) serves as a primary extender due to its unique properties, including low basic color, high water resistance, and pH stabilizing effect (Jimoh et al., 2017). It also acts as a rheology modifier in sealants, especially in PVC plastisol formulations, and imparts desirable properties such as thixotropy. Throughout these applications, calcium carbonate maintains its structure, ensuring long-term preservation of carbon dioxide sequestration in shell calcium carbonate (Alonso et al., 2021).

### *1.2.3 Personal care and wellness*

Calcium carbonate sourced from oyster shells has found extensive application as a dietary supplement for replenishing calcium levels in the body. Oyster shell powder is sometimes consumed as a dietary supplement for humans. It provides a natural source of calcium carbonate, supporting bone health, tooth strength, and overall mineral balance in the body. Research conducted in Japan validates that the carbonate derived from these shells is effectively assimilated by the intestines, leading to enhanced bone mineral density, particularly in the lumbar region among those deficient in calcium (Fujita et al., 1990).

### *1.2.4 Agriculture and gardening*

Crushed oyster shells are utilized as a soil amendment to provide calcium carbonate and improve soil pH levels. They also enhance soil structure, water retention, nutritional status and aeration, benefiting plant growth and overall crop yield (Lee et al., 2008; Chen et al., 2018; GOPA AFC, 2022; Blunk et al., 2024). Oyster shell can be used as an alternative liming material to restore the soil chemical and microbial properties in upland soil and to increase crop productivity (Lee et al., 2008). Additionally, oyster shells possess antifungal properties and can serve as agricultural fungicides by altering the membrane permeability of fungi. Untreated oyster shell powder has demonstrated notable antifungal efficacy against *Physalospora piricola Nose* (*P. piricola*) and *Rhizoctonia solani* (Xing et al., 2013).

Oyster shells are crucial in oyster farming as they serve as substrate material for oyster larvae settlement. They provide a suitable surface for oyster spat attachment, aiding in the cultivation and growth of oysters. They also serve as a substrate for larval settlement. Previous studies have consistently highlighted the importance of shell substrate for the attachment and metamorphosis of shellfish larvae. The physical structure of shells provides a suitable surface, influencing settlement success and subsequent juvenile development (Poirier et al., 2019).

### *1.2.5 Pollution prevention and environmental care*

The importance of bivalve shells for environmental remediation and pollution reduction has been widely documented. They are critical in bio-ecological research, providing reliable information on environmental conditions. For Instance, Bettencourt and Guerra (1999) found that the isotope composition of aragonite, a common mineral in bivalve shells, appears to be in isotopic equilibrium with the ambient seawater, and that stable carbon and oxygen isotopes from it are natural tags for determining the degree of spatial connectivity between nearshore and offshore environments. Moreover, the bio-adsorbent efficacy of bivalve shells make them an efficient, low-cost and eco-friendly technology for wastewater treatment and oil-water separation (Vibhatabandhu & Srithongouthai, 2016; Xu et al., 2022).

Bivalve shells are also recognized as an important material for mitigating environmental pollution and addressing climate change through carbon sequestration (Filgueira et al., 2019; Jansen & van den Bogaart, 2020; Alonso et al., 2021; Mahu et al., 2024). Although the shell microstructure varies among bivalves of different taxonomic groups, all bivalve shells are composite ceramic/organo-minerals, constituted of 90 percent $CaCO_3$ and one percent to ten percent proteins and polysaccharides (Alonso et al., 2021). Bivalve shells can serve as a carbon sink through a process called carbon mineralization. As bivalves build their shells, they extract carbonate ions from the surrounding water to form calcium carbonate. When bivalves die, their shells sink to the ocean floor, where they are accumulated over time, effectively sequestering carbon from the atmosphere. This process helps mitigate ocean acidification and contributes to long-term carbon storage.

### *1.2.6 Crafts and art*

One other area in which bivalve shells have been found to be of useful application in Africa is the handicraft industry, where different bivalve shells have been noted to be used in the construction of art products throughout human history (Clarke, 2006; Bouzouggar et al., 2007; Ogbechie, 2007; Simbao et al., 2017; Pawłowska, 2020; Mouton & Antonites, 2023). For instance, Bouzouggar et al. (2007) as well as Mouton and Antonites (2023) argued that the discovery of shell beads and other art materials of shell origin in archaeological records across Africa demonstrates that various tribes and local communities along the African coast had a well-developed shell-based art industry, at least before colonial relations or western civilization. Mounton and Antonites' analysis also shows that arts from bivalve shells had a tremendous influence on the political economy of the African Iron Age, and have remained so even in modern times. Commenting on the significance of handicrafts for livelihoods and wellbeing in the Akuapim South District of Ghana, Entsua-Mensah (2021) notes that the construction of arts from various materials has always been part of the history of the tribes of West Africa. Though this study did not specifically investigate the use of bivalve shells for handicrafts, there is an implicit link since the study took place in a region that cannot be described as deprived of bivalve shell generation and utilization opportunities (Chuku et al., 2021). Clam, cockle and oyster shell necklaces are popular goods in the craft markets of many coastal communities in West Africa (Etsy.com, 2024) and are major expenditure items for international tourists visiting such destinations

(Dayour et al., 2016), as are cowrie shells which are included in both traditional and modern costumes to symbolize beauty and royalty (Clarke, 2006; Hikmatunnisa & Wahida, 2020).

## 1.3 Problem statement and significance of the study

Despite the promising outlook for a shell by-product economy in West Africa, the real economic yield of this industry has not been analyzed, leading to a potentially undervalued farm gate price for women harvesters (the primary producers) and an underdeveloped industry. This current deficit in the data might engender a disproportionate distribution of the economic dividend in the trade, as the women harvesters lack market understanding, knowledge, and shell transformation, transportation, and marketing capacity. The women harvesters may, therefore, offer the shells for low prices. Understanding the full breadth of the existing activity, opportunities, and challenges holds the key to informed decision-making and realizing the potential for improved outcomes. This is of particular importance for shellfisher associations that have been delegated exclusive use rights and management authority for sustainable management of shellfisheries in approved fisheries co-management plans for designated management areas. Developing market opportunities for shellfisheries products that incentivize sustainable management and ensuring that such opportunities do not drive overexploitation of the resource are among the management responsibilities of these associations and their members, as well as the government authorities who support them.

## 1.4 Aim of the study

The aim of this study, therefore, was to conduct separate analyses to construct the shell supply/value chains for three bivalve species (West African mangrove oysters, West African bloody cockles, and the Volta clam) and ascertain the opportunities and challenges along their value chains. The study will further analyze the full spectrum of economic activity in the bivalve shell powder production industry in the two countries. This study is applied research specifically for shellfish harvesters and other value chain actors to discover and recommend possible new avenues of marketing or improvements to the value chain, and especially entryways for optimizing the benefits to shellfishers along the value chain.

## 1.5 Specific objectives of the study

The specific objectives of the study were to:

1. Establish the major locations for production of shells of the bivalves of interest in this study in Ghana and The Gambia through desk literature search and key informants;
2. Map out the chain of activities (economic and non-economic) for the shell by-product of the West African mangrove oyster, the Volta clam, and bloody cockle fisheries in Ghana and The Gambia, from production to the end user;
3. Conduct profitability analysis of the economic activities along the nodes of the shell value chain for the various shell species and for the various end uses (inputs, labor, transportation, value addition, etc.);

4. Identify and quantify the bivalve shells used for habitat/reef restoration and profile the bio-economic benefits (profitability analyses) of returning the shells to the estuaries for ecosystem regeneration;
5. Identify opportunities and challenges toward improving the economic benefit of shellfish harvesters (primary producers) along the shell value chain, including new potential value chains non-existent in Ghana and The Gambia, but with promise of transferability and avenues for carbon trade-offs.

# 2. METHODS

Due to the general dearth of literature on shell value chains, and bivalve shells particularly, the study team conducted a comprehensive desk review, focusing more on methods for value chains and shellfish value chain assessments. Some of the key shellfish value chain literature which the study team reviewed are value chain analysis of a women-led mud crab fishery in Fiji (Mangubhai et al., 2024), and the recent market study on new oyster products and oyster byproducts in The Gambia conducted by the FAO FISH4ACP project (Baldeh, 2024). Information from this and other literature were used to design the thematic areas of the survey and data collection instruments. To establish the major harvesting and production locations of shells of the bivalves of interest in this study, the study team also reviewed a previous scoping report on shellfishing locations in Ghana and The Gambia (Chuku et al., 2020).

## 2.1 Study locations

The shell value chain assessment was conducted in Ghana and The Gambia, the two countries where site-based activities are being implemented through the USAID Women Shellfishers and Food Security project to document lessons learned and identify successful approaches for scaling in West Africa. Ghana has an estimated 17,952 ha of mangroves (Global Mangrove Watch, 2020) fringing its lagoons, estuaries, and coastal marshlands. Conservatively, 4,333 shellfishers harvest several species of shellfish (predominantly oysters, cockles, and clams) from these ecosystems annually (Chuku et al., 2022). The Gambia has nearly 60,975 ha of mangrove cover (i.e. 2.1 percent of the total mangrove cover in Africa) and a significant shellfishing population. A total of 2,042 shellfishers are estimated to be involved in the fishery annually, harvesting predominantly oysters and cockles. These bivalve fisheries produce a significant tonnage of shell by-product which, although yet to be quantified, remains important raw material for agricultural, construction, and other sectors.

## 2.2 Identification of major production locations for the shell by-product study in Ghana and The Gambia

The locations for the assessment were identified based on (1) a previous scoping for selection of locations for site-based studies in Phase I of the USAID Women Shellfishers and Food Security project which mainly focused on the existence of a shellfishery with significant involvement of women (Chuku et al, 2020), (2) major harvesting locations for the main bivalve species of interest (oysters, cockles, and clams), (3) reconnaissance field trips conducted to gather the necessary background information for unfamiliar sites, and (4) consideration of sites that provide dynamism in shellfishing activities and minimize homogeneity. Based on these criteria, four sites were selected in each country as presented in Table 1 and mapped in Figure 1. Due to the location of some value-chain actors, additional sites were eventually visited to carry out interviews of shell aggregators, processors, and manufacturers (Table 2).

*Table 1: Shellfishing locations for the shell value chain studies and common shellfish harvested.*

| Country | Location | Common species |
|---|---|---|
| Ghana | Densu Delta | Oysters |
| | Narkwa Lagoon | Oysters and Cockles |
| | Whin Estuary | Oysters and Cockles |
| | Lower Volta - Big Ada | Clams |
| The Gambia | Tanbi Wetlands - Kamalo | Oysters |
| | Tanbi Wetlands- Old Jeshwang | Oysters |
| | Tanbi Wetlands - Lamin | Oysters and Cockles |
| | Allahein River- Kartong | Oysters and Cockles |

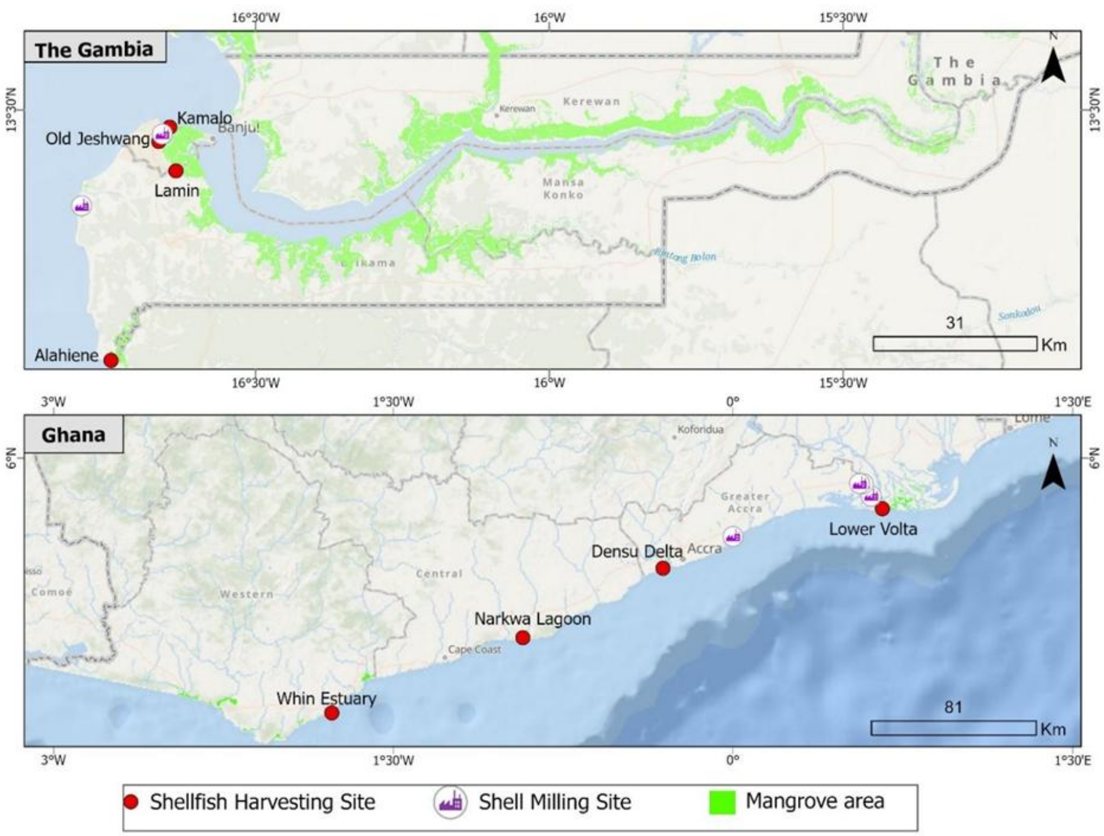


*Figure 1: Sites selected for the shell value chain assessment in Ghana and The Gambia.*

## 2.3 Survey of shell by-products and value chains

### *2.3.1 Ethical considerations*

Given that the study had humans as research subjects, ethical approval was obtained from the host institution of the USAID Women Shellfishers and Food Security Project, the University of Rhode Island's Institutional Review Board before data collection was carried out (IRB REFERENCE #: 1661892-4).

### *2.3.2 Research approach*

The study adopted mixed methods, involving both qualitative and quantitative approaches. Qualitative research techniques were employed in gathering data and information on the value chains for the shell by-products from all actors along the value chain. Quasi-structured interview guides were designed to solicit information from the various actors along the shell value chain. The questions targeted three main groups of actors: (1) primary producers of shells (shellfish harvesters), (2) shell aggregators, gatherers, or miners, and (3) shell processors or manufacturers of shell products. The diagram below shows the flow of engagement of study participants and data collection during the survey (Figure 2).


*Figure 2: Flow of engagement of study participants and data collection during the survey.*

The study team developed a semi-structured questionnaire as well as two interview guides (Appendix I). The questionnaire targeted the primary producers of shells (shellfish harvesters) and the interview guides targeted the shell aggregators and shell processors or manufacturers of shell products. The team used these instruments to collect data for mapping out the shell value chains, profitability analysis and identification of opportunities and challenges for improving the economic benefit of shellfish harvesters (primary producers) along the shell value chain.

*2.3.3 Sampling of participants*

The study adopted a purposive sampling method to reach participants with information relevant to the study. The inclusive criteria used in sampling participants were to: (1) be involved in producing bivalve shells from harvesting and processing bivalves, (2) aggregate, gather or mine bivalve shells, or (3) process bivalve shells into semi-finished products or manufacture an end-product with shell as a component.

*2.3.4 Data collection on value chain of shell by-product*

Prior to conducting the focus group discussions (FGDs) and interviews, the study team explained the purpose of the study as well as confidentiality measures to participants and sought their consent to participate in the study. The team also sought permission to record the discussions and participants were allowed to speak off-record whenever they opted.

The study team conducted (FGDs) with primary harvesters, shellfish processors, and shell miners whose activities result in the generation of shells (Figure 3). A total of eight FGDs (one per location) involving 176 participants were held with women shellfish harvesters at the selected study locations (Table 2). The discussions focused on their participation in shell production activities, utilization and marketing of shells, gender inclusion, capacity to process and processing shells, earnings from shells, and other anticipated opportunities from shells. The data produced through the FGDs provided important insight on key topical issues surrounding the shell value chain that the various shellfish women's associations should focus on.


*Figure 3: Sessions of Focus Group Discussions at Narkwa and Lamin.*

*Table 2: Number of participants engaged in the assessment of the shell by-product value chain.*

| Category of respondent | Ghana | | | | | Gambia | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Whin Estuary | Narkwa Lagoon | Densu Delta | Lower Volta-Big-Ada | Tema | Tanbi -Kamalo | Tanbi –Old Jeshwang | Tanbi-Lamin | Allahein- Kartong | Tanji | Sotokoi | Old Yundum |
| Shellfish harvesters /Shell generators | 23 | 45 | 20 | 34 | | 14 | 8 | 17 | 15 | | | |
| Aggregators | 1 | | | | | | | | | | | |
| Shell processors (Granular powder) | | | | 4 | | | | 1 | | 1 | 1 | |
| Manufacturers (Animal feed producer) | | | | | 1 | | | | | | | 1 |

The study further employed key informant interviews (KII) using the in-depth interview guides to elicit information from shell aggregators as well as industry operators involved in processing bivalve shells into semi-finished products or manufacturing an end-product with shell as an ingredient. The study team conducted a total of ten interviews involving one aggregator and nine shell processors including end-product manufacturers. The interviews mainly covered their participation in shell activity, business history, experience, employment, gender inclusion, processing, production, marketing, financial and technical capacity, social networking, challenges, and interventions (Appendix I). The FGDs and interviews were complemented with field observations where notes and photographs were taken for reporting.


*Figure 4: Sessions of Key Informant Interviews at Lower Volta and Lamin.*

### *2.3.5 Transcription and analyses of qualitative data from FGDs and interviews*

The audio taped data from the focus group discussions and in-depth interviews were thoroughly read for familiarization and transcribed verbatim. The transcribed data were imported into Nvivo version 14 and analyzed thematically. The data were categorized and coded into main themes (parent nodes) and sub themes (child nodes) which enabled highlighting of the various issues in the data for categorization. From the main themes and subthemes, linkages within the data were established, and outputs including word clouds were generated.

## 2.4 Shell value chain analysis

The shell value chain analysis involved examination of the processes and stakeholders involved in the production, processing, distribution, and utilization of the shells of the West African mangrove oysters, West African bloody cockles, and the Volta clam in Ghana and The Gambia. The methods used for the analysis included:

1. *Mapping the Value Chain* which involved: (i) identification of key activities and stakeholders in the value chain, and (ii) tracking the flow of activities and identifying inputs and outputs at the various stages of the value chain;
2. *Value Addition Analysis* which involved assessment of cost incurred, revenue generated, and value addition at each stage of the value chain;
3. *Stakeholder Analysis* which involved: (i) determination of roles and responsibilities of each stakeholder, (ii) analyses of power dynamics and influence of different stakeholders on the value chain, and (iii) analyses of benefit distribution and disparities among stakeholders in the value chain;
4. *Market Analysis* which involved: (i) Evaluation of the market demands of bivalve shells and shell products, (ii) Analyses of market trends, including seasonal variations and price fluctuations, and (iii) Identification of competitors within the market.

## 2.5 Profitability analysis of shell value chains

The economic data associated with this study was analyzed in line with the enterprise budget procedure using total revenue and total variable cost associated with each value chain activity (Aheto *et al.*, 2019). But unlike Aheto *et al.* (2019), the team employed the gross margin approach to assess the profitability of each value chain actor. As a static measure of viability, Kamangira *et al.* (2014) argued that gross margin is a good measure of profitability even amidst price volatilities. For the purposes of this study, gross margin is conceptualized as the residual between total revenue and the total variable cost incurred by that value chain activity. Gross margin percent, on the other hand, is the ratio between the gross margin and total revenue. While total revenue was computed by multiplying the price per kilogram of product generated and sold by each value chain actor with the total kilograms of goods produced, total variable cost was estimated as the sum of expenses on nine broad items namely; transportation/haulage, labor/employees, storage, packaging and labeling, energy cost (electricity, fuel, water, firewood, and other utilities), maintenance and repairs, marketing (advertising and billboards), interest charges, and taxes (waybills, market tolls, road tolls, council levies/charges) (Appendix II). The formulae for calculating gross margin and gross margin percentage are respectively stated as:

$$\text{Gross Margin} = \text{Total Revenue-Total Variable Cost} \quad (1)$$

$$\text{Gross Margin Percentage} = \left(\frac{\text{Gross Margin}}{\text{Total Revenue}}\right) *100 \quad (2)$$

## 2.6 Bio-economic valuation of reef shells and shell cultches for oyster reef enhancement

To evaluate the economic value of oyster shell by-product used for oyster reef enhancement in some communities, the shells from previously restocked areas in the Densu delta were sampled. At sampling (about one year after restocking), the restocked shells were observed to have formed new colonies from newly settled oysters becoming fully developed as adults. The number of new oysters attached to these shells were counted. First, the economic value of restocked shells, which would otherwise be sold directly to buyers and specific prices, was determined (Equation 3). Secondly, the economic benefit of restocking a shell instead of selling it was deduced by subtracting the price of a dry shell from the economic value of restocking the shell (Equation 4).

$$\text{Economic value of restocked shell (EV)} = H*N \quad (3)$$

$$\text{Economic benefit of restocking (EB)} = EV - C \quad (4)$$

Where, C = market price per dry shell of previously heaped and ready-to-sell oyster shells (price estimates were sampled from Densu and Narkwa), N = Average number of market size oysters on restocked shells (after a year), and H = market price of one table-size whole oyster harvested from restocked shells.

To estimate C, the price of heaps of dry oyster shells were obtained, samples weighed to deduce the total weight of a heap, and the price per kg [a] was calculated. Subsequently triplicate samples of one kilogram (kg) dry shells were taken, and the average number of dry shells in a kg [b] estimated to determine the price per dry shell [a/b]. H was estimated as the product of the price of a table-size whole oyster [f], drawing on previously published data by Chuku et al. (2020), and the average per gram (g) ratio of live weight of a table-size oyster in a kg [g = 50 g/1000 g = 0.05] sampled from harvester landings. To estimate N, a total of 18 colonized cultches from a restocked area in the Densu were assessed for the average number of market-size oysters.

## 2.7 SWOT analysis of shell value chain with a gender lens

The study team conducted a SWOT analysis to gain a deeper understanding of the different gender dynamics in the shell value chains. This was done as follows:

1. *Strengths*: Internal strengths that benefited both genders or specific strengths unique to men or women were identified. This included the traditional knowledge on shell use, skills and capacity in shell collection, aggregation and processing, and existing support networks. Sale and marketing of the shells and shell products unique to both men and women were identified.
2. *Weaknesses*: Internal weaknesses, such as gender disparities in access to resources (e.g., credit, equipment), training opportunities, processing and marketing of shells and shell products, or decision-making power were also determined.
3. *Opportunities:* External opportunities to enhance gender equity, such as policy support, market demand for shells or shell products, the potential for women-led enterprises, and available funding for gender-inclusive projects or enterprises were explored.
4. *Threats*: External threats that might exacerbate gender inequalities, such as market volatility, climate change impacts, restrictive cultural norms, or legal barriers were identified.

# 3. RESULTS AND DISCUSSION

## 3.1 Major bivalve shell production and processing locations in Ghana and The Gambia

### *3.1.1 Ghana*

Major bivalve harvesting and shell production sites in Ghana that were visited in this study included Whin estuary, Narkwa lagoon, Densu delta and Volta clam landing sites at Big Ada (Lower Volta). Mangrove oyster and cockle shells were produced at Whin estuary, Narkwa lagoon and the Densu delta, with the oyster shells forming the bulk of the shells produced in these areas. Volta clam shells were limited to the Lower Volta area including Big Ada and the surrounding villages in Ghana. Significantly higher volumes of clam shells compared to oyster shells were produced in the Volta estuary, mainly due to its great expanse (the largest estuary in Ghana) spanning across two regions (Greater Accra and Volta), as compared to the Whin, Densu and Narkwa that are much smaller systems. The oyster fishery was also seasonal and regulated by rainfall, compared to the clam fishery that operates nearly all year round. For these reasons, while trucks full of shells are hauled weekly from the clam sites, trucks of shells are hauled from the oyster sites only once or twice in a year (Figure 5), mainly at the end of the shellfishing season (that is, from December to February, and March to May). The closed season for oyster fishing in Ghana tends to coincide with festive occasions (such as Christmas and New Year) and the re-opening of schools. Thus, the marketing of shells from oyster sites in the country can be viewed as a closed season economic venture that enables shellfishers to raise additional income to meet key household expenses related to the Christmas and New Year festivities and payment of school fees.

*Figure 5: A pile of aggregated oyster shells at Narkwa for haulage.*

Given the frequent production of large volumes of shells from the clam fishery (Figure 6), nearly all the shell milling enterprises that process the shells into coarse and fine granules as semi-finished products are located within the Lower Volta area along the eastern coast of Ghana. The semi-finished products are transported to other coastal areas (Accra and Tema) as well as inland areas in the Bono and Ahafo regions for livestock feed formulation.

*Figure 6: A shot of clam processing site at Big Ada in the Lower Volta.*

### *3.1.2 The Gambia*

Bivalve shellfish harvesting sites visited in The Gambia in this study were Kamalo, Old Jeshwang, Lamin (located within the Tanbi wetlands), and Kartong (located along the Allahein River estuary), but there are several other locations extending along the Gambia River estuary to the North bank where shells are generated. Mangrove oyster (*Crassostrea tulipa)* was the main bivalve species exploited in The Gambia, though the West Africa bloody cockle (*Senilia senilis*) was also exploited in relatively smaller quantities. There are no clams in The Gambia. Contrary to Ghana where there is no accumulation of shells over years, the oyster fishery generates large volumes of shells in The Gambia that are not processed, leading to accumulation of shells over half a decade that are still in storage (Figure 7). There are only a few local enterprises milling shells into granules for livestock feed formulation and other uses, mostly located around the Tanbi wetlands (Figure 1), with one of such family enterprise owned and operated by a woman shellfish harvester. Most shell inputs for animal feed formulation are imported from Senegal (details discussed in Section 3.6).

*Figure 7: Piles of oyster shell aggregated over years at the Lamin landing site.*

## 3.2 Sale and prices of bivalve shells in Ghana and The Gambia

Shells generated by shellfish harvesters are mainly sold (Figure 8), even though they are also utilized for other purposes discussed in detail in the analyses of the shell value chain in Section 3.3


*Figure 8: Word cloud of responses from shellfish harvesters on what they do with shells.*

In Ghana, shells are sold in heaps at Densu and Ada where the prices are negotiated arbitrarily based on the size of the heap while at Narkwa, a standardized basin is used at a fixed price (Figure 9). In The Gambia, shells are sold in sacks, with generally the same size sack used across all sites, but the prices are negotiated and differ across sites.


*Figure 9: The study team weighing (a) a basin of cockle shells at Narkwa and (b) a sack of oyster shells at Old Jeshwang.*

Shells at Lamin had the highest price (Table 3). In both countries, shells at the peri-urban areas (Densu, Ada, Lamin, and Old Jeshwang) cost about two to three times higher than shells in more rural areas (Narkwa, and Allahein-Kartong). This is possibly due to the high cost of transporting shells from the rural areas to shell milling sites. Comparatively, prices of shells in The Gambia (US$ 0.04-US$ 0.12 per kg) were about four times higher than in Ghana (US$ 0.01-US$ 0.04 per kg).

*Table 3: Prices of shells at the study locations in Ghana and The Gambia.*

| Variable | Ghana | | | | | The Gambia | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Densu Delta (oyster) | Narkwa Lagoon(oyster) | Narkwa Lagoon(cockle) | Whin Estuary | Lower Volta - Big Ada (clam) | Tanbi - Kamalo (oyster) | Tanbi-Old Jeshwang (oyster) | Tanbi – Lamin (Oyster) | Allahein – Kartong (oyster) |
| Unit of Sale | Heap | Basin | Basin | Not sold | Heap | Sack/bag | Sack/bag | Sack/bag | Sack/bag |
| Avg. Weight (kg) | 1025 | 28.9 | 49.3 | - | 1750 | 27.2 | 27.2 | 27.2 | 27.2 |
| Avg. Price (US$) | 41 | 0.34 | 0.68 | - | 70 | 1.10 | 2.21 | 2.94 | 1.10 |
| Avg. Price per kg (US$) | 0.04 | 0.01 | 0.01 | - | 0.04 | 0.04 | 0.08 | 0.12 | 0.04 |

NOTE: 1 Gambian Dalasi =US$ 0.01471; 1 New Ghanaian Cedi = US$ 0.06771

## 3.3 Value chains of bivalve shells in Ghanaian and The Gambian shellfisheries

### *3.3.1 Actors and products in the value chains of bivalve shells in Ghana and The Gambia*

The actors, products and flow of activities in the value chains of bivalve shell by-product is illustrated in Figure 10. Five main actors were identified in the bivalve shell value chains in Ghana and The Gambia. These were categorized as:

1. *Shell generators* – shell generators were mainly shellfish harvesters (mostly women shellfishers) who generate the shells through processing of bivalves, and shell miners (a few men engaged in shell mining) who mine fossil shells. Shells were mostly generated as a by-product from shellfish processing by the women, and shells from this source constitute the greater proportion (conservatively over 90%) of shells while mined shells were sparingly encountered. Interestingly, the team observed that some men in the clam fishery at Ada in Ghana were involved in harvesting from the deeper areas that required diving. This was also the case in the cockle (Narkwa) and oyster (Densu) fisheries, but the harvests were always sold to the women who process to generate the shells as by-products. Women were therefore the main generators of shells. Shell mining was reported to occur at the Whin Estuary and some communities (Asutuare, Volivo, Aveyime, Battor, etc.) along the lower Volta region of Ghana. Shells generated from bivalve processing were dried to remove moisture by the primary harvesters while the mined fossil shells were washed to remove sand and debris before drying. Harvesters and miners sold the shells mainly to shell aggregators, shell millers, and other users, but some were channeled into lime production (in Lamin), used as cultches for oyster aquaculture (many areas in The Gambia), used in reef restoration (in Densu), and for other personal uses (see Figure 10). Each shell generator sold shells as an individual and were also responsible for bargaining with buyers to determine prices.

2. *Shell aggregators* – these were usually intermediaries (mainly men) between shell generators and semi-finished product producers (mainly shell millers), or in some instances the shell millers themselves aggregate shells from the shell generation sites and transport to the processing sites.

3. *Semi-finished shell product producers* – typically small-scale enterprise operators running shell milling businesses, who mill shells into semi-finished coarse and fine granules for livestock feed formulation, and other purposes. These actors were mostly men.

4. *End-product manufacturers* – these were either large-scale livestock feed formulators as well as individual poultry and other livestock farmers who use the granular shell powder together with other feed ingredients to formulate animal feed. This category also includes those who use shells to produce shell crafts for decoration and other uses. Apart from the large-scale feed formulators who were mostly men, both men and women were involved in the poultry and livestock farming businesses that made use of the granular shell powder.

5. *End users* – include poultry and other livestock farmers who purchase or produce feed for their animals, retail shops that sell shell crafts to users, as well as users who buy shells, milled

granular shell powder, and lime for various purposes including painting (whitewash), land reclamation, pond fertilization, soil nourishment, and pavement construction (Figure 10).

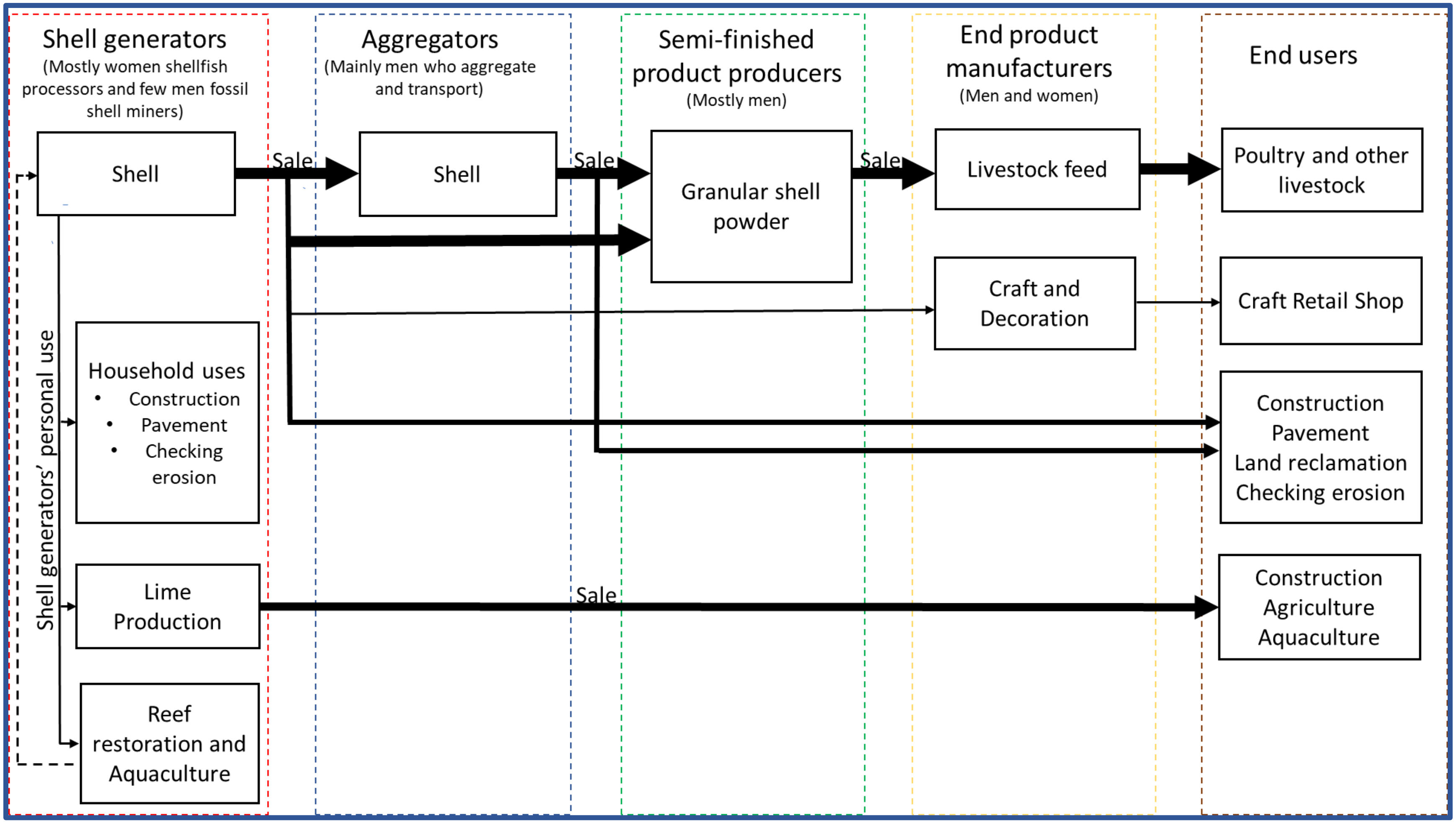


*Figure 10: Value chain of bivalve fishery shell by-product and shell products.*

*3.3.2 Value chain channels for the milled shell products*

The number of value chain channels and actors within each channel varied depending on the shell product. The study documented three main value chain channels involving the milled shell granule product as illustrated in Figure 11.

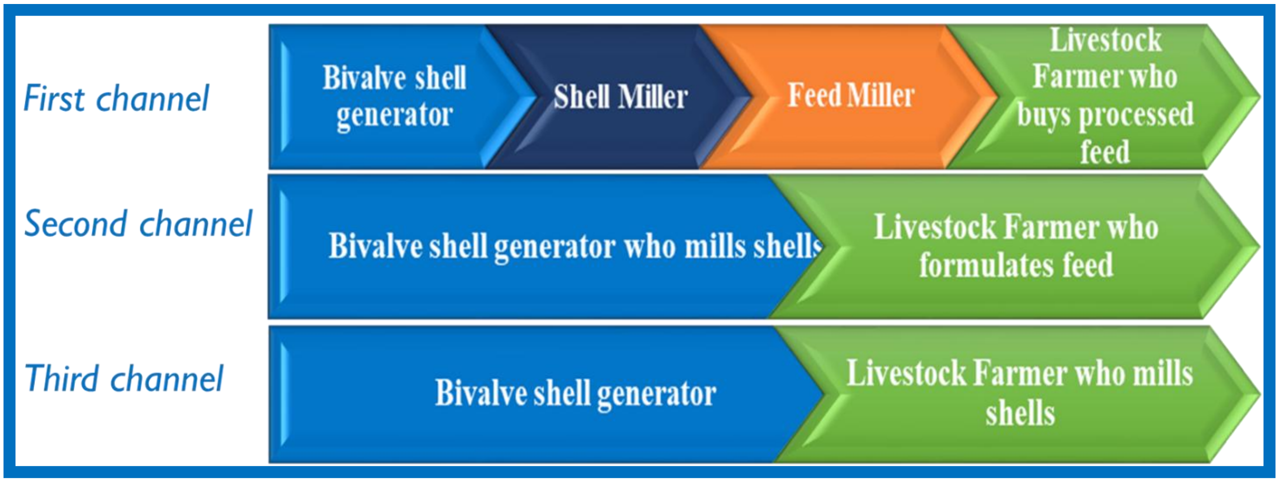


*Figure 11: Key value chain channels involving milled shell granule product.*

*i. First Channel*

The first channel describes the network of relationships involving the transition of shells from shell generators to shell mill operators, feed formulators, and livestock farmers, with or without intermediaries in addition to those shown in this channel. It was the prevalent channel encountered in seven out of the eight shellfish sites analyzed. In this channel, the shell generator sells the shells to shell mill operators. The shell mill operator crushes the shells into a granular powder for sale to the feed formulator (Figure 12), who then combines this powder with other ingredients (e.g. maize, soya, wheat etc.) to produce feed concentrates for sale to livestock farmers.


Figure 12: Shots of (A) pile of clam shells for milling, (B) shell milling machine, and (C) bagged milled shell product.

When intermediation takes place between the shell generator and the shell miller, it involves the services of the drivers of large trucks (8-wheeler and above in The Gambia) and a set of loaders and off-loaders who provide a commercial link by transporting shells from the shellfish sites to shell milling points for a fee. Commercial renters of shovels, head pans, and other work tools also participate in these networks by hiring out their tools. Other active participants in this channel are the sellers of jute bags or sacks (used or new, branded or unbranded). When needed, similar commercial transportation and loading/off-loading services can also be provided between the shell millers and feed millers, albeit, without the participation of tool renters. Finally, intermediation between the feed miller and farmer involves two other actors, namely the wholesalers and the retailers, and their network of transport and loading and off-loading service providers. Typically, the wholesaler buys large quantities from the feed mill, on an order basis, transports and sells to the retailer who in turn transports and offers them to the farmer in smaller units.

*ii. Second Channel*

The second value chain channel identified with the milled shells product depicts a supply network involving only the bivalve shell generator, who also doubles as the miller, and the livestock farmers as the final consumer. Although this channel was very rare, occurring in one out of the eight shellfish sites studied, the prices received by the bivalve shell generator and paid by the farmer per unit of milled shell were more economical than the ones encountered in the first channel due to the absence of intervening actors. Four conditions are required for a meaningful realization of this channel. First, the bivalve shell generator must have the relevant capacity to mill the shells. Second, he/she must have gathered enough shells ready to be milled. Third, he/she must have established contacts with livestock farmers. Finally, the livestock farmers contacted must be willing to purchase milled shells from the bivalve shell generator and miller and must have the capacity to formulate/mix their own feed concentrates. In the case where these conditions are met, the shells are crushed/milled by the bivalve shell generator using his/her heaps of shells and sold directly to the farmer who arranges with his/her transport service provider and loaders/off-loaders to pick up and deliver the products. From a women empowerment perspective, this channel is the most significant of the milled shell value chain, considering the preponderance of women in the small-scale shellfisheries (Frangoudes et al., 2013; Chuku et al., 2022; McClenachan & Moulton, 2022; Purcell et al., 2020) and livestock sectors (Mulugeta & Amsalu, 2014; Mthi et al., 2018).

*iii. Third Channel*

The third value chain channel noted with respect to the milling of shells was the case where the bivalve shell generator sells unprocessed shells directly to farmers who practice integrated livestock production and have the capacity to mill the shells themselves. In this value chain, farmers arrange with transport service providers, mostly mini truck drivers and operators of tricycles that can easily navigate marshy terrains to pick up and deliver the shells to them for onsite milling and formulation of usable feeds for their livestock production. Even though this value chain was not observed in any of the four sites in Ghana, it was common in the Tanbi site of The Gambia.

### *3.3.3 Value chain channel for the lime by-product*

Another unique value chain associated with the bivalve shells is the conversion of the shells into lime (whitewash) for use in paint by the construction industry. Although this practice was not observed at any of the four sites in Ghana, it was vibrant in The Gambia, particularly at the Lamin site. Key informants indicated that the first most essential stage in the lime production is the selection of dried shells with good combustible qualities. Then the selected shells are arranged in a bond with fuelwood and burned in an open space, sometimes overnight. To achieve quality lime for the market, the burning is usually done in the dry season to meet all the relevant weather conditions for a good burning of the shells and also to facilitate easy access to the processing sites by transporters and their loading assistants who provide lime producers with fuelwood and also help in the carting of the finished products to retailing points. The study did not identify the participation of wholesalers in this value chain. Thus, the team assumes that the shell generator who manufactures the lime deals directly with the final consumers of these products, the majority of whom are builders of mud houses. Because the shellfish harvesters produce and market the lime by-product themselves, this value chain is one of the significant paths that could potentially be harnessed to advance women's empowerment and gender equity.

*Figure 13: Bagged lime at the Tanbi site.*

## 3.4 Profitability of bivalve shell trade in Ghana and The Gambia

Results of the profitability analysis of the various value chain actors identified in the two countries are presented in Table 4. Shell value chain actors in Ghana sell their products between US$ 0.07 and US$ 0.64 per kg compared to between US$ 0.15 and US$ 0.59 per kg by their counterparts in The Gambia.

On average, shell millers in Ghana produced between 360,000kg and 840,000kg of milled shells per month while those in The Gambia produced between 15,000kg and 40,000kg per month. These output levels resulted in total revenue ranging between US$ 3,600 and US$ 116,667 for shell millers in Ghana and between US$ 5,643 and US$ 156,350 for their counterparts in The Gambia. In terms of costs (Appendix 2), shell millers in Ghana spent US$ 812-US$ 12,187 on shell inputs and between US$ 2,750 and US$ 9,342 on other variable inputs, culminating in an average total variable cost of US$ 10,274 whereas those from The Gambia incurred US$ 197-US$ 75,603 on variable inputs and an average of US$ 13,325 on fixed items.

Table 4 also shows that the average gross margin percent for shell millers in Ghana of 13.10 percent is smaller than the average for shell millers in The Gambia (48.92%). This disparity in gross margins across shell millers in the two countries could be ascribed to the general low cost of production and ready availability of oyster shells in The Gambia. Within countries, Table 4 further reveals that feed formulators in Ghana have higher gross margins than shell millers. The disparity in gross margins between feed formulators and shell millers in the country could be attributed to the high demand for processed feed because of the booming poultry and livestock industry. In The Gambia, lime makers are identified to be the most profitable value chain actors followed by shellfishers who milled their own shells, and feed formulators. Although the study team did not encounter lime makers at any of the shell sites in Ghana, lime production has generally been documented to be a viable economic venture in the country (Arkhurst & Andoh, 2016).

Table 4: *Profitability analysis (in US$) for shell product production in Ghana and The Gambia.*

| Value Chain Actor | Location | Price per kg | Quantities per month (kg) | Total Revenue | Cost of shell inputs | Other variable cost | Total Var. Cost | Total Fixed Cost | Gross Margin | Gross Margin (%) |
|---|---|---|---|---|---|---|---|---|---|---|
| Ghana | | | | | | | | | | |
| Feed formulator | Tema | 0.14 | 833,333 | 116,667 | 12,187 | 9,342 | 21,529 | 33,000 | 95,138 | 81.55 |
| Shell miller | Ada | 0.05 | 840,000 | 42,000 | 2,600 | 4,728 | 7,328 | 2,236 | 34,672 | 82.55 |
| Shell miller | Ada | 0.05 | 612,000 | 30,600 | 4,875 | 2,750 | 7,625 | 1,625 | 22,975 | 75.08 |
| Shell miller | Ada | 0.05 | 360,000 | 18,000 | 812 | 4,063 | 4,875 | 2,607 | 13,125 | 72.92 |
| Shell miller | Ada | 0.01 | 360,000 | 3,600 | 2,708 | 7,306 | 10,014 | 1,253 | -6,414 | -178.17 |
| The Gambia | | | | | | | | | | |
| Feed formulator | Old Yundum | 0.59 | 265,000 | 156,350 | 5,559 | 70,044 | 75,603 | 50,239 | 80,747 | 51.65 |
| Shell miller | Lamin | 0.37 | 15,250 | 5,643 | 33 | 164 | 197 | 706 | 5,446 | 96.51 |
| Shell miller | Sotokoi | 0.15 | 40,000 | 6,000 | 809 | 5,111 | 5,920 | 2,353 | 80 | 1.33 |
| Lime maker | Lamin | 0.37 | 64,200 | 23,754 | 0 | 804 | 804 | 0 | 22,950 | 96.62 |

NOTE: 1 Gambian Dalasi =US$ 0.01471, 1 Ghanaian New Cedi = US$ 0.06771.

## 3.5 Bio-economic valuation of bivalve reef shells in Ghana

Using the formulae described in the methods, the values for the key parameters required for the analysis of economic benefit of shell restocking are presented in Table 5. The results of the economic benefit analyses are also presented below for a single shell and for a kg of restocked shells, respectively, based on the average shell prices in Ghana. Restocking of empty oyster shells into the estuarine environment is known to provide substrate crucial for the attachment and growth of juvenile oysters, known as spat. This helps to replenish depleted oyster reefs and expand existing ones within the estuary's ecosystem. This study found remarkable evidence of the potential economic benefit of returning old oyster shells to estuaries for reef building. The value received on a shell sold to buyers is a very minimal GHS 0.01. However, if this shell was returned to the estuary, it has the potential to yield GHS 0.12 from live oyster sales after about a year. This represents a 15-fold revenue and over 1,300 percent more value. Such economic value has to date been illusive as, to the best of the study team's knowledge, there has not been such detailed analysis of the economic benefits of returning oyster shells for stock regeneration.

*Table 5: Bio-economic analysis of using shells for reef enhancement in Ghana.*

| Parameter | Formula | Value |
|---|---|---|
| Market price per dry/restocked shell based on average prices from Densu and Narkwa (C) | C = a/b = 0.4/39 | GHS 0.01 |
| Average number of market-size oysters on restocked shell *based on data from the Densu site* (N) | N = 1.35 | 1.35 |
| Market price per whole oyster for table-size oysters *based on regional data from* Chuku et al. (2022) (H) | H = f*g<br><br>f = US$ 1.10 = GHS 6.5; for 1 kg live/whole weight; Exchange rate 2021 US$ 1.00 = GHS 5.88<br><br>g (avg. whole weight of one oyster) = 50 g / 1000 g = 0.05 | GHS 0.33 per oyster<br><br>GHS 6.50 per kg oysters |

*For a single restocked shell in Ghana (1 year after restocking)*

Market price of a dry (restocked) shell (C) = GHS 0.01

Economic value of restocking shell (EV) = H*N = GHS 0.3250*1.35 = GHS 0.44

Economic benefit of restocking (EB) = EV - C = GHS 0.44- GHS 0.01 = GHS 0.43

*For a kilogram of restocked shells in Ghana (1 year after restocking)*

Market price per kg of dry (restocked) shell (C) = GHS 0.40

Number of dry shells per kg of restocked shells = 39

Yield per kg of restocked shells = 1.35*39 = 53 oysters

Economic value per kg of restocking shell (EV) = GHS 0.325*53 = GHS 17.23

Economic benefit per kg of restocking (EB) = EV - C = GHS 17.23 - GHS 0.40 = GHS 16.83

## 3.6 Scenarios of profitability for shellfishers along the shell by-product value chain

This section examines the potential economic benefit for women Shellfishers under different scenarios of shell processing (i.e. if shellfishers were to mill the shells or produce lime) and utilization (for reef enhancement) along the value chain (Table 6). It importantly dovetails into the prospects for empowering women shellfishers to engage in the enterprise of milling their own shells for value addition. *Scenario 1* presents the business-as–usual arrangement in which shellfishers sell unprocessed shells to shell millers and other end users. Based on the assumption that the revenue from the sale of oyster meat offsets the cost of generating the shells (e.g. cost of harvesting, transport and shucking of the bivalves), and also considering that shell millers are responsible for transporting shells from the shellfishing sites to the milling site, it is assumed that there will be zero variable cost (operational cost) for shellfishers when they sell the shells. This will result in a profit per kg of shell equal to the current selling price of shells at the various sites as shown in Table 6 (also already presented in Table 3).

*Scenario 2* examines a situation where women engage in establishing a shell milling enterprise to mill their shells before sale. This scenario is examined and discussed within site-specific contexts as follows:

1. *Densu oyster fishery* - Should shellfishers at this site establish a shell milling enterprise to mill their shells before sale, a marginal profit will be made given that this is a site where shell prices are already high (GHS 0.6 per kg). Shellfishers at the Densu site will realize an increase of GHS 0.32 in profit per kg of shell representing 53 percent gains. This profit must be considered within the context that fixed costs (e.g. cost of buying and installing a milling machine which is on average US$ 1,083, land rental, electricity connection, etc.) were not factored into the estimates. In addition, the cost of transporting the milled granular shell from the Densu to the feed formulation sites might contribute to a lower price offered for the product as the feed formulators are not located in proximity to the Densu. The overall profit gains might therefore be lower than the estimated 53 percent. Aside from costs, the seasonal nature of the oyster

fishery and the volume of shells produced at Densu which is hauled only once or twice in a year after the season, suggests that the availability of shells as raw materials for continuous running of the milling business would be limited for running an all-year round business, raising questions about sustainability. As presented in Table 4, the shell milling factories in Ghana process a minimum of 360,000 kg (360 tons) of shells per month. Based on the 2023 simple landings data, Densu produces roughly 103,000 kg (103 tons) of oysters per year. The demand for shells in Ghana is very high providing a great opportunity, but the supply might be limited by the volume of shells generated. It is therefore important for the shellfishers to consider whether the marginal profit (possibly less than 50 percent) would be worth engaging in milling business, and should they decide to mill, explore the possibility of securing start-up support from the Government of Ghana's women's economic empowerment programs.

*Table 6: Scenarios of profitability of shell products along the value chain for shellfishers.*

| Site | Scenario 1 (Shellfishers sell unprocessed shells) | | Scenario 2 (Shellfishers mill unprocessed shell) | | Scenario 3 (Shellfishers produce lime) | | Scenario 4 (Shellfishers use shells for reef restoration) |
|---|---|---|---|---|---|---|---|
| | Price per kg | Profit per kg | Avg. Variable Cost per kg | Profit per kg | Avg. Variable Cost per kg | Profit per kg | Profit per kg |
| Densu(oyster) | 0.6 | 0.6 | 0.15 | 0.92 (0.74)* | | | 4.9 |
| Narkwa (oyster/cockle) | 0.2 | 0.2 | 0.15 | 0.92 (0.74)* | | | 4.9 |
| Big Ada (clam) | 0.6 | 0.6 | 0.15 | 0.92 (0.74)* | | | |
| Old Jeshwang (oyster) | 5.5 | 5.5 | 4.71 | 12.79 (0.622)* | 0.85 | 24.35 | |
| Kartong (oyster) | 2.8 | 2.8 | 4.71 | 12.79 (0.622)* | 0.85 | 24.35 | |
| Kamalo (oyster) | 2.8 | 2.8 | 4.71 | 12.79(0.622)* | 0.85 | 24.35 | |
| Lamin (oyster) | 7.3 | 7.3 | 4.71 | 12.79(0.622)* | 0.85 | 24.35 | |

NOTE: Values are in local currency. At the time of the work (June 1, 2024): 1 GMD = 0.01471 USD; 1 GHS = 0.06771 USD. * The value in parentheses denotes estimated profit if shellfishers were to buy the shells for milling.

2. *Narkwa oyster fishery* – On the face of the estimates, it appears that the Narkwa shellfishers would make significant profit (an additional GHS 0.72 representing 360 percent gain) for every 1 kg of shell milled should the women engage in the shell milling business. This is mainly because

the current unprocessed shell sale price of GHS 0.2 is very low. It is highly unlikely that milling shells at Narkwa will yield this high profit because Narkwa is very remote from potential users of milled shell products, and accessibility and transport will be very challenging, the possible reason why unprocessed shells are bought at very low price. This factor, coupled with fixed costs not included in the estimate, and the fact that Narkwa lagoon is a much smaller system than Densu and hence lower oyster production, with seasonality issues challenging continuous production, might also not make a milling enterprise highly viable.

3. *Big Ada clam fishery* – Like the Densu shellfishers, clam shell generators currently receive GHS 0.6 from selling 1 kg of unprocessed shells and will make GHS 0.32 more by milling the shells, a profit margin of 53 percent. This would certainly be lower when costs on fixed items (such as buying and installing a milling machine, land rental, and electricity connection) are taken into consideration. However, unlike the oyster fishery where women are likely to be the main beneficiaries of any efforts aimed at empowering primary harvesters to mill their own shells, there is some gender complexity in the clam fishery (in which men are the primary harvesters and women do the shucking). Despite this complexity, the general high production of clams and availability of shells implies that empowering clam fishing households at the Lower Volta estuary to set up their own shell milling enterprises could be a worthwhile intervention. Moreover, considering that the demand for milled shell products is high in Ghana, and that most of the shell milling businesses are located within the Lower Volta area, a shell milling enterprise for clam fishing households could be viable. The challenge may be how these households will secure initial start-up capital to set up the business, and secondly, how they can compete with well-established shell milling operators. Some of these challenges could be addressed by exploring the possibility of securing financial support from the Government of Ghana's economic empowerment programs and lowering the sale price of milled shell below the average prevailing price of GHS 1.10, since no cost will be incurred on the procurement of clam shells.

4. *The Gambian oyster fishery*– Given the current prices at which unprocessed oyster shells are sold per kg in Lamin (GMD 7.3), Old Jeshwang (GMD 5.5), Kartong (GMD 2.8) and Kamalo (GMD 2.8), the estimates portray that the shellfishers could make significant profits if they engaged in milling the shells. For example, the women at Lamin would make on average GMD 12.79 profit which is an additional GMD 5.49 (75.2%) gain over and above the profit of GMD 7.3 from sale of the unprocessed shell. The Old Jeshwang women would make an additional GMD 7.29 (132.5%) while the Kartong and Kamalo women would make an additional GMD 9.99 (356.8%). However, a viable shell milling business for the Gambian shellfishers might be very challenging due to factors including very low demand for milled shell product and high variable (processing) cost. Currently the average price per kg of milled shell granules is GMD 17.5 compared to the same product imported from Senegal which costs GMD 3.6. Including the cost of transport and customs taxes which total GMD 1.52, the total cost of purchasing and transporting 1 kg of milled shells from Senegal to feed formulation sites in The Gambia is GMD 5.12. Surprisingly, the average variable (processing) cost alone for milling 1 kg of shells

in the Gambia is GMD 4.71 excluding the fixed costs (a milling machine costs US$ 1,213), making shell milling expensive in the country. For this reason, feed formulators resort to importing large quantities of milled shell products from Senegal; an interviewee reported importing 105 tons per month. The interviewee also indicated that the milled shell from Senegal was of higher quality in terms of the fineness of the milling compared to the local alternatives.

This situation has unfortunately led to the generation of large volumes of shells in The Gambia that are not processed due to lack of buyers, resulting in accumulation of shells over half a decade that are still in storage (see Figure 7). Establishing and sustaining a shell milling enterprise for the Gambian shellfishers will therefore require a viable model that minimizes the processing cost and offers milled shell products at prices competitive to the prices of the product imported from Senegal, including meeting the quality demand.

*Scenario 3* examines the benefit of producing lime from the shells, which seemed the most profitable in The Gambia yielding from 230 percent profit in Lamin to 770 percent profit in Kartong with only minimal input cost of GMD 0.85 per kg. However, this option is also challenged with low demand for lime, unavailability of fuel wood for burning the shells, and environmental concerns including climate implications for harvesting and burning fuel wood. This scenario was examined for only The Gambia because lime production was not encountered at any of the sites studied in Ghana, though its prospects have been widely reported (Arkhurst & Andoh, 2016).

*Scenario 4* projects the economic benefit of re-using shells for reef enhancement to provide substrate for spat settlement and produce more oysters for sustained stocks. This scenario was examined for only Densu and Narkwa where oysters are harvested from the waterbed and was not applied to any of the other sites where oysters settle on mangrove roots. The option of using shells for reef enhancement emerged as the most profitable, and possibly the most sustainable measure, yielding oysters valued at GHS 4.9 for every 1 kg of shells restocked per annum. This represents 716 percent profit for the Densu women who would have sold the 1 kg shells for only GHS 0.6, and 2,350 percent gains for the Narkwa women who would have sold the shell for GHS 0.2. The practice of using shells for reef enhancement (including using as cultches for oyster culture) therefore needs to be promoted and popularized among shellfish harvesters as it ensures environmental sustainability in addition to the significant economic benefit.

## 3.7 Challenges of actors in the bivalve shell value chains in Ghana and The Gambia

### *3.7.1 Challenges faced by shellfish harvesters in Ghana and The Gambia*

The shellfish harvesters in Ghana and The Gambia face numerous and significant challenges that pose difficulty to their shellfishing livelihoods activity and sustainability of the fishery that ultimately determine the productivity and sustainability of shell generation. A word cloud of responses from shellfish harvesters on their challenges is shown in Figure 14.


*Figure 14: Word cloud of responses from shellfish harvesters on their challenges.*

A summary of the challenges reported by shellfish harvesters are presented in Table 7. In both countries, physical and environmental hardships, combined with a lack of resources and market access, exacerbate the difficulties for the harvesters. In Ghana, sites such as Ada and Densu Delta experience physically demanding work conditions, where harvesters start working as early as midnight, enduring long hours. This labor-intensive process is compounded by exposure to health hazards such as malaria due to mosquito bites during these nocturnal activities. In addition to this, the inadequate appropriate gear, such as protective clothing and footwear, exposes workers to injuries, as seen in Narkwa, where harvesters suffer cuts from oyster shells.

*Table 7: Challenges faced by shellfish harvesters in Ghana and The Gambia.*

| Study Site | Challenges |
|---|---|
| Ghana | |
| Densu Delta | - Freshwater intrusion from Weija dam killing shellfish<br>- Lack of boats/canoes, impacting profitability due to rental costs<br>- Difficulty in removing fish from shells |
| Narkwa | - Risk of cuts during harvesting and processing due to lack of protective gear<br>- Cultural practices prevent the use of footwear during harvesting |
| Whin Estuary | - Frequent cuts from oyster shells during harvesting |
| Big Ada | - Long, tiring work hours<br>- Exposure to mosquitoes and malaria<br>- Difficulty drying fish/shells during rain<br>- Lack of alternative income sources |

| Study Site | Challenges |
|---|---|
| The Gambia | |
| Old Jeshwang | - Inadequate customers to buy shells<br>- Insecurity leading to shell theft |
| Kamalo | - Lack of customers for shellfish<br>- Inadequate space for storing shells |
| Lamin | - Lack of customers and fuelwood for processing shells into lime<br>- Inadequate storage space<br>- Uninformed shell selling due to customer scarcity |
| Kartong | - Lack of canoes and working gear<br>- Absence of storage facilities for shellfish |

These challenges are reflected in broader studies, such as Olaoye & Ojebiyi (2020) who emphasized that unsafe working conditions are common in many artisanal fisheries, contributing to health problems and reduced productivity. Belton et al., (2019) also established the link between harsh working conditions and decreased labor productivity in fisheries. The environmental challenges, specifically the freshwater intrusion in the Densu Delta underscore the vulnerability of shellfish ecosystems to anthropogenic activities like dam operations. Freshwater intrusion from the Weija Dam disrupts the salinity of the shellfish habitat, resulting in mass mortality of shellfish. This phenomenon aligns with findings by Velasco et al. (2019), who highlight the adverse impacts of water salinity changes on marine species' survival.

In The Gambia, the challenges extend beyond environmental factors to include a lack of essential resources such as canoes, working gear, and storage facilities. Harvesters in Kartong and Kamalo reported difficulties in accessing customers and lack of proper storage, which contributes to wastage and financial instability. Moreover, fuelwood shortages in Lamin further hinder shellfish processing, affecting income generation. This is consistent with existing literature on the importance of access to infrastructure and market access in improving the viability of small-scale fisheries (FAO, 2007). The challenges in the Gambian shellfisheries were also highlighted in part in the recent market study on oyster fishery conducted by the FAO FISH4ACP project (Baldeh, 2024).

A recurring theme across both Ghana and The Gambia is the lack of boats or canoes, as well as inadequate processing and storage facilities, which significantly hinders the productivity and profitability of shellfish harvesters and aggregators. In several locations, such as the Densu Delta in Ghana and Kartong in The Gambia, harvesters struggle with insufficient access to boats and canoes, which are essential for harvesting shellfish. Many workers are forced to rent boats, reducing their profits and complicating the sustainability of their livelihoods. The reliance on rented equipment adds a financial burden, decreasing the economic viability of the shellfish sector in these communities.

### *3.7.2 Challenges faced by shell processing and feed formulation industry in Ghana and The Gambia*

The shellfish milling and livestock feed formulation industry in both Ghana and Gambia faces several challenges that impede its productivity, profitability, and overall sustainability. A word cloud of responses from shell millers and feed formulators on their challenges is shown in Figure 15.


*Figure 15: Word cloud of responses from shell millers and feed formulators on their challenges.*

A summary of the challenges is presented in Table 8. In Ghana, the high cost of electricity is a recurrent issue, as noted by respondents in Ada and Tema. This is consistent with reports on energy costs being a significant burden for small-scale processors across Africa, limiting their ability to scale production (Hafner *et al.*, 2018). The labor intensity of the work, particularly in Ada, results in physical exhaustion and health concerns, such as chest pains and coughing. The long-term exposure to dust from shells exacerbates these health risks, highlighting the need for better occupational safety measures. Additionally, millers in Ada also face challenges with theft from hired workers, which indicates a broader issue of workplace security and trust within the value chain. The adulteration of milled shells with sand and inconsistent weight per bag reported by manufacturers in Tema also points to quality control issues, which can undermine consumer trust and market growth.

*Table 8: Business challenges faced by shell millers and feed formulators in Ghana and The Gambia.*

| Respondent | Location | Challenges |
|---|---|---|
| Ghana | | |
| Processor 1 | Ada | High cost of electricity |
| Processor 2 | Ada | Fatigue from the work, leading to frequent breaks; occasional coughing and chest pains |
| Processor 3 | Ada | Health risks from shell dust; theft by hired workers |

| Respondent | Location | Challenges |
|---|---|---|
| Feed formulator | Tema | Adulteration of milled shells with sand; inconsistency in weight per bag/standardization |
| The Gambia | | |
| Food formulator | Old Yundum | High and multiple tax rates; foreign currency exchange issues |
| Shell miller | Lamin | Low patronage due to lack of awareness about the business |
| Shell miller | Sokotoi | Lack of electricity connection, relying on generators; poor market access; difficulty in transporting shells |
| Shell miller | Tanji | Difficulty in milling hard oyster shells |

In The Gambia, processors experience a unique combination of market access limitations and infrastructure challenges. For instance, the study participant in Sokotoi lamented that they are disconnected from the national electricity grid and rely on generators, which further increases operational costs and affects productivity. Additionally, the preference of Gambians for Senegalese products over locally produced ones reveals a market preference issue, likely influenced by perceptions of quality or pricing. Lastly, challenges related to taxation and foreign exchange rates were reported, particularly by manufacturers in The Gambia. These macroeconomic factors are well-documented barriers to business expansion in many developing countries, as they introduce financial volatility and uncertainty.

## 3.8 Strengths, weaknesses, opportunities and threats for shellfishers in the bivalve shell value chains of Ghana and The Gambia

Results of the SWOT analysis conducted to assess the opportunities for women shellfishers to participate at the different nodes of the shell value chain are presented in Table 9.

*Table 9: SWOT for women shellfishers participation in the shell value chain.*

| Country/Site | Strengths | Weaknesses | Opportunities | Threats |
|---|---|---|---|---|
| Ghana | | | | |
| Densu | - High price of shells<br>- Organized Shellfisher association (DOPA)<br>- Existing co-management measures including reef restoration and closed seasons that sustain the oyster fishery | - Low volume of shells generated to effectively run a milling business all-year round (shell millers process minimum 360 tons monthly while Densu produces 103 tons of oysters per year | - High demand for shells<br>- Possibility of financial support from Ghana Government's women economic empowerment programs for organized groups | - Seasonal nature of oyster fishery<br>- Perennial freshwater invasion causing oyster mortalities during rainy season<br>- Feed formulators in far-off locations from Densu. (high cost of transport) |
| Narkwa | - Organized Shellfishers association (NOHA)<br>- Developing a shellfishery co-management plan | - Low price of shells.<br>- Low volume of shell generated (lower than Densu) | - High Demand for oyster shells<br>- NOHA is in the process of developing co-management measures including reef restoration and closed seasons to improve oyster production<br>- Possibility of financial support from Ghana Government's women economic empowerment programs for organized groups | - Seasonal nature of shellfishery<br>- Overexploitation of oyster stocks<br>- Accessibility and transport challenges |

| Country/Site | Strengths | Weaknesses | Opportunities | Threats |
|---|---|---|---|---|
| Whin | - Existence of oyster and clam fishery | - Difficulty transporting shells from landing site to homes, hence shells are abandoned and not sold.<br>- Non-existence of organized Shellfisher group | - High demand for shells | - Rising pollution levels of the Whin estuary |
| Lower Volta - Big Ada | - High price of unprocessed shell.<br>- High production of clams and generation of clam shells<br>- Organized Shellfisher group | - Possible difficulty in securing start –up capital for shell milling business. | - High demand for shells<br>- Thriving shell milling business in lower Volta area<br>- Possibility of financial support from Ghana Government's women economic empowerment programs for organized groups | - Competition from other shell milling business competitors |
| The Gambia | | | | |
| Kamalo | - Availability of large volumes of shells<br>- Ability to produce lime from shells<br>- Organized Shellfisher association (TRY) | - Low price of shells<br>- Low demand for shells from the Gambian market<br>- High cost of processing shells | - Availability of milled shells user companies (feed formulators) in The Gambia. | - Preference for low-cost shell by-products from Senegal<br>- Low demand for lime.<br>- Unavailability of fuel wood for lime production |
| Old Jeshwang | - Availability of large volumes of shells<br>- Ability to produce lime from shells | - High cost of processing shells | - Availability of milled shells user companies (feed formulators) in The Gambia | - Preference for low-cost shell by-products from Senegal<br>- Low demand for lime |

| Country/Site | Strengths | Weaknesses | Opportunities | Threats |
|---|---|---|---|---|
| | - High price of shells<br>- Organized Shellfisher association (TRY)<br>- Using shells for oyster culture | - Low demand for shells from the Gambian market | - The potential of using shells for crafts for the vibrant Gambia tourist industry is yet to be explored | - Unavailability of fuel wood for lime production |
| Lamin (Oyster) | - Availability of large volumes of shells<br>- Ability to produce lime from shells<br>- High price of shells<br>- Organized Shellfisher association (TRY)<br>- Using shells for oyster culture | -High cost of processing shells<br>-Low demand for shells from the Gambian market<br>-Low fineness quality of milled shells | - Availability of milled shells users (feed formulators) closer to Lamin<br>- The potential of using shells for crafts for the vibrant Gambia tourist industry is yet to be explored | -Preference for low-cost shell by-products from Senegal<br>-Low demand for lime<br>-Unavailability of fuel wood for lime production |
| Kartong | - Availability of large volumes of shells<br>- Ability to produce lime from shells<br>- Organized Shellfisher group | -Low price of shell<br>-High cost of processing shells<br>-Low demand for shells from the Gambian market<br>-High cost of transporting shell and shell by-products to users due to remote location | - Availability of milled shells users (feed formulators) in Gambia | -Preference for low-cost shell by-products from Senegal<br>-Low demand for lime<br>Unavailability of fuel wood for lime production |

# 4. CONCLUSIONS AND RECOMMENDATIONS

## 4.1 Conclusions

This study is one of the rare studies focusing on the value chain of bivalve shellfishery shell by-product in a predominantly women-driven fishery. The study offers very important insights into the economic prospects and potentials of a neglected fishery, the women-led shellfisheries of West Africa, which offers value chain benefits that spill over to other food systems (poultry, livestock, finfish aquaculture, and crop production) as well as construction and other industries.

The results suggests that the women shellfish harvesters are highly constrained in deriving the full benefits at the different nodes of the value chain beyond oyster meat production and sale of the shells, as confounding factors, including production costs, equipment and other fixed costs, transport, low demand from local markets in The Gambia, and marginal profits in Ghana, seriously challenge the potential of the women to effectively engage in the shell milling business for production of a granular shell product which is the major first processed product from the shells.

Beyond producing shell granules, the ability of the women to transition to the next higher and most resource intensive level of the value chain, which is feed formulation, would be even more difficult as the average cost of procuring and installing a feed formulation machine alone is US$ 5,867 in Ghana, and US$ 1,596 in The Gambia, which is unaffordable to the shellfishers and shellfisher associations.

An effort of the governments to support the women shellfishers with start-up, especially the oyster harvesters to establish shell milling enterprises to participate in the value chain through national women's economic empowerment policies and programs would seem helpful. However, this must be gauged against the limiting factors of sufficient production of shells that ensures continuous availability of raw materials all-year round for a viable and sustainable gendered enterprise in the case of Ghana, and a viable model that minimizes the processing cost and offers milled shell products at prices competitive to the prices of the product imported from Senegal, including meeting the quality demand in the case of The Gambia.

The results also highlight the need to promote re-use of bivalve shells (importantly oyster shells) for reef enhancement (and by extension oyster culture) as it emerged as the most economically profitable option that yields 716 percent to 2,350 percent gains per year over and above the profit made if it was sold or milled. Promoting the re-use of shells for reef enhancement and oyster cultures has environmental sustainability benefits, and thus should be encouraged in all shellfisheries sites in Ghana where oyster reefs currently exist on bottom substrate. The rationale is that whereas bivalve shell generators in the studied areas could realize some marginal gains in profits if they milled the shells, the practical difficulties of owning and running a successful shell milling enterprise makes shell re-use and wild reef restoration an even more viable policy option. For areas in The Gambia where there are stockpiles of oyster shells, options for supporting the women to establish shell processing enterprises need to be explored as only a limited proportion of shells produced could be used for reef enhancement or oyster culture.

## 4.2 Recommendations

In view of the need to promote gender-focused business opportunities for women shellfishers to maximize the benefits from the bivalve shells they produce in the face of the identified challenges within the shell value chain, the study team recommends the following:

1. The Ghana women shellfisher groups (DOPA, Volta Clam Association, etc.) should explore prospects from the national women economic empowerment programs of the government to access start-up capital to establish pilot shell milling business. DOPA could leverage on their capacity as a group to accumulate the shells during the open shellfishing season and mill them for sale during the closed season. Technical advice will be required in determining the appropriate capacity of the milling machine that can be acquired, based on the tonnage of shells generated. Lowering the sale price of milled shell below the average prevailing price would offer the women a competitive advantage.
2. For the women in The Gambia, a practical option would be to access shell milling start-up capital support from either the government or development partners interested in supporting gendered shellfisheries livelihoods, and additionally explore ways of minimizing the processing cost including labor to offer shell products at prices competitive to the prices of the product imported from Senegal, including meeting the quality demand. This can also be run on a pilot basis.
3. Further research is required to understand the shell generation and milling value chain in Senegal to identify modalities that could be adopted in The Gambia to produce milled shell products as competitive price.
4. Lime production could be harnessed and improved through research into design of combustible systems such as oven or furnace that optimizes effective combustion and minimizes smoke emission to address the environmental concerns. The women could cultivate woodlands to produce their own fuel wood and address the high cost of fuel and deforestation.
5. The practice of using shells for reef enhancement (including using as cultches for oyster culture) must be promoted and popularized among shellfish harvesters as it ensures environmental sustainability in addition to the significant economic benefit.

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# APPENDICES

## APPENDIX I: RESEARCH INSTRUMENT

Value Chain and Economic Analysis of the Shell By-Product of Commercial Bivalve Fisheries in Ghana and The Gambia: An Assessment of Oyster, Cockle, and Clam Shells

RESEARCH INSTRUMENTS (QUESTIONNAIRE) FOR VALUE CHAIN AND ECONOMIC ANALYSIS OF THE SHELL BY-PRODUCT OF COMMERCIAL BIVALVE FISHERIES IN GHANA AND THE GAMBIA

Introduction

Hello, my name is ________________ and I am part of a team of researchers, from University of Cape Coast Women Shellfishers and Food Security Project, funded by the USAID, that are conducting an assessment of the value chain and economic analysis of the shell by-product of commercial bivalve fisheries in Ghana. I would like to interview you on your participation in shell activity, processing and marketing, earnings, social networking, challenges and interventions, business history/experience and employment in the shell value chain.

You are being invited to take part in this interview because we feel that given your position, as a harvester, aggregator/Gatherer/shell miner, processor/manufacturer, you can provide relevant information for the assessment. It would be greatly appreciated if you could offer your time (maximum of 60 mins) to engage in this interview. The findings from this study can help inform Government agencies, donors and NGOs in identifying potential support that could be provided to add value to bivalve shells. The confidentiality of your responses is assured, and your individual responses will not be revealed in any way to anyone in government or others. The information collected from these interviews will only be reported in a summary form. If at any time during the interview you are not comfortable answering any questions, you can refuse to answer, and we will move on to the next question or you may decide to stop the interview altogether. Your participation in this survey or not will in no way affect your relationship with UCC or WSFS Project. Thank You.

Primary producers'/harvesters' questions (Focus Group Discussion)

<u>Section A: Participation in shell activity</u>

1. Do you engage in any activity that generates bivalve shells? [yes/no]
2. On the average, how many people are engaged in the activity?
3. What is the gender of the people involved in this activity? [probe for numbers or proportion]
4. The shells you produce mostly come from ----------------------? [*multiple choice*]

| Shells | Quantity per day [*estimate in baskets/ basins*] |
|---|---|
| Oysters | |
| Clams | |
| Cockles | |
| Other (Specify……..) | |

5. What do you do with the shells produced? [discard, gather for sale, I take it home for personal use, I use it for restocking, other] [*multiple choice*]

6. Do you know any person or persons who gather, aggregate or mine shells?

7. Have you or any member of your household attended training workshops on shell related activities?

    a. If yes, how many of such have you attended in the past one year?

    b. How much did it cost you to attend? [probe if it was funded]

<u>Section B: Processing and marketing</u>

8. How do you treat the shells? [washing, sun drying, sorting]

9. Do you sell any shells?

10. If yes, who do you sell to?

11. What do the buyers use the shells for?

12. How often do you sell? [*Do you sell shells all year round or seasonal? Probe: If seasonal when and why that time? Try to understand if the time of sale is driven by the buyer/market or by the seller for their own convenience or higher price periods. This is an important area of understanding whereby women might be able to make a small adjustment in unifying or organizing a sales plan that maximizes their price…*]

13. How do you sell the shells? Individually? As a group? Other?

14. In what units do you sell them? [*baskets/ basins/heaps/sacks?*]

15. Do you sell to one buyer? Multiple buyers?

16. What proportions are sold to these buyers? [if sold as a association/individual/household, then response will be as such]

| Buyer | Proportion[basins/baskets/sacks] |
|---|---|
| | |
| | |
| | |
| | |

Section C: Processing and earnings

17. Do you process some of the shells yourself?

18. If no,

    a. Why don't you process?

    b. Do you have any intension of processing them in the future?

    c. Do you have the capacity to process?

    d. What additional capacity/resources do you require? [probe for cost, etc.]

19. If yes,

    a. What do you process them into?

    b. Do you process all year round/seasonal? [Probe: If seasonal when and why that time? Try to understand if the time of sale is driven by the buyer/market or by the seller for their own convenience or higher price periods. This is an important area of understanding whereby women might be able to make a small adjustment in unifying or organizing a sales plan that maximizes their price…]

    c. On the average how much shells do you process in a day/week?

    d. How much does it cost to process a kilo (or any unit/basket/basin) of shell? [*probe for different products*]

    e. How much do you sell that kilo (or any unit/basket/basin) of shell after processing?

    f. What is your level of profit?

    g. What additional capacity/resources do you require?

20. Do you sell to processors in Ghana or export them?

21. How much income do you make from sale of shells?....GHS

22. What proportion of your income comes from the sale of shells?

23. Are there some challenges you face in this business? [probe for details]

24. What interventions do you propose?

## Aggregators'/Gatherers'/shell miners' questions (Key Informant Interview)

Section A: Participation in shell activity

1. On the average, how many people are engaged in the activity in this community?

2. What is the gender of the people involved in this activity? [probe for numbers or proportion]

3. What is the nature of ownership of the business? [sole owner, partnership, local, foreign]

4. How long have you been in this business?

5. Do you have any employees? [If yes, probe for details: part-time, fulltime, casual, gender, payment types; If no, probe for use of family labor]

6. How do you obtain your shells? (Probe for buy, gather, mine)

7. Which shell type do you mostly deal with?

| Shells | Quantity in kg (per day/week) |
|---|---|
| Oysters | |
| Clams | |
| Cockles | |
| Other (Specify……..) | |

8. Do you have any intentions of dealing with other shell types?

9. If yes, which type? And why?

10. Where do you buy the shells from?

11. Who do you buy the shells from?

12. How often do you buy the shells?

13. In what units do you buy them?

14. What is the price per unit for the purchase of the shells?

15. What is the cost build up in buying the shells?

| Items | Cost per day/week/month |
|---|---|
| Transportation/haulage [probe for mode: head porters, trucks, tricycles, etc.] | |
| Personnel/security | |
| Storage | |
| Bagging | |
| Waybills, market tolls, council levies | |
| Others | |

16. Are the quantities of shells you obtain enough for you?

    a. Are you willing to buy more if available?

    b. How much more are you willing to buy per period (day/week/month)?

17. Do you buy from the communities, or the sellers bring it to you?

Section B: Processing and marketing

18. Do you sell the shells?

19. [If no, proceed to question 20] If yes,

    a. Who do you sell to? [*Probe for where*]

    b. In what units do you sell them?

    c. What is the price per unit for sale of the shells?

    d. What proportion of your income comes from the sale of shells?

    e. Do you sell to processors in Ghana or export them?

    f. What do the buyers use the shells for?

    g. Can you mention some of the products that these processors make?

20. Do you process some of the shells yourself? [*probe for quantities/proportions processed*]

21. If no,

   a. Why don't you process? [*Probe if aggregated for a company for a fee*]

   b. Do you have any intention of processing them in the future?

   c. Do you have the capacity to process?

   d. What additional capacity/resources do you require?

   e. How much will it cost to process a kilo/any unit of shell?

22. If yes,

   a. What do you process them into?

   b. Do you process all year round/seasonal? If seasonal why at that period?

   c. On the average how much shells do you process in a day/week?

   d. How much does it cost to process a kilo of shell? [*probe for different products*]

   e. How much do you sell that kilo (or any unit/basket/basin) of shell after processing?

   f. What is your level of profit?

   g. What additional capacity do you require?

<u>Section C: Social networking, challenges and interventions</u>

23. Are you a member of any association that supports this business? [probe for other associations]

24. Are there some challenges you face in this business? [probe for details]

25. What interventions do you propose?

26. Apart from this business do you engage in any other business activities?

Processors/Manufacturers of Shells (Key Informant Interview)

Section A: Participation in shell activity

1. Do you process shells?
2. Which shell type do you mostly deal with?

| Shells | Quantity in kg (per day/week) |
|---|---|
| Oysters | |
| Clams | |
| Cockles | |
| Other (Specify……..) | |

3. Where do the shell you process come from? (*Probe for buys, Gathering, Mining*)
4. If buys,
    a. Who do you buy the shells from?
    b. How often do you buy the shells?
    c. What is the price per unit? [*probe if price is fixed or negotiated each time*]
    d. What volume of the shells come from this source? [*probe if there are more*]
    e. Are you willing to buy more shells if available?
    f. How much more are you willing to buy per period (day/week/month)?
5. If any other method, probe the source of the shells. [*gathering and mining*]

Section B: Business history/experience

6. In which year did you start this business?
7. When did you start commercial production?
8. How long have you been in business?
9. Is the business formally registered? [probe for classification]
10. What is the nature of ownership of the business? [sole owner, partnership, local, foreign]
11. What is the gender of the owner(s)? [*probe for gender proportion of other owners*]

12. Will you need new partners in your business?

13. What is the source of funding for the business?

Section C: Production and marketing

14. What products do you produce?

    a. Principal products

    b. Other products

15. What is the nature of production? [*on order basis, for stock and distribution, both*]

16. Do you process all year round/seasonal? [[Probe: If seasonal when and why that time? Try to understand if the time of processing/sale is driven by the buyer/market/input availability]

17. Do you sell these products? [If no, why……………….. skip to 18]

    a. Geographical region [*Ghana/The Gambia, some regions, WA, Africa, others…specify*]

    b. Type of clients [*probe for gender of clients, and if they care or their clients would care about sustainable sourcing- mangrove protection, harvesting mature shellfish, shell restocking, aquaculture*]

    c. Quantities to clients in "b" [*probe for proportions*]

    d. What is the unit price of your product?

| Product | Unit price |
|---|---|
| | |
| | |
| | |
| | |

18. What is the total sales estimate for the last three years?

| Year | Estimate |
|---|---|
| 2023 | |
| 2022 | |
| 2021 | |

19. What volume of the shells do you process in a day/week?

| Shells | Quantity in kg (per day/week) |
|---|---|
| Oysters | |
| Clams | |
| Cockles | |
| Other (Specify……..) | |

20. How many days do you engage in processing in a week?

21. This means, you process … volume of shells per month…. and …. per year

| Shells | Quantity in kg (per day/week/month/year) |
|---|---|
| Oysters | |
| Clams | |
| Cockles | |
| Other (Specify……..) | |

22. What is the cost of operation?

| Items | Unit Cost per day/week/month |
|---|---|
| Transportation/haulage [probe for mode] | |
| Employees | |
| Storage | |
| Packaging and labelling | |
| Electricity /fuel | |
| Maintenance and repairs | |
| Advertisement and billboards | |
| Interest charges | |
| Waybills, market tolls, council levies/charges | |
| Others (Specify…..) | |

23. Do you or your workers attend training workshops on shell processing?

    a. If yes, how many of such have you attended in the past one year?

    b. How much did it cost you?

24. Machinery/equipment/Rent

    a. Requirement [production capacity]

    b. Source [probe for foreign components and proportions]

    c. Cost of purchase and installation

    d. Skills for operating

    e. Cost of rent [if not purchased], premises rental

Section D: Employment

25. Do you use any family labor? [*probe for number, payment, gender, and hours worked*]

26. How many people are employed in this business, including yourself?

| Gender of employee | Part time | Fulltime | Total |
|---|---|---|---|
| Male | | | |
| Female | | | |

27. What is the total employment by qualification?

| Qualification | Proportion |
|---|---|
| No formal education | |
| Basic education | |
| Secondary education | |
| Technical education | |
| Tertiary education | |

28. What additional capacity do you require?

Section E: Social networking, challenges and interventions

29. Are you a member of any association that supports this business? [*probe for other associations*]

30. What is the dominant gender of the members of this association?

31. Are there some challenges you face in this business? [*probe for details*]

32. What interventions do you propose?

33. Apart from this business do you engage in any other business activities? [*probe for nature of business as well as earnings*]

# APPENDIX II: COST BUILD-UP OF SHELL VALUE CHAIN ACTORS IN GHANA AND THE GAMBIA.

*Table 10: Cost build-up of shell value chain actors in Ghana and The Gambia (in US$).*

| Item | Ghana | | | | | The Gambia | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Tema-Feed Formulator who buys milled shells | Riverbank-Shell Miller who buys raw shells | Faith Kope-Shell Miller who buys raw shells | Gorm- Shell Miller who buys raw shells | Dogo Junction-Shell Miller who buys raw shells | Old Jeshwang-Feed Formulator who buys milled shells | Lamin (Miller)-Shell generator Mills shells | Sotokoi-Shell Miller who buys raw shells | Lamin(Lime)-Shell generator who produces lime |
| *Fixed Cost* | | | | | | | | | |
| Machine | 25,000 | 542 | 542 | 1,693 | 1,016 | 32,353 | 368 | 2,059 | - |
| Installation | - | 339 | - | 169 | 34 | - | - | - | - |
| Rent | 8,000 | 1,016 | 812 | 203 | 203 | 1,626 | 15 | 294 | - |
| Others | - | 339 | 271 | 542 | - | 16,260 | 324 | - | - |
| **Total** | **33,000** | **2,236** | **1,625** | **2,607** | **1,253** | **50,239** | **706** | **2,353** | **-** |
| *Variable cost* | | | | | | | | | |
| Shell inputs | 12,187 | 2,600 | 4,875 | 812 | 2,708 | 5,559 | 33 | 809 | - |
| Transportation/ haulage | 339 | 203 | 34 | 102 | 4,875 | 61,765 | 44 | 3,382 | 21 |
| Labor | 6,771 | 2979 | 2543 | 3,331 | 1,706 | 185 | 44 | 1,176 | 441 |
| Storage | 336 | - | - | - | - | 5,882 | - | - | - |
| Packaging & Labeling | 812 | 1,137 | 51 | 487 | 203 | 618 | 67 | 118 | 283 |
| Electricity/Fuel | 677 | 339 | 68 | 102 | 284 | 1,397 | 7 | 23 | 59 |

| Item | Ghana | | | | | The Gambia | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Tema-Feed Formulator who buys milled shells | Riverbank-Shell Miller who buys raw shells | Faith Kope-Shell Miller who buys raw shells | Gorm- Shell Miller who buys raw shells | Dogo Junction-Shell Miller who buys raw shells | Old Jeshwang-Feed Formulator who buys milled shells | Lamin (Miller)-Shell generator Mills shells | Sotokoi-Shell Miller who buys raw shells | Lamin(Lime)-Shell generator who produces lime |
| Maintenance and Repairs | - | 68 | 54 | 41 | 156 | 108 | 2 | 44 | - |
| Advertisement and billboards | 339 | - | - | - | 68 | - | - | 74 | - |
| Interest charges | - | - | - | - | - | 88 | - | - | - |
| Taxes (Waybills, market tolls, council levies) | 68 | 2 | - | - | 14 | 1 | - | 294 | - |
| Others | - | - | - | - | - | - | - | - | - |
| **Total Variable cost (Excluding shell inputs)** | **9,342** | **4,728** | **2,750** | **4,063** | **7,306** | **70,044** | **164** | **5,111** | **804** |
| **Total Variable Cost (including shell inputs)** | **21,529** | **7,328** | **7,625** | **4,875** | **10,014** | **75,603** | **197** | **5,920** | **804** |