



Spotlighting Women-Led Fisheries Livelihoods Toward Sustainable Coastal Governance: The Estuarine and Mangrove Ecosystem Shellfisheries of West Africa

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The governance of coastal and marine resources remains a complex socio-ecological endeavor in many African countries, but women are leading the way and demonstrating a pathway for food fish security through rights-based co-management of shellfisheries in estuarine and mangrove ecosystems in West Africa. We report comprehensively, for the first time, the scale of estuarine and mangrove ecosystem-based shellfisheries across the West African coast (Senegal, Gambia, Guinea Bissau, Guinea, Sierra Leone, Liberia, Côte d'Ivoire, Ghana, Togo, Benin, and Nigeria), the gender dynamics, and implications for the sustainable management of this small-scale fishery. We find an extensive geographical coverage of active shellfisheries within these ecosystems with close to 571,000 household beneficiaries and over 50,000 harvesters, mainly women, being the primary resource users. An annual shellfish harvest of over 300,000 MT valued at USD 336 million is potentially undocumented across the region. Harvested shellfish species of economic importance comprised 18 species of mollusks, 11 species of crustaceans, and a few unidentified groups of gastropods, crustaceans, and cephalopods. The West African mangrove oyster, periwinkle, bloody cockle, whelk, and razor clam were, in that order, the most harvested estuarine shellfish. The bivalve and gastropod value chains are dominated by women harvesters at all nodes whereas women play significant roles

in the processing and marketing of crustacean and cephalopod fisheries. Formal laws specific to the regulation of estuarine shellfisheries are generally nonexistent, however, the organized women shellfish harvester groups of the Tanbi wetlands (The Gambia) and Densu Delta (Ghana) have championed sustainable governance actions resulting in successful women resource user-led fisheries co-management. The elements of success and opportunities for scaling up these examples are discussed. The presence of such groups in several locations offers an entry point for replicating a similar co-management approach across the West African coast.

Keywords: shellfish, women, livelihood, fisheries governance, co-management, estuary, mangrove, Africa

INTRODUCTION

Fish and fisheries resources remain critical components of global food production and nutrition, providing livelihoods for many with an estimated production volume of 179 million tonnes amounting to a total value of about USD 401 billion by the end of 2018, globally (FAO, 2020). In Africa, the management of the fisheries sector has centered on marine and inland fisheries as these have contributed the most to reported fish production volumes. These sub-sectors receive the most attention and investments while estuarine fisheries are largely unknown, and more so, the role of women in estuarine and mangrove ecosystem-based shellfisheries (EMES).

Coastal intertidal ecosystems are easily accessible, allowing women residing in adjacent coastal communities to engage in fish harvesting, an activity largely perceived as a preserve of the male gender. Many coastal households in West Africa engage in small-scale fishing in estuarine and coastal systems, especially young men using canoes and gill nets, but women and children also operate on foot or with small hand paddled canoes to harvest mollusks and bivalves such as oysters, clams, periwinkles, and other invertebrates. These marine species provide critical livelihood and nutritional support for the women and their households in Africa, and globally (Harper et al., 2013; Harper and Kleiber, 2019; Harper et al., 2020).

Prior to this study, women were observed in selected communities in Senegal, The Gambia, and Ghana to be the main exploiters of some shellfish, particularly bivalves and gastropods. These were, however, hypothetically assumed as isolated occurrences with their true extent not well-known at the regional scale. In addition, there is the emergence of women oyster harvesters from Ghana and The Gambia mobilizing into formalized groups and spearheading the governance through rights-based fisheries co-management arrangements. In the current context of African fisheries governance, however, women governing a fishery Africa could be described as unusual as the existing structures of fisheries governance in the region conform to the ideological notions of gender identity and roles (Thorpe et al., 2014). An idea that places women's role at the processing and marketing nodes of the fisheries value chain (Thorpe et al., 2014; Lentisco and Lee, 2015), skewing the governance of fisheries and water resources in general toward fisher "men" (Weeratunge et al., 2010; Tantoh et al., 2021).

The highly centralized framework for governing fisheries in the region has resulted in a policy direction with a sectoral bias rather than a multisectoral approach, thus, derailing the stewardship of the fisheries resources of interest (Tantoh et al., 2021). The absence of sound gender analysis in the governance of fisheries and its policies in West Africa may result in measures unbeneficial to the people's livelihoods and well-being, and to the ecosystem from which food and other ecosystem services are derived (Béné et al., 2010; Weeratunge et al., 2010; Béné and Friend, 2011). For a fishery so connected to other natural assets and with such gender sensitivity, its management requires critical nature-based and gender-centric solutions.

In spite of the observed participation of women in estuarine and mangrove ecosystem shellfisheries, there is little information on the extent of their involvement. While there has been a recent global study on mangrove associated fisheries (zu Ermgassen et al., 2020) that highlights the importance of this fishery in West Africa, no mention was made of the gendered dimensions of mangrove fisherfolks. Data required for sound management such as annual catch and aquaculture statistics are not available for the estuarine shellfisheries in many coastal West African countries. Where information is available, it is not up to date. Neither is the breakdown by gender of the fisherfolks involved in these fisheries available (Harper et al., 2020). Women's role in decision making and access to fisheries resources ought to be strengthened and secured by promoting their education and empowerment in the fisheries sector as an important strategy for enhancing food and nutrition security in the region (Hasselberg et al., 2020).

This study, therefore, sought to broadly explore the opportunities available at the regional level to leverage the successful implementation of women-led fisheries co-management models in The Gambia (Adité et al., 2018) and Ghana (Ghana Ministry of Fisheries and Aquaculture Development and Fisheries Commission, 2020; Ministry of Fisheries and Aquaculture Development, 2020) for potential further replication and scale-up in similar ecosystems of the region. Through a participatory process involving the resource users, government, academia, NGOs, and local authorities, we describe the socio-ecological aspects of the estuarine and mangrove ecosystem-based shellfisheries, highlighting the participation of women, in 11 countries on the West coast of Africa, from Senegal to Nigeria.

We apply a livelihood-gender-governance lens on a value chain structuring, considering a combination of the socio-economic elements and the ecological system (mainly mangroves and estuarine ecosystems) supporting a somewhat neglected fishery. We attempt to establish the presence or otherwise of shellfisheries in coastal communities of each of the 11 countries and quantify the number of harvesters and household beneficiaries. The study details shellfish exploitation in the estuarine and mangrove ecosystems of West Africa by identifying the species exploited, estimating the volume and value of the fishery and its reliance on mangroves. We further examine the gender dynamics across the region, the role of women in its governance, highlight existing examples of successful governance frameworks, and discuss the potential for scaling up this sustainable governance system across West Africa's estuarine and mangrove ecosystems.

METHODS

Study Area

The West Africa region in this assessment comprises 11 continental coastal countries of the Economic Community of West African States (ECOWAS) where coastal shellfisheries are noted to provide livelihood, income, and nutrition, and are of conservation value for the natural habitats including mangroves. The countries of the assessment were, from west to east, Senegal, The Gambia, Guinea Bissau, Guinea, Sierra Leone, Liberia, Côte d'Ivoire, Ghana, Togo, Benin, and Nigeria.

The length of the coastline is approximately 4,472 km and spans the eastern Canary Basin and the Gulf of Guinea. This region of Africa is endowed with several river basins giving rise to many smaller rivers and streams that flow southwards into the Atlantic Ocean (Plank and Forsyth, 2016). An identifiable feature of the coastal greenery in this region is the large expanse of mangrove vegetation fringing the shores, especially in the intertidal zones where estuaries are formed by the convergence of rivers and the ocean (Figure 1).

Research Design

A mixed-method exploratory approach was employed comprising a social survey of shellfish stakeholders, and a literature review on estuarine and mangrove ecosystem-based shellfisheries. The semi-structured survey questionnaire was designed to collect data from each country through a participatory approach, conducting interviews with key informants from various stakeholder groups consisting primarily of the resource users (EMES harvesters) and others from government, academia/research, NGOs/CSOs, and traditional authorities. The survey questionnaire included both closed and open-ended questions and was crafted to collect data on the background of respondents, shellfisheries activities, the status of mangrove ecosystems present, and governance/management regimes established. All questions were relevant to respondents of the resource-user category whereas the other stakeholders were exempted from answering questions related to the direct exploitation of the resource as they were not expected to be able to adequately provide responses to such questions.

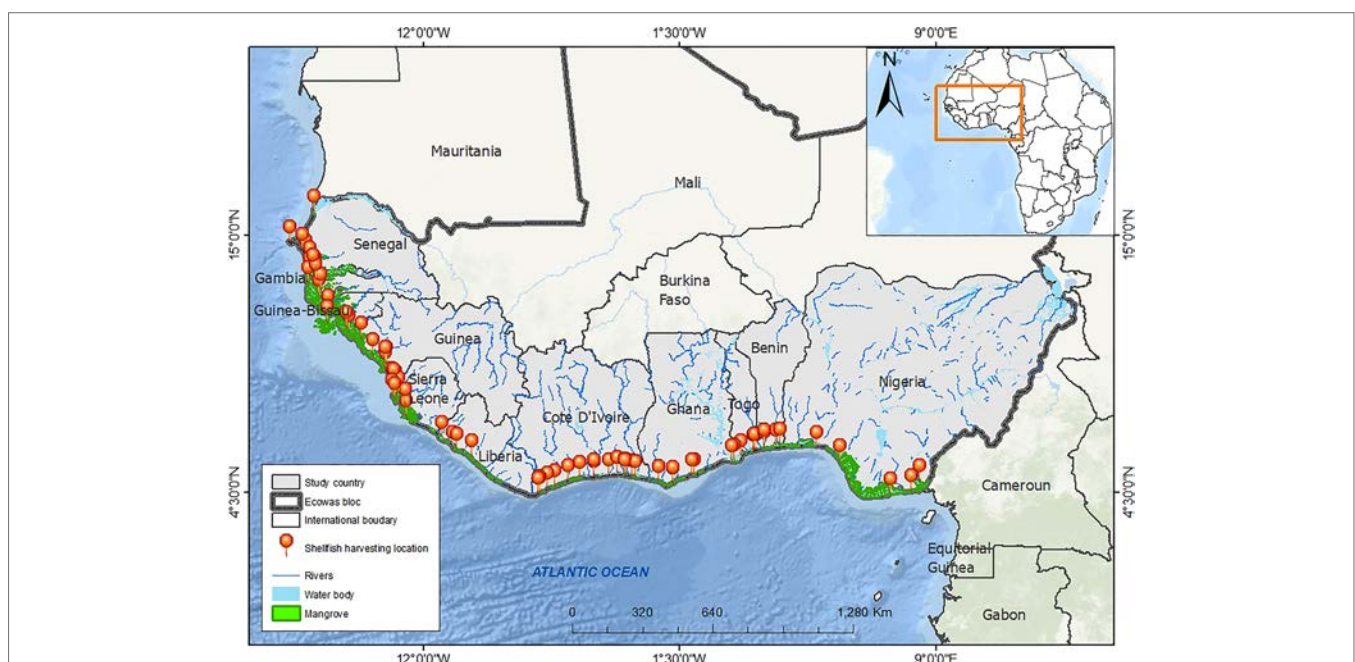


FIGURE 1 | Coastal countries of the Economic Community of West African States where estuarine and mangrove ecosystem-based shellfisheries are located. These areas present continental rivers, entering the Atlantic Ocean, with mangrove shores. [The map was developed originally by this study. Data sources: Shellfishing location points from this study; Mangrove data from Global Mangrove Watch; Africa Administrative Level 2 shape file from the Intergovernmental Authority for Development Climate Prediction and Application Centre Geoportal; Rivers data from Diva GIS].

To administer the questionnaire, a lead enumerator was contracted for each country based on their relevant experience in fisheries issues. A virtual training and a questionnaire-testing session was held for all the lead enumerators through online video conferencing. These lead enumerators then visited coastal communities in their respective countries where there was EMES, conducted in-person interviews with individuals identified as shellfish resource users, and held focus group discussions in some instances. The research was conducted during the COVID-19 pandemic when there were varying country restrictions on international travel, meetings, and social gatherings. To ensure the safety of enumerators and participants, there was strict compliance to social research ethics; ethical approval from the University of Rhode Island's Institutional Review Board, verbal informed consent from participants, COVID-19 risk information sheets provided to participants, and social distancing and wearing of face masks during interviews.

The questionnaire was developed in English but was translated to the local languages of each community visited. To avoid translation errors and bias, local knowledge and experience in the subject and English proficiency were key considerations in selecting the enumerators. This control and the training of enumerators were used as checks, to ensure that the instrument solicited the right answers to the questions posed. The inclusion criteria for participation as a resource user were to be directly engaged in EMES activities including mainly harvesting, processing, transporting, and retailing/marketing. For other stakeholders, their occupational engagement was related to fisheries or shellfisheries and mangrove area management. Survey response data was entered by the enumerators *via* a web-based version of the questionnaire, then cleaned and de-identified prior to analysis.

The number of surveys conducted differed among countries due to varying scales and numbers of communities with shellfisheries activities. In all, the total number of key informant interviews (KIIs) conducted across the 11 countries for the respective stakeholder groups were 217 for resource users, 22 for government, 20 for academia/research, 16 for NGO/CSOs, and 3 for traditional authorities. Responses from resource users were analyzed to describe the exploitation, gender dynamics, and value chains whereas responses from the other stakeholders were used as supporting data on harvested species, governance, and mangroves. The surveys were conducted from February to August 2021. Insights were drawn from the open-ended questions in the interviews by synthesizing key themes around all the responses to specific questions. Quantitative questions were analyzed in percentages and figures obtained for volume and value of production were extrapolated to obtain an approximation of the regional scale across West Africa.

Two apparently successful examples of estuarine and mangrove ecosystem shellfish co-management arrangements, one each from Ghana and The Gambia, emerged from the regional survey as the only formalized management arrangements in the region. Therefore, a detailed review and inductive synthesis of interviews at these sites were conducted

including a desktop review of reports and available documents on the implementation of the co-management plans. From this exercise, these two case examples are presented to highlight key elements of success, lessons, and principles for potential scale-up in West Africa.

Estimating the Number of Harvesters and Their Household Beneficiaries

Resource users were asked to give an indicative estimate of the number of harvesters in their communities and/or harvesting areas for each community visited in each country. Conservative estimates were made with the assumption that each respondent represents exclusively one harvesting area/community. This approach likely underestimated the number of shellfish harvesting sites as the total number of EMES areas in the region is not known, and hence, a statistical computation of a threshold number of sites to consider in this assessment could not be done. Nonetheless, in communities with very intensive EMES where individual respondents repeatedly gave high numbers of harvesters for the same area, the responses were averaged to represent that single community. The total number of harvesters was estimated as the sum of harvesters indicated by each respondent for their representative community for each country except Guinea. The estimated number of women shellfishers for Guinea assumed 10% of the total artisanal fishers reported by Cormier-Salem et al. (2010) as cited in (Ottaviani, 2020). The respondents (resource users) were also asked for the number of members in their household. The product of the average number of household members and the total harvesters was used to estimate the number of direct beneficiaries.

Estimating Harvest Quantities/Volumes and Value

In the absence of standardized metrics for quantifying shellfish harvests in the study countries, harvest weights were obtained as unstandardized measurements used by the harvesters themselves such as pans, trays, buckets, baskets, tins, or cans per day. Where possible, respondents gave a corresponding price per unit of shellfish for various shellfish species. This challenge notwithstanding, for countries like The Gambia, Ghana, and Nigeria, standardized metric equivalents were probed further by taking sample weights of the indicated containers filled with shellfish and subtracting the empty container's weight. A conservative regional estimate was then calculated using oyster catch and prices and by drawing on assumptions from the results of the survey.

For The Gambia, the price obtained was for 63 g of meat weight which translates to approximately 500 g of the whole weight of shell-on or unshucked oysters using a regression equation derived from oyster biometric data collected from March to May 2021 in a parallel study under the USAID Women Shellfishers and Food Security Project (see **Supplementary Figure 1**). Data ($n = 1,080$) for the "whole weight"–"meat weight" relationship was drawn from monthly sampling from six different ecosystems, three each in Ghana

and The Gambia, over 3 months, hence, variations in condition due to spawning are possibly accounted for.

The total estimated annual harvest volume of EMES by women harvesters in West Africa was deduced using the equation:

$$\text{Volume EMES} = \text{Avg. total catch (kg)} \\ \times \text{Estimated number of shellfishers}$$

The total estimated annual harvest value of EMES by women harvesters in West Africa was deduced using the equation:

$$\text{Value EMES} = \text{Volume EMES (kg)} \\ \times \text{Avg. Price of Shellfish kg}^{-1}$$

Mapping the Estuarine and Mangrove Ecosystem-Based Shellfisheries Locations

A map of the shellfish harvesting sites was developed using Geographic Information Systems techniques. First, the Global Positioning System coordinates of survey locations visited were converted into shape files. Where coordinates were not obtained directly from the country enumerators, participatory mapping was conducted remotely *via* video conferencing where the enumerator indicated the harvesting location on a map shared *via* “share screen”. The aerial extent of mangrove cover for each country (1996-2016) was downloaded from the Global Mangrove Watch¹ database and converted from raster to vector format in ESRI ArcMap 10.5 to improve on its visualization. The Africa Administrative Level 2 shape file data was also obtained from the Intergovernmental Authority for Development Climate Prediction and Application Centre Geoportal² to create the country boundaries. River shape file data was downloaded from the Diva GIS website³. All the datasets were overlaid on ESRI ArcMap 10.5 base map.

RESULTS

Geographical Coverage of Estuarine and Mangrove Ecosystem-Based Shellfisheries in West Africa

Estuarine and mangrove ecosystem-based shellfisheries were found in all the 11 countries in this study, from Senegal to Nigeria (see **Figure 1**). In each country, there were a minimum of four major locations, including communities and ecosystems, that have active shellfisheries connected to estuaries, lagoons, and mangroves. The mapping of rivers showed several rivers discharge into the Atlantic Ocean at these harvesting locations, forming estuaries with large expanses of mangrove vegetation with total coverage of 1,532,443 ha. The eastern and western coasts of the region had wider mangrove coverage as compared to the central coast, from Liberia to Benin. The eastern coast, mainly the Nigerian coast, had 689,417 ha, the western coast,

bordering Senegal, The Gambia, Guinea-Bissau, Guinea, and Sierra Leone, had 790,671 ha, and the central coast spanning Liberia, Côte d'Ivoire, Ghana, Benin, and Togo, had 52,355 ha of mangrove area.

Estimated Number of Harvesters

Across the 11 countries assessed, are an estimated 55,558 shellfishers (**Table 1**), mostly women. Nigeria had the most, with 39,340 shellfishers, or on average, 79 per community, for the approximately 500 coastal settlements; the number of coastal settlements (fishing communities) in Nigeria is constructed from data available in the literature. There were an estimated 2,000 shellfishers each for Senegal, Ghana, and The Gambia. The number of shellfishers in Guinea-Bissau, Sierra Leone, Côte d'Ivoire, Togo, and Benin were each less than 1,000. The average household size of these shellfishers was nine people, with Ghana having the smallest average household size (seven) and The Gambia having the largest average of thirteen. Considering the household sizes presented for each country, 571,935 people were estimated to be directly dependent on the shellfish resources within the West African estuarine and mangrove ecosystems.

Gender Dynamics and the Shellfish Value Chain

The local shellfishing communities surveyed were involved in harvesting, processing, retailing/marketing, transportation, consumption, and a few other limited activities. Generally, women were the dominant users of estuarine shellfish resources, constituting more than 60% of shellfishers identified in each country (**Figure 2**) and 79% regionally. There was further gender differentiation of harvesters, based on species harvested (**Figure 3**). Women harvesters in the bivalve and gastropod shellfisheries cut across the value chain with complete

TABLE 1 | Total estimated number of shellfishers and estimated direct shellfisheries beneficiaries from shellfishers' households in the coastal countries of West Africa.

Country	Estimated number of shellfishers	Estimated members of shellfishing household	Estimated direct beneficiaries
Nigeria	39,340	11	415,548
Senegal	5,270	11	59,288
Ghana	4,333	7	31,731
The Gambia	2,042	13	26,199
Liberia	1,066	8	8,436
Guinea Bissau	836	10	8,569
Guinea	780*	8**	6,240
Benin	710	8	5,774
Côte d'Ivoire	544	8	4,305
Sierra Leone	354	10	3,487
Togo	283	8	2,358
TOTAL	55,558		571,935

*Estimated number of EMES harvesters for Guinea assumed 10% of artisanal fishers reported by Cromier-Salem et al. (2000) as cited in (Ottaviani, 2020).

**Estimated number of household members of EMES harvesters in Guinea assumes the modal household size for the ten other countries in this study. Countries are presented in order of highest to lowest number of shellfishers.

¹ <https://globalmangrovetwatch.org>

² <http://geoportal.icpac.net/>

³ <http://www.diva-gis.org/gData>

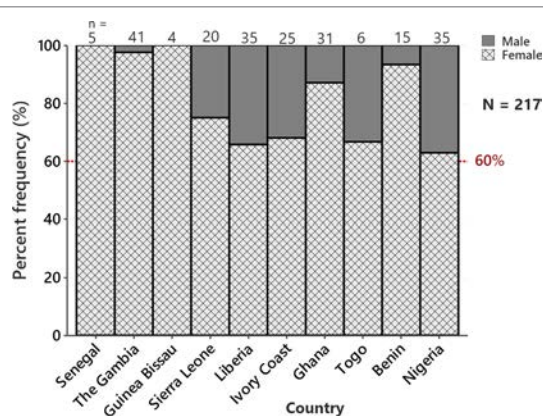


FIGURE 2 | Gender disaggregation of shellfishery resource users' overall participation for each country. Number of respondents, $n = 217$; Senegal, Guinea-Bissau and Togo had focus group discussions of at least five resource users per meeting—the response from each meeting counted as one ($n = 1$) for these countries. [Data source: Resource user survey from this study].

representation at the processing, marketing and transportation nodes. Men controlled the harvesting and transportation nodes of the crustacean and cephalopod fisheries whereas women remained chiefly in the processing and marketing nodes.

Figure 4 depicts the involvement of actors surveyed at the various nodes of the shellfish value chain indicating as many as 80% of the respondents consume shellfish. Following

consumption, in terms of relative involvement, are harvesting, retailing/marketing, processing, transportation, and “others”, in that order. Of the 210 actors (96.8% of respondents) responding that they were directly engaged in some part of the value chain, 6.2% were involved exclusively in one node along the value chain (**Supplementary Table 1**). This was either exclusive consumption (0.48%), harvesting (5.24%), or processing (0.48%) of shellfish. The majority were involved in multiple activities along the value chain. The highest percentage of multiple-node involvement was those who combined harvesting, transportation, processing, retailing/marketing, and consumption, representing 29% of the actors. The second-largest group in the value chain, which is 17% of resource users surveyed, combined harvesting, processing, retailing/marketing, and consumption without transportation. About 8% of the respondents were involved in harvesting and consumption but did not engage in processing. Only 4% of respondents indicated involvement to include “Other” activities. The “other” category included open water ranching of clams, rack culture of oysters, shell trade, use of shells for designs and decorations, or participants in the governance of shellfish.

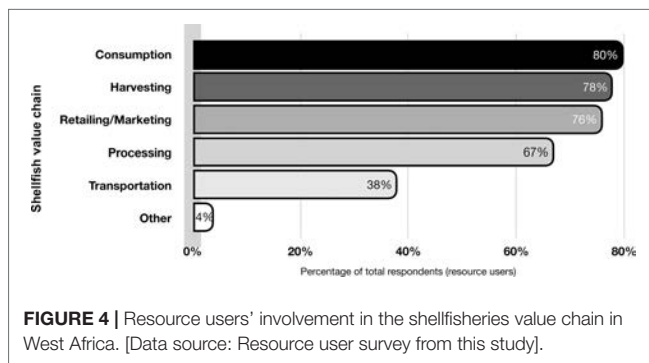
Species Harvested

A total of 18 mollusk species, 11 crustacean species, and a few unidentified gastropod, crustacean, and cephalopod groups were found to be harvested as economically valuable or for household food and nutrition (**Table 2**). The West African mangrove oyster (*Crassostrea tulipa*), the West

Shellfish group/ fishery	DOMINANT GENDER AT DIFFERENT NODES OF THE VALUE CHAIN			
	Harvesting	Processing	Marketing	Transportation (during harvest)
Bivalves 	Female	Female	Female	Female
Gastropods 	Female	Female	Female	Female
Crustaceans 	Male	Female	Female	Male
Cephalopods 	Male	Female	Female	Male

Female
 Male

FIGURE 3 | Gender dominance of shellfish harvesters along the value chain of different shellfisheries along the West African coast. Gender dominance is determined by more than 60% participation by a particular gender. [Infographic developed originally by this study. Data source: Resource user survey from this study].



African bloody cockle (*Senilia senilis*), and the freshwater clam (*Galatea paradoxa*) a.k.a. "Volta clam", were among the region's most harvested and widespread bivalves. Mangrove oysters were found in all 11 countries making them the most popular commercially harvested shellfish in the estuarine and mangrove ecosystems. Second in importance in terms of geographic distribution was the gastropod *Tympanotonus fuscatus*, a periwinkle, with substantial utilization in seven of the eleven countries. Five countries namely Senegal, The Gambia, Côte d'Ivoire, Ghana, and Nigeria were significant exploiters of the whelk *Pugilina morio*. Found in four countries—Ghana, Guinea, Sierra Leone, and The Gambia—the West African bloody cockle, *S. senilis*, was fifth in

TABLE 2 | Shellfish species harvested in the estuarine and mangrove ecosystems along the coast of West Africa from Senegal to Nigeria.

Species	Country										
	Senegal	Gambia	Guinea Bissau	Guinea	Sierra Leone	Liberia	Ivory Coast	Ghana	Togo	Benin	Nigeria
Bivalves (oysters, cockles, clams, mussels)											
<i>Crassostrea tulipa</i>	•	•	•	•	•	•	•	•	•	•	•
<i>Senilia senilis</i>	•	•			•			•	•	•	
<i>Galatea paradoxa</i>	•				•			•			•
<i>Tagelus adansonii</i>	•		•		•	•			•		
<i>Pinctada</i> spp.	•	•									
<i>Perna</i> spp.	•						•	•			
<i>Mytilus</i> spp.	•										
Gastropods (snails, periwinkles)											
<i>Snail (Unspecified)</i>					•						
<i>Nerita senegalensis</i>											•
<i>Pugilina morio</i>	•	•					•	•			•
<i>Cymbium</i> spp.	•										
<i>Littorina littorea</i>											
<i>Laniste varicose</i>							•			•	
<i>Achatina achatina</i>										•	
<i>Tympanotonus fuscatus</i>	•					•	•	•	•	•	•
<i>Pachymelania aurita</i>	•								•		•
<i>Bolinus cornutus</i>	•										
<i>Murex</i> spp.	•										
<i>Stramonita haemastoma</i>									•		
Crabs											
<i>Crab (unspecified)</i>					•	•					
<i>Cardisoma armatum</i>								•		•	
<i>Uca tangeri</i>								•			
<i>Callinectes amnicola</i>								•			•
<i>Callinectes sapidus</i>		•									
<i>Callinectes</i> sp.										•	
Shrimps/prawns											
<i>Shrimp (Unspecified)</i>					•	•					
<i>Penaeus notialis</i>											•
<i>Penaeus monodon</i>								•			
<i>Penaeus</i> spp.										•	
<i>Parapenaeopsis atlantica</i>								•			•
<i>Macbrachium</i> spp.										•	•
Other											
<i>Lobster</i>					•						
<i>Squid</i>					•						
<i>Octopus</i>					•						
Total no. of shellfish species	10	5	2	1	9	5	5	11	6	9	10

TABLE 3 | Details and rationale of assumptions used in the estimation of the volume and value of estuarine and mangrove ecosystem-based shellfisheries (EMES) in West Africa.

Assumption	Detail/ rationale
EMES is a women-led fishery	Results from this study showed a 79:21% gender split in favor of women. Hence, the total number fishers used for estimates are the number of women, i.e., 79% of 55,558.
All EMES resource users are oyster harvesters	Oysters are the most commonly harvested species by women in the EMES across West Africa.
Average total catch (per harvester per annual season) is equivalent to that for oysters from the Narkwa Lagoon, Ghana	Oysters are among the lowest-priced shellfish in the EMES Oysters are the most commonly harvested species by women in the EMES across West Africa. The most reliable volume estimates for oysters came from Ghana, and the Narkwa Lagoon had the most production [Avg. per day = 87 kg; 4 days harvest per week; 5 months (20 weeks) harvesting per annum = 6,960 kg].
Per kg oyster value average from The Gambia, Ghana, and Nigeria	The most reliable value estimates for whole weight of oysters came from Ghana and Nigeria; that for The Gambia was extrapolated from per cup of meat weight estimates [Avg. = USD 1.10/kg whole/live weight]. These represent high (The Gambia), moderate (Nigeria), and low (Ghana) oyster prices, by whole weight.

importance regionally. **Figure 5** is a depiction of the region's most harvested shellfish species in estuarine and mangrove ecosystems. Reportedly harvested by some women at the North bank of the Gambia river, and identified in Senegal, was a species of the pearl oyster *Pinctada* spp.

Harvest Volume and Value

The assumptions underlying the estimation of volume and value of shellfish in this study are presented in **Table 3**. Following these

assumptions, the total estimated annual harvest volume of shellfish by women harvesters in West Africa was deduced as follows:

$$\begin{aligned}
 \text{Volume EMES} &= \text{Avg. total catch} \times \\
 &\quad (79\% \text{ of Total Estimated Number of Shellfishers}) \\
 \text{Volume EMES} &= 6,960 \text{ kg} \times 43,890.82 \\
 \text{Volume EMES} &= 305,480,107.2 \text{ kg} \\
 \text{Volume EMES} &= 305,480 \text{ MT}
 \end{aligned}$$

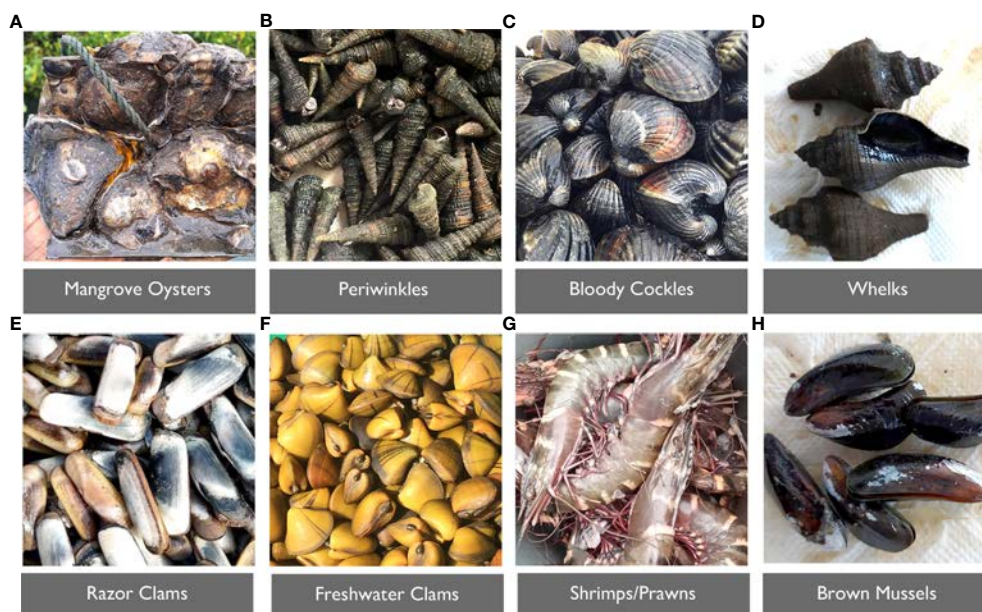


FIGURE 5 | Common shellfish species harvested along the coast of West Africa; left to right on top row—(A) The West African mangrove oyster (*Crassostrea tulipa*), (B) periwinkles (*Tympanotonus fuscatus*), (C) bloody cockle (*Senilia senilis*), and (D) whelks (*Pugilina morio*). Left to right on bottom row—(E) razor clams (*Tagelus adansonii*), (F) freshwater/Volta clam (*Galatea paradoxa*), (G) shrimps (Penaeids), and the (H) brown mussel (*Perna perna*). [Data source: All images captured by authors for this study].

Standardized shellfish prices were obtained from only a few locations in Ghana, The Gambia and Nigeria. The mangrove oyster was the least priced shellfish throughout the locations in Ghana, with prices ranging from USD 0.10 to USD 0.40/kg of live (unshucked) oysters. In The Gambia, a cup equivalent to 63 g of oyster meat (wet meat weight) was sold at about USD 1.00 (Saine et al., 2021). The price of unshucked oysters in The Gambia translates to USD 2.00/kg using the derived equation for the “whole weight”–“meat weight” relationship. Unshucked oysters were also reported to cost USD 0.10/kg, USD 0.30/kg, and USD 0.90/kg in Nigeria’s Ondo, Akwa Ibom, and Cross Rivers states, respectively. Averagely, 1 kg live weight of oysters was priced at USD 1.10. The total estimated annual harvest value of EMES by women harvesters in West Africa was deduced as follows:

$$\text{Value EMES} = \text{Volume EMES}(\text{kg}) \times \text{USD}1.10 \text{ kg}^{-1}$$

$$\text{Value EMES} = 305,480,107.2 \text{ kg} \times \text{USD}1.10 \text{ kg}^{-1}$$

$$\text{Value EMES} = \text{USD}336,028,117.92$$

Mangrove Ecosystems as Support for Shellfisheries

Mangrove ecosystems were present in over 90% of the shellfish harvesting locations identified. These mangroves were found to provide critical habitats for shellfish, most visibly as a substrate for the settlement and growth of the West African mangrove oyster. Nonetheless, more than 60% of the harvesters surveyed attested to the active exploitation of mangrove products within their harvesting sites by community members. These were mainly non-shellfishing community members. Shellfish harvesters were minimally involved in mangrove trading, mainly utilizing mangroves as fuel wood for processing shellfish as well as for constructing and fencing processing sheds. Some shellfish harvesters appeared to know the importance of mangroves to shellfish, therefore, employed harvesting techniques that do not harm mangroves.

Governance Regimes

The estuarine and mangrove ecosystems in West Africa, to a large extent, were found to be open and accessible to all. In most shellfish harvesting locations surveyed, there were either no specialized formal laws or legislation for the regulation of the shellfisheries and mangrove systems, or resource users were not aware of them. Some of the survey locations are designated Ramsar sites and Biosphere Reserves with varying degrees of protection for mangroves and wetlands, but rarely if at all regulate shellfish harvesting. More than 495,000 hectares of coastal Ramsar sites across the region have potential shellfisheries (see **Supplementary Table 2**).

Two examples of explicit and formalized community-based governance arrangements in the region are found in Ghana and The Gambia. These were a cockle and oyster co-management plan regulating harvesting in the Tanbi Wetlands National Park in The Gambia (Gambia Ministry of Fisheries Water Resources and National Assembly Matters, 2012) and a similar co-management plan for the Densu Delta oyster fishery

in Ghana (Ghana Ministry of Fisheries and Aquaculture Development and Fisheries Commission, 2020).

There were several women shellfisher groups in the region (see **Supplementary Table 3**), some of whom are the chief custodians of management and regulation of the conduct of harvesting within their catchment areas. All countries except Guinea and Togo had such women groups. The Gambia had the highest number of formalized community-based women’s groups, followed by Senegal and Côte d’Ivoire. Among all these groups, the TRY Oyster Women’s Association in The Gambia is the only national women shellfishers association with membership from formalized satellite groups in different communities.

Customary laws were identified to contribute to the traditional governance of mangroves and shellfish, such as the “cut one, plant three” rule used to protect mangroves in some locations in Sierra Leone. Shellfish were also not exploited during periods of customary rites usually preceding traditional festivals. An example is in the Densu Delta in Ghana where there is a ban on all forms of fishing including shellfishing for about a month before the “Homowo” festival—a traditional festival that signifies the end of hunger by people of the Ga tribe. At many coastal shellfish harvesting locations across the region, there were fishing holidays believed historically to be sacred days for the gods. In a few communities, certain locations within the wetlands and estuarine/mangrove areas were designated as sanctuaries where only traditional authorities are allowed to enter to perform traditional rites and rituals. Some other gender-centric norms prohibit menstruating females and lactating mothers (for about 3 months after childbirth) from entering coastal ecosystems.

Success Elements of The Ghana and The Gambia Shellfish Co-Management Plans

The inductive synthesis of the two co-management plans identified revealed five key success elements. These were found to be based on the principle of sustainability and driven by the resource users in response to the need to protect their livelihood. The five success elements were:

1. Existence, or formation if absent, of organized resource user groups;
2. Empowerment of these organized groups to enhance their capacity to appreciate and lead conservation action;
3. Evidence of the socio-ecological issue/problem;
4. Strong and inclusive stakeholder constituency building; and
5. Financing and partnerships for the co-management process.

DISCUSSION

Estuarine and Mangrove Ecosystem-Based Shellfish Exploitation in West Africa

This study reveals shellfishing livelihoods derived from the estuarine and mangrove ecosystems are widely interspersed along the entire stretch of the West African coast. The numerous rivers

forming estuaries at the point of discharge into the Atlantic Ocean provide suitable locations and flourishing mangrove habitats that increase the productivity of many different shellfish species. Notable estuarine and mangrove ecosystem-based shellfishing areas in the region include the Saloum Delta, designated as a biosphere reserve in 1981, a wetland of international importance under the Ramsar Convention in 1984, and a UNESCO world heritage site in 2011. As a result of the abundance of oysters in many of the estuaries and mangrove ecosystems in the region, oyster harvesting, processing, and marketing are commonplace in several coastal communities. The Casamance river estuary or Lower Casamance region of Senegal, the Densu Delta, Narkwa lagoon and the Volta estuary in Ghana, and the Tanbi wetlands of The Gambia are examples of these ecosystems. Coastal communities in Benin harvest in coastal lagoons due to the abundance of shellfish in this area. In Nigeria, shellfish harvesting areas include the Calabar river estuary and the Niger Delta. All these areas are almost exclusively accessible to the public, with no private ownership.

The features of the estuarine and mangrove systems in the region vary considerably. Senegal, Gambia, and Guinea Bissau have many sheltered bays, deltas, and wetlands with marine or brackish features. Other countries have classic brackish water estuaries formed by rivers discharging into the ocean. Certain shellfishing areas have few mangroves (Narkwa and Densu lagoons in Ghana), whereas others are associated with dense stands (Gambia river mouth and Saloum Delta). The whole coast of Togo is a legally protected conservation area and dominated by coastal lagoons. Benin's Coastal Lagoon is dispersed along its entire shore, serving as critical habitat for shellfish. The large expanse of estuarine and mangrove systems and large populations in coastal Nigeria are probable reasons for the relatively high estimate of estuarine and mangrove ecosystem-based shellfishers for that country in comparison to the others. Although mangroves are important indicators of the presence of active shellfisheries, countries with significant artisanal fisheries and high per capita fish consumption but with low mangrove cover such as Ghana had relatively high numbers of shellfishers possibly due to the importance of fish in the diets of coastal households. Several countries, including Ghana, Togo, and Benin, have dominant and thriving oyster populations residing on the bottom sediment of lagoons and estuaries in addition to those attached mainly to mangrove roots which are typical of Senegal and The Gambia. Relative to the coastal stretch of the region, subsequent studies on countries with larger populations like Nigeria, Senegal or others with extensive mangrove and estuarine areas need more in-depth and larger sample sizes, which is a limitation in this study.

A majority of the significant shellfish species found in the regional estuarine and mangrove ecosystems are mollusks, which represent the second biggest phylum of invertebrate organisms and the second most abundant animal group on earth. The bivalve and gastropod subgroups of mollusks were the most frequently exploited species for food and subsistence. Naturally, these are considered as the main species of mangrove forests; gastropods are well distributed in mangrove habitats probably due to their mobility and bivalves are confined to a narrow area, due to feeding and reproductive behavior, and substrate requirements

(Kabir et al., 2014). All other shellfish species are known natives of the region except for the pearl oyster (*Pinctada* spp.) identified in Senegal and The Gambia. Until now, the geographical distribution of the pearl oyster, either of natural stocks or by introduction, was not documented to include locations along West Africa but in regions of the Indian and Pacific Oceans, as well as the Caribbean (Sims, 1992a; Sims, 1992b; Aidede et al., 2014; Whalan et al., 2021). According to some women harvesters, “marble-like materials” (pearls) have been extracted from these oysters.

The apparent non-existence of standardized methods and fisheries officers responsible for estimating the catch volumes and pricing of shellfish harvests in West Africa makes attempts to construct the catch volumes and value very challenging at the regional scale (Hutchison et al., 2015). In Ghana, earlier research evaluated the value of oysters at USD 1.07 for 15 kg live whole weight (unshucked) at Narkwa Lagoon (Asare et al., 2019) and USD 7.00 for 29 kg at the Densu Delta (Osei et al., 2020), or around USD 0.10–0.20/kg, which is comparable to the lower end of the price range for shellfish identified in this assessment. The higher price of oysters in The Gambia is due partial processing before sale; the oysters are parboiled, shucked and the meat is sold. Hence, the cost of processing influences the shell-on price per kilogram deduced from the indicative price. In addition, oysters have relatively greater popularity in The Gambia where the harvest season usually coincides with Ramadan festivities when the oyster meat is a delicacy and in high demand, particularly at localities in and near the capital of Banjul.

The production volumes (305,480 MT) and value (USD 336 million) estimates of this study are likely to be close to real values, or at worst an underestimation, as they are drawn from data collected from shellfish harvesters but also based on conservative assumptions on key parameters such as the total number of harvesters, total catch, and the price per kilogram. The West African shellfish production value represents 6% of the USD 5.6 billion landed value of the fish catch by women globally (see Harper et al., 2020) and the regional catch is close to the annual small-scale catch by women in the Pacific (Harper et al., 2017).

Estimating the number of actors, in this case shellfish harvesters, especially where there is no data, is challenging (Teh et al., 2013). An earlier attempt to estimate women oyster harvesters and construct estimates was premised on two assumptions; first by assuming the number of oyster harvesters to be equal to the number of coastal artisanal fishers and second by assuming that oyster harvester households equaled the number of fishing households, but with a note of caution (Ottaviani, 2020). This proxy method may not be appropriate due to the enormity of artisanal fisheries in the region compared to the relatively smaller scale women shellfisheries. Using a proportion of the artisanal fishers to women shellfishers may be more appropriate method for future studies as was done for estimating global coral reef fishers (Teh et al., 2013) and applied to estimate the number of women shellfishers in Guinea in this study.

Harvesting methods vary among sites (Figure 6) and men may specialize differently due to their peculiar capabilities. Men employ diving techniques with no special apparel in collecting shellfish from depths. This is common for the clam fishery of the

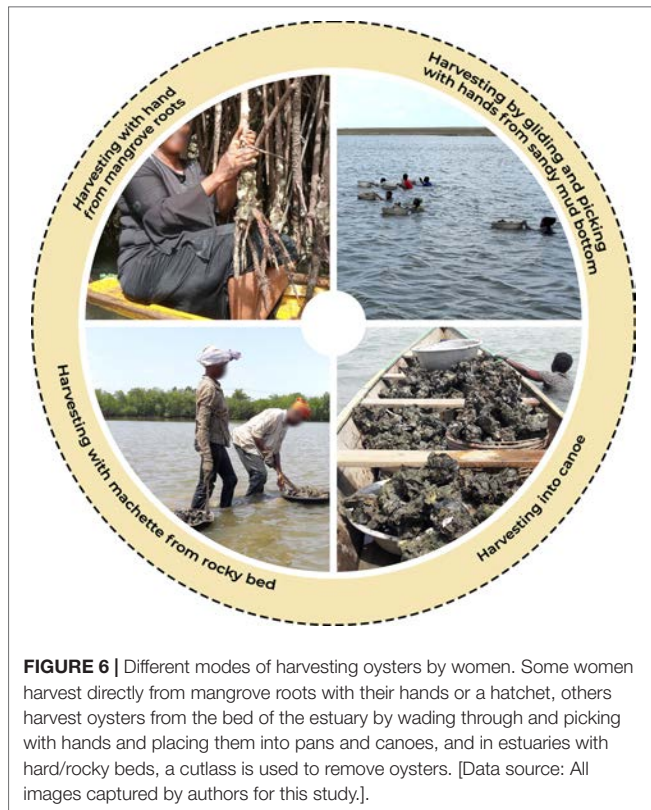


FIGURE 6 | Different modes of harvesting oysters by women. Some women harvest directly from mangrove roots with their hands or a hatchet, others harvest oysters from the bed of the estuary by wading through and picking with hands and placing them into pans and canoes, and in estuaries with hard/rocky beds, a cutlass is used to remove oysters. [Data source: All images captured by authors for this study].

Volta estuary and the oyster fishery of the Densu Delta, both in Ghana. Women wear improvised foot protection gear to avoid injury for harvesting shellfish. The footgear is usually made of old clothing such as severed trouser trunks, worn on the feet, and tied firmly for wading during under-water harvesting at high water levels. Men in the Volta clam fishery use motorized air compressors with a hose (hookah) to supply air while they are underwater and a hauling net to aid in diving for clam collection.



FIGURE 7 | Specialized mini axe (hatchet) used for harvesting oysters from mangrove roots without cutting the mangroves. [Data source: Image captured by authors for this study].

Men also deploy traps with bait for the exploitation of crabs (e.g., *C. armatum*), and use seine nets for shrimp harvesting.

The observation of oyster harvesting with a hatchet, a specialized mini axe (see **Figure 7**), without severing the roots on mangroves corroborates the finding that shellfish harvesters were not the main harvesters of mangroves and were not key actors in the trade of mangroves. The economic benefits derived from oysters associated with mangrove resources could be a primary motivating factor limiting the widespread exploitation of mangroves by the women (Aheto et al., 2016). Nonetheless, the general decline in mangrove covers from 1996 to 2016 in all countries of the region except Benin and The Gambia (Chuku et al., 2020) is a concern.

Gender Dynamics, Value Chain, and the Governance of Estuarine and Mangrove Ecosystem-Based Shellfisheries in West Africa

Small-scale fisheries are generally seen as “everybody’s business” in many developing countries and its gendered resource use concentrates production in the hands of fishermen while women resort to postharvest processing and retailing (Thorpe et al., 2014; Lentisco and Lee, 2015). This stems from a long-held perception of a highly gender-segregated division of labor, i.e., men fishing and women processing (Lentisco and Lee, 2015; Harper et al., 2017), which has long influenced the generalized approach for supporting development initiatives and governance structures for small-scale fisheries (Lentisco and Lee, 2015). This narrative has been shifting since 2012 after World Fish and the World Bank estimated that 47% of fishworkers worldwide were women (World Bank et al., 2012; Harper and Kleiber, 2019), drawing significant attention to women’s involvement in small-scale fisheries. Nonetheless, there remains much to be learned about the gendered contribution to fisheries at the different nodes of the value chain. This study contributes to this body of knowledge by demonstrating women’s central role in the shellfisheries of West Africa and further reveals their specialization with keystone groups of marine organisms in a specific environment.

Such specialization by women is probably due to the accessibility of the harvesting grounds, the ease of capture of the target species, i.e., bivalves and gastropods in particular, and the unsophisticated technologies required for the current scale of the fishery. Men’s participation in estuarine fisheries appears greater where crustaceans and cephalopods were the main species exploited with more sophisticated gear (nets and traps) and by using boats. Even in these fisheries, however, women maintained traditional roles as processors and retailers.

The value chain analysis provides insights relevant to the governance of the fishery. The involvement of women harvesters at multiple nodes of the shellfish value chain—harvesting, processing, marketing, and transportation, including consumption—especially for bivalves and gastropods, shows how strongly women harvesters dominate the sector and how vertically integrated the value chain is. Vertical integration increases the opportunity for women harvesters to benefit from improvements at any node in the value chain. This provides

an opportunity and a potential incentive to adopt sustainable management measures. It also could reduce the risk of external capture of benefits other than the women harvesters who may be disconnected from longer-term sustainable resource management that can incentivize rapid overexploitation of the resource.

Transportation to and from harvesting locations occasionally involved men because they own the canoes, although the women were capable of rowing their own canoes. Men's involvement was also pronounced in the other livelihoods related to shellfishing. For instance, in the Volta river clam fishery in Ghana, men are the main harvesters as exploitation uses boats and hookah gear for harvesting. The men also engage in a form of capture-based aquaculture (or "aqua-ranching") of the Volta clam. Another economic activity in the Volta clam fishery is shell processing controlled by medium-scale companies. Togo has five such shell processing units, the largest seen in the region in this study. The main customers of the processed shells are feed mills or manufacturers of animal feed ingredients and large poultry producers. The shell value chain in Togo illustrates the opportunity to strengthen links between sustainably managed shellfisheries and improve local production in the poultry value chain in the region for food security and livelihoods, which is now dominated by imports. In some communities, shell processing involves the production and sale of lime for construction whereas some women return shucked shells back into the estuaries to improve settlement substrate for stock enhancement.

Shell planting is an indigenous conservation measure employed by shellfishers in some communities. That and other pro-environment customary laws form the traditional governance mechanisms regulating fishing in general and by extension the shellfisheries. The general lack of a formalized governance of estuarine and mangrove ecosystem-based shellfisheries in the region leaves the sector unregulated and woefully underreported. Some of the customary laws documented in this assessment serve as de-facto fishing closed seasons (holidays) and no-take zones essential for regulating exploitation levels. Other community level by-laws help protect mangroves, which are essential habitat for healthy adult oyster populations, for example the prohibition of, "Akadja" or "Atidza" (brush park) fishing. This method of involves the use of tree branches (mainly mangroves) to create micro-habitats that lure fish in for shelter and food, the area is encircled with a net and harvested after about one to three months. Increasing population pressure, in coastal zones, unrestricted use of common-pool resources (as is the case for open access fisheries), cultural changes, new markets, and technological advances, threaten the effectiveness of traditional norms and respect for traditional laws and consequently could result in further depletion of fisheries resources (Pomeroy et al., 2007; Eigaard et al., 2014; Urquhart et al., 2014; Cinner et al., 2021). All of these represent threats and drivers of excessive mangrove and shellfishery exploitation for the West Africa region as well.

The importance of mangrove ecosystems to shellfisheries makes them a critical resource for conservation. Mangroves in the region are generally protected by forestry and environmental protection laws. Shellfishing locations within Ramsar sites benefit indirectly from the protection and conservation priorities of the

Ramsar Convention. Hence, the over 495,000 hectares of coastal Ramsar sites across the region present the opportunity to align investment in improved shellfisheries management with existing national and international commitments.

This assessment identified only two examples in West Africa of formalized governance arrangements for shellfisheries, with legally approved and gazetted co-management plans for areas in Ghana and The Gambia. They reference fisheries and other existing laws and regulations and formalize the delegation of exclusive shellfish harvesting or use rights in these areas to legally recognized associations. These co-management examples in Ghana and The Gambia are prime examples and archetypes for potential scale-up across the region, and therefore, are described in more detail in the next section. Where there were strong co-management arrangements, there are active and organized shellfisheries groups that were the main drivers of these management regimes.

Lessons From Ghana and The Gambia Women-Led Estuarine and Mangrove Ecosystem-Based Shellfisheries Co-Management, and Opportunities for Scale-Up in West Africa

The examples of resource-user-driven fisheries co-management from Ghana and The Gambia targeting the sustainable exploitation of oysters and cockles in specific brackish and mangrove ecosystems are rare in the region. They were both motivated by the realization by an active resource user group of the need to reverse declining yields to protect their primary source of livelihood and based on the fundamental principle of sustainability, limiting extraction while taking measures to improve abundance. Sustainability is only achievable with restricted access to a large extent of the exploited stock (Pauly et al., 2005). Management measures specified in these plans are decisions made by the resource users through a participatory capacity development and planning processes. They include annual harvesting closed seasons, minimum sizes, and ecosystem stewardship actions. These two co-management plans are touted in both countries as some of the most successful fisheries management efforts in aspects of resource-user led sustainable fisheries management and environmental stewardship decision-making [for Ghana see (Okyere et al., 2020)]. Several factors play critical roles in the creation process and the effectiveness of the co-management arrangements seen in Ghana and The Gambia.

First was the existence, or formation, of organized user groups with the social capital to take up stewardship of the shellfishery upon the devolution to them by national fisheries authorities through exclusive use rights in a co-management arrangement. These groups were formalized with proper internal organizational governance structures and an active membership. The TRY Oyster Women's Association of The Gambia (Equator Initiative, 2013) and DOPA of Ghana have robust governance structures consisting of a Board of Directors, an Advisory Council, a Local Governing Board, and an Executive Director. The existence of many other shellfisher groups in West Africa as found in this study provides an excellent entry point for

scaling up shellfishing use rights and co-management plans as successfully demonstrated in Ghana and The Gambia.

Second, as part of the co-management creation process, these organized groups were empowered through capacity building and boosting their confidence through active engagement and participation in meetings. This is seen as critical for community-based management (Hasselberg et al., 2020). Peer-to-peer learning was another empowerment strategy applied in these cases. Both women's associations had several training and peer exchange programs (USAID/BaNafaa Project, 2014; Development Action Association, 2017; Adité et al., 2018). These experiences helped change the perspective of the resource users on the possibilities and potential benefits of managing their own fishery. In the case of the Densu Delta, the establishment and legal registration of the Densu Oyster Pickers Association (DOPA) was a result of the co-management planning process. Co-management planning processes can strive to integrate the local ecological knowledge and social capital that are the foundations for traditional systems of natural resource management with scientific knowledge and evidence-based decision making. Co-management planning processes that strengthen use rights can empower resource users to join forces to lead and maintain the implementation of sustainable practices for their mutual benefit.

Third is gathering substantial baseline data and monitoring to understand the biological, ecological, fishery and environmental sanitary conditions of the specific ecosystem of interest, as conducted in both Ghana and The Gambia cases. A poor judgement of the socio-ecological dimensions of natural resource and ecosystem management needs could lead to misguided recommendations for management that may not yield the desired benefit (Crawford et al., 2010). A useful approach is to apply citizen science where the resource users have first-hand experience participating in data collection and grasp the basic scientific concepts underlying such activities, which makes the uptake of results much easier (Fairclough et al., 2014; Fulton et al., 2019; Wilmoth et al., 2020). These participatory monitoring practices were applied in Ghana and The Gambia where women harvesters were involved in data gathering and educated on the basic biology and ecology of oysters and cockles. The specificity and narrow focus of co-management arrangements on species groups and ecosystems that are primarily of interest to women harvesters may also appear to hold more potential for success.

Fourth, a transparent and inclusive process of stakeholder constituency building from the bottom up was demonstrated in the two countries (Development Action Association, 2017; Development Action Association, 2018). Theoretically, to be successful at scaling up co-management demands active engagement with all facets of national and local governing regimes to coalesce a diverse group of actors, which makes it an endeavor that is larger than its smaller units (Steenbergen et al., 2022). In Ghana, co-management committees were set up that included resource users where local and national authorities were tasked with advisory committees (Ghana Ministry of Fisheries and Aquaculture Development and

Fisheries Commission, 2020). This process is beneficial as the state authorities were willing to delegate power to the resource user and commit resources for its success. For example, government buy-in and support led to the allocation of land to the TRY Oyster Women's Association in The Gambia for the future construction of an office, processing, and training facility to further facilitate the co-management (USAID/BaNafaa Project, 2014).

Fifth is financing and partnerships. Support is required to undertake co-management planning activities leading to the establishment of the co-management plan, and for financial assistance towards eco-remediation measures such as mangrove replanting and sanitation. Both co-management plans of Ghana and The Gambia were significantly supported by donor funding and development programming. In The Gambia, microfinance schemes were initiated to help resource users establish the habit of saving and to support supplementary livelihoods during closed harvest seasons. Closely linked to financing is partnerships for research, capacity building, and behavior change communications during and after the co-management development process. These community groups were supported by technical experts from donor-funded development projects in partnership with university researchers, NGOs, and the government in the gathering of data and drafting of the technical document, with the resource users at the center, coordinating and leading the process. Extension initiatives by universities were pivotal in building the capacity of communities as well as engaging with government towards the successful implementation of co-management in the gleaner women-based shellfisheries in Nicaragua and Tanzania (Crawford et al., 2010).

The five elements discussed above could form the main pillars for scaling up EMES co-management in the West Africa region. However, the mechanisms and processes to success may have to be adapted to the prevailing social, ecological, and political landscape as well. Identifying the needed changes and distinguishing structure from process as suggested in the theory of scaling for community-based fisheries management is essential (Steenbergen et al., 2022). Structural change will be characterized by the changes in social behavior or policy outputs in support of co-management whereas process-driven change will involve the push and pull factors that influence structures. These cut across the success elements discussed and may differ from country to country, and at different locations within each country in the region. For instance, the operational architecture of the resource user (women) groups in Ghana and The Gambia are quite different but have both obtained exclusive use rights for their primary livelihood resource and its associated ecosystem.

The TRY Oyster Women's Association of The Gambia is a resource-user-led umbrella oyster women association, more of an autonomous parent organization, coordinating activities of several satellite community-level oyster women groups, all formally registered. Their Ghanaian counterparts, the Densu Oyster Pickers Association, operate on a different model where their activities and programming are coordinated by a farmer based non-governmental organization, Development Action

Association, which is not operated by the resource users. Both models have proven effective for the co-management process, however, questions on their varied capacities to propel continued innovation and maintain a grasp on their resource user base to sustain the gains as pressure on the resource continue to increase, and required further determination. In southern Africa, after 10 years of implementing fisheries co-management in Malawi, Mozambique, and Zambia, it was concluded that co-management responsive to the community whose institutions are constituted of fishers mainly, and whereby conservation efforts are seen as local contributions to village life other than rule enforcement mechanisms, have been the most successful (Wilson et al., 2010).

CONCLUSIONS

The observation of an across-the-region presence of estuarine and mangrove ecosystems with several harvested species of socio-economic importance to women harvesters and their households signals the feasibility of women-led shellfisheries as an avenue for an integrated approach to sustainable management of these systems in West Africa. The results spotlight the unrecognized regional scale of shellfisheries

and women's dominance in many of these in West Africa (summarized in **Figure 8**). It highlights the critical importance of this small-scale fishery on the livelihoods, food security and socio-economic empowerment of women and their households. With an estimated yield of about 300,000 MT and over USD 300 million realized annually, there is a need to enhance the sustainability of shellfishing to protect women's livelihoods and create more opportunities for the sector. There was a strong vertical integration of shellfisheries value chains dominated by women harvesters throughout the region (i.e., for the bivalve and gastropod value chains). This further indicates an opportunity to incentivize sustainable management of these resources through improvements at all nodes of the value chain, and the empowerment of women to retain control even with the emergence of an industry in the future. The sector, however, remains vulnerable to the loss of critical habitats, mainly mangroves, whose conservation is required to improve stocks but would also benefit from sustainable shellfish harvesting practices. The potential effect of the COVID-19 pandemic on this assessment is unclear. Although there could be inherent market disruptions because of lockdowns and market closures, fishing was classified as an essential service in some countries, hence, the impact on production could be minimal.



FIGURE 8 | Summary infographic for the estuarine and mangrove ecosystem-based shellfisheries of West Africa. [Infographic developed originally by this study. Data source: Values for the number of shellfishers and their beneficiaries, women's participation, volume, and value of shellfisheries were obtained from the resource user survey from this study; mangrove area data from Global Mangrove Watch].

The study further highlights two women-led co-management regimes that are working well, drawing from the successful examples of the TRY Oyster Women's Association of The Gambia and Development Action Association (Densu Oyster Pickers Association) of Ghana, and provides a framework for its scaling up in the region. The five elements of success identified are (1) the existence, or formation if absent, of organized resource user groups, (2) empowerment of these organized groups to enhance their capacity to appreciate and lead conservation action, (3) evidence of the socio-ecological issue, (4) strong and inclusive stakeholder constituency building and involvement, and (5) financing and partnerships to support the co-management process.

The organized women's groups throughout the region identified in this study, several of which are formalized, provide the initial enabling condition for initiatives on scaling up women-led shellfishery co-management in West Africa. These existing groups could be the focus of government and the donor community, but should not be engaged in isolation. Shellfisheries co-management arrangements involving government, research institutions, non-governmental organizations, and the shellfish harvesters, and grounded on rule-setting and compliance as the central operational practices should be promoted. Achieving region-wide sustainable shellfisheries management could improve the food security and livelihoods of at least 565,000 vulnerable coastal dwellers, especially women, and sustain a healthy coastal marine environment through the conservation of mangroves, estuaries, and the plethora of marine and freshwater species that depend on these areas covering more than 1.5 million hectares for various ecosystems services.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation. The online questionnaire for data collection and link to the survey data are included in the supplementary material.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by University of Rhode Island Institutional Review Board (IRB), University of Rhode Island (STUDY TITLE: USAID Women Shellfishers and Food Security, IRB REFERENCE #: 1661892-2). Written informed consent for participation was not required for this study in accordance with the national legislation and the institutional requirements.

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AUTHOR CONTRIBUTIONS

BC, KK, EC, and DA contributed to conception, design of the study, performed the statistical analysis, and revised the manuscript critically for important intellectual context. EC organized the database, and wrote the draft manuscript. EC, EE, JA, SA, RA, IO, and DA coordinated the research. MW, DS, AA, EO, IKO, SS, YS, and KA contributed to reviewing the study methodology, data collection and review of manuscript. All authors contributed to manuscript revision, read, and approved the submitted version.

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SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: <https://www.frontiersin.org/articles/10.3389/fmars.2022.884715/full#supplementary-material>

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