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WOMEN SHELLFISHERS AND FOOD SECURITY PROJECT

PARTICIPATORY ASSESSMENT OF SHELLFISHERIES IN THE ESTUARINE AND MANGROVE ECOSYSTEMS OF **GHANA**

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Cover Photo: Exploitation of shellfishes (a) women handpicking oysters at Densu Delta (b) a woman returning from shellfishing with a basin at Keta Lagoon (c) a woman with an improvised footwear, red circled.

Photo Credit: Isaac Osei Kofi

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ACRONYMS

CSO	Civil Society Organization
DAA	Development Action Association
DOPA	Densu Oyster Picker's Association
FC	Fisheries Commission
MoFAD	Ministry of Fisheries and Aquaculture Development
NGO	Non-Governmental Organization
USAID	United States Agency for International Development
SFMP	Sustainable Fisheries Management Project
VSLA	Village Savings and Loans Associations

Executive Summary

Basic Contextual Information	
Country	Ghana
Total land area	238,535 km^2
Population	29.77 million (2018)
Percentage population living in/near the coast	25%
Gross Domestic Product (GDP)	65.56 billion USD (2018)
Human Development Index Rank	0.596 (142 out of 189)
Length of coastline	550 km
Fish consumption (as a percent of animal protein)	50–80%
Anemia prevalence	78.4% among under-five children 46.4% among women of reproductive age (15-49)
Estimated mangrove cover	20,418 ha
Estimated estuarine and mangrove ecosystem-based shellfish harvesters	4,333
Estimated women shellfish harvesters (percent)	3,813 (88%)
Estimated direct household shellfish beneficiaries	31,731 (60% female)
Estimated percentage of shellfish harvesters at all nodes of the value chain (vertical integration)	+77%
No. of coastal systems with mangrove-based shellfishing	11
Shellfish management regulations	Oyster Fishery Co-Management Plan for the Densu Delta
Mangrove management regulations	-
Coastal ecosystems with shellfisheries identified as Ramsar sites	Densu Delta = 5,893 ha Keta Lagoon Complex = 101,022 ha

Source: Chuku et al. 2020, Global Mangrove Watch, Ramsar Sites Information Service (RSIS)

Status of shellfisheries:

- Largely, the exploitation of shellfisheries in Ghana has not been accounted for, partly because it is assumed the fishery is not lucrative enough leading to its neglect in the country's annual fish production estimation (Osei, 2020) and the necessary interventions for sustained food production

and income generation along the coast, especially for women. Shellfisheries provide livelihoods and a cheap source of protein and micronutrients to many coastal dwellers.

- This country assessment is aimed at gathering data on the scale and scope of shellfisheries and shellfish-based livelihoods associated with mangrove and estuarine ecosystems in Ghana. The study led to the identification of key stakeholders comprising resource users, government, academics/researchers, NGOs/CSOs and traditional institutions whose activities are associated with shellfisheries livelihoods and the management of mangrove and estuarine ecosystems.
- A total of 34 resource users out of the estimated 4,333 shellfishers and 10 non-resource users were interviewed using a semi-structured interview guide.
- Both stratified purposive and purposive sampling techniques were used in selecting the key stakeholders in the shellfisheries business, owing to the difference in organization of the various fisheries. The background data of respondents were analyzed by descriptive statistics using Statistical Package for Social Sciences (SPSS).
- The coastal water bodies/sites covered in this study, i.e., the Amanzule Estuary, Whin Estuary, Amissano Estuary, Narkwa Lagoon, Densu Delta, Volta Estuary (Tunu), Volta Estuary (Big Ada), and Keta Lagoon, support commercial shellfisheries. The observed shellfisheries in these areas are bivalves, gastropods, and crustaceans.
- The West African mangrove oyster (*Crassostrea tulipa*), West African mud creeper/periwinkle (*Tympanotonus fuscatus*) and whelk (*Pugilina morio*) are the most important species by harvest across the study sites. The bivalves and gastropods are exploited by handpicking or diving with improvised footwear. Some of the crabs (e.g., *Cardisoma armatum*) are collected by the deployment of traps with bait. Generally, shellfish are harvested during the dry season from November to March/April depending on the month the rains begin, while *T. fuscatus* is harvested year-round in most of the sites. Nonetheless, the harvesting period for *C. tulipa* coincides with the rainy season in the Densu Delta and shellfishers in the Volta Estuary (Tunu) also exploit oysters during the rainy months.
- Women are extensively engaged in the harvesting, processing, and trading of the shellfisheries, while men play harvesting roles only, particularly in the Volta clam fishery (Volta Estuary, Big Ada).
- The most productive shellfisheries by yield are the Volta clam (*Galatea paradoxa*) of the Volta Estuary (Big Ada) and *C. tulipa* fisheries of Narkwa lagoon producing up to 320 kg/day, 5,120 kg/month and 40,960 kg/season as well as 116 kg/day, 1,939 kg/month and 10,859 kg/season, respectively per crew in the case of the Volta clams, and per oyster harvester in Narkwa.
- The price per kilogram of shellfishes varies within and among coastal communities. *P. morio* (USD $8.40/kg) and *T. fuscatus* (USD $3.50/kg) from the Whin Estuary are the highest priced among the shellfisheries from all sites assessed. The Volta clam fishery generates the highest revenue of USD $1,106.90/month for a crew of harvesters.

- There are general concerns from stakeholder groups other than the shellfisheries resource users of the potential consumption of unwholesome shellfish by regular consumers as they perceive shellfish harvesting areas to be polluted with fecal matter and possibly heavy metals.
- Mangrove vegetation in all the study sites is exploited to some extent. In the Amanzule, Whin, and Amissano estuaries, as well as Narkwa Lagoon, mangrove coverage is described by resource users as high to moderate, whereas that of the Keta Lagoon and Densu Delta is said to be low.
- All the study sites support open access fisheries. Moreover, the fisheries are unregulated, except the Densu Delta oyster fishery and Volta clam fishery, which are co-managed in a gazetted community based plan (MoFAD, 2020) and traditionally managed, respectively.
- The livelihoods of shellfishers are lost during the unfavorable period of high inundation in the coastal areas caused by rainfall for most of the shellfisheries, which subsequently affects food (shellfish) security.

Recommendations:

- All commercial shellfisheries along the coast of Ghana should urgently be regulated to ensure their rational management, development, and sustainability.
- A comprehensive program of action research should be developed to harness the aquaculture potential of Ghana's shellfisheries, as well as to expand the market and improve the value of shellfish through business models for the various species.
- Education of shellfish harvesters on the ecological services provided by shellfish and mangrove systems should be prioritized to promote rational utilization of the resources.
- The use of mangroves as firewood must be discouraged and degraded mangrove vegetation should be restored by replanting to maintain the ecological integrity of mangroves.
- The general sanitation of coastal aquatic systems and their catchment areas should urgently be improved to produce high quality shellfish, which in turn would stimulate good health and make wild shellfish consumption more appealing.
- Shellfish harvesters should be educated and trained in entrepreneurial skills to promote the construction of lucrative varied income sources to better the standard of living of resource users, particularly during the lean or off-season for shellfish harvesting.
- Shellfish resource users should be equipped with skills in value addition to generate higher income, extend the shelf life of the product, and possibly penetrate high-value markets.
- Shellfishers should be assisted with soft loans and protective gear (i.e., diving apparatus, shucking gloves, waders etc.) to enhance their businesses.

1. Introduction

Ghana is a West African country bordered on the north, east, south, and west by Burkina Faso, Togo, Gulf of Guinea (Atlantic Ocean) and Côte d'Ivoire, respectively. The coastal area of Ghana stretches over 550 km, covering four coastal regions namely Volta, Greater Accra, Central and Western Regions. According to Obodai (1997), Ghana has 108 coastal water bodies, 15 are in the Volta Region, 14 in the Greater Accra Region, 38 in the Central Region and 41 in the Western Region. These water bodies comprise closed lagoons, open lagoons and estuaries with its accompanied mangrove vegetation, mud and tidal flats and marshes, which support many commercially important fisheries. Five of the coastal water bodies in Ghana comprising the Keta, Muni, Sakumo, and Songor lagoons, as well as the Densu Delta, are designated as Ramsar sites. The primary occupation of the coastal inhabitants is fishing, and fish-related businesses of which women form an integral part.

Women are actively engaged in the harvesting, processing, and trading of shellfishes in Africa. Female dominance has been reported for oyster fisheries in Ghana (Asare, Obodai & Acheampong, 2019; Osei, Yankson & Obodai, 2020), Nigeria (Ansa & Bashir, 2007) and The Gambia (Njie & Drammeh, 2011). Moreover, the Volta clam fishery in Ghana is reported to have supported the livelihood of mostly women (Abarike, Alhassan & Alipi, 2015; Adjei-Boateng et al., 2012). The same can be said about the periwinkle fishery of Rivers State, Nigeria (Akinrotimi, Abu, Ibemere & Opara, 2009). Hence the opportunity for women to lead and benefit from sustainable exploitation of shellfisheries.

In Ghana, research has advanced the understanding of shellfisheries, particularly *Crassostrea tulipa* (= *gasar*) (Lamarck, 1819) to guide policies and make meaningful interventions for the rational exploitation and mass cultivation of shellfishes (bivalves). Studies on the socioeconomics of the Volta clam, *Galatea paradoxa* (Born, 1778) (Abarike et al., 2015; Adjei-Boateng et al., 2012) and oysters (Asare et al., 2019; Osei et al., 2020) as well as the reproductive biology of oysters (Obodai, Yankson & Blay, 1994; Osei, 2020; Yankson, 1996) and cockles, *Senilia senilis* (Linnaeus, 1758) (Yankson, 1982) have been undertaken. Some culture investigations of *C. tulipa* have been conducted on spat collection, growth and survival (Chuku, Yankson, Obodai, Acheampong & Boahemaa-Kobil, 2020; Obodai & Yankson, 1999, 2000, 2002; Osei, Yankson & Obodai, 2021; Yankson, 1990) and efficient approach to cultch construction (Chuku & Osei, 2020). Currently, the Government of Ghana through the Ministry of Fisheries and Aquaculture Development (MoFAD) and the Fisheries Commission (FC) has promulgated the Densu Delta Community Based Fisheries Management Plan, which was drafted by stakeholders, including Development Action Association (DAA), with the assistance of the USAID/Ghana Sustainable Fisheries Management Project (SFMP).

The current study assesses the scale and scope of shellfisheries and shellfish-based livelihoods connected with mangrove systems and coastal water bodies in Ghana through a participatory approach. The main objectives were the identification of key stakeholders and assessment of the scale and scope of existing shellfisheries and shellfish-based livelihoods in mangrove systems or its related water bodies. This study complements a Literature Review covering shellfisheries in each of the 11 coastal West Africa countries from Senegal to Nigeria. The specific objectives were to:

a. Identify types of mangrove/estuarine ecosystem-based shellfisheries, by species and location.
b. Estimate catch per day/month/season, fishing calendar, seasonality of shellfisheries and harvesting methods, processing and trading of shellfishes.
c. Estimate revenue generated from mangrove/estuarine ecosystem-based shellfisheries.
d. Determine the challenges and health-related conditions associated with the consumption of shellfishes.
e. Assess mangrove exploitation, its uses, gender attributes in its harvest, condition, and protection status.
f. Determine the governance/management regimes as applied to shellfisheries and mangrove systems.
g. Determine the effect of climate risks on the livelihoods and food security of women who depend on coastal mangrove and estuarine systems.

2. Methodology

2.1. Study sites

Eight water bodies/sites along the shoreline of Ghana were selected for the study based on the presence of mangrove-based or estuarine/lagoonal shellfisheries. The sites were Amanzule Estuary (5° 48′ 26″ N; 0° 37′ 03″ E, Fig. 1), Whin Estuary (4° 52′ 50″ N; 1° 46′ 46″ W, Fig. 2) in the Western Region; Amissano Estuary (5° 12′ 07″ N; 1° 00′ 19″ W, Fig. 3), Narkwa Lagoon (5° 12′ 26″ N; 0° 55′ 06″ W, Fig. 4) in the Central Region; Densu Delta/Estuary (5° 30′ 55″ N; 0° 18′ 40″ W, Fig. 5), Volta Estuary, Big Ada (5° 48′ 26″ N; 0° 37′ 03″ W, Fig. 6) in the Greater Accra Region; and Volta Estuary, Tunu (5° 12′ 26″ N; 0° 55′ 06″ W, Fig. 6), Keta Lagoon (5° 55′ 06″ N; 0° 55′ 28″ W, Fig. 8) in the Volta Region.

Figure 1: Map of Amanzule Estuary in the Western Region of Ghana (Image Source: Google Earth).

Figure 2: Map of Whin Estuary in the Western Region of Ghana (Image Source: Google Earth).

Figure 3: Map of Amissano Estuary in the Central Region of Ghana. Note the salt pans in proximity to the wetland. (Image Source: Google Earth).

Figure 4: Map of Narkwa Lagoon in the Central Region of Ghana (Image Source: Google Earth).

Figure 5: Map of Densu Delta/Estuary in the Greater Accra Region of Ghana (Image Source: Google Earth).

Figure 6: Map of Volta Estuary, Big Ada and Tunu in the Volta Region of Ghana (Image Source: Google Earth).

Figure 7: Map of Keta Lagoon in the Volta Region of Ghana (Image Source: Google Earth).

2.2. Field survey/data collection

Data collection was carried out by participatory engagement of key stakeholders from 11th March 2021 to 23rd April 2021. Stakeholders were categorized into two groups namely resource user and non-resource user. The non-resource user group is composed of individuals from government, academic/research, NGO/CSO and traditional institutions (Appendix 3). In all, 34 resource users and 10 non-resource users were interviewed using a semi-structured interview guide. For the resource users, three to six key stakeholders were interviewed for a given water body/site. The survey instrument is available in the regional summary report (Chuku et al, 2021).

Both stratified purposive and purposive sampling techniques were used in selecting the key stakeholders in the shellfisheries business. For an organized fishery like the Densu Delta shellfishery, the stratified purposive sampling technique was used and vice versa. For example, in the Densu Delta shellfishery three main communities have been reported by Osei et al. (2020) to exploit the resource (i.e. Bortianor, Tsokomey and Tetegu) so in sampling, individuals were drawn from each of these communities. The background data of respondents were analyzed by descriptive statistics to summarize features of the data in frequencies and percentages using Statistical Package for Social Sciences (SPSS).

2.3. Estimation of catch and revenue

Catch (kg) per person/crew per day: For example, shellfishers were asked the number of basins of oyster, *C. tulipa* they exploit in a day. A basin full of oysters weighs approximately 29 kg (see Appendix 2), so the day's catch could be estimated given the number of basins for the day for an individual or

a crew (as in the case of the Volta clam fishery). A bucket full of clam, *G. paradoxa* weighs approximately 16 kg (Appendix 2).

Catch (kg) per person/crew per month: This was estimated by taking into consideration the number of fishing expeditions a shellfisher makes in a week multiplied by 4 weeks.

Catch (kg) per person/crew per harvest season: This was estimated by multiplying the catch/month by the number of months in the fishing season of a given shellfishery.

Price ($) per person/crew per kg: This was determined by asking fishers the price at which they would sell a basin/bucket full of shell-on or unprocessed shellfish.

Revenue ($) per person/crew per month: This was estimated by multiplying the price/kg by the catch (kg) and then extrapolated for the month (by accounting for the number of fishing trips in a week multiplied by 4 weeks).

2.4. Summarized background data

2.4.1. Background data of resource users

Thirty-four (34) resource user respondents were interviewed. The large majority (91%) of resource user respondents were above 29 years, while about 71% were 50 or under. This is important to note because women 15-49 years are considered as women of reproductive age, an important target age group for health and nutrition initiatives. About 29% were 51 years and above. Resource user respondents were mainly females (88.2%). The data on resource users surveyed is presented in Section 3 below.

2.4.2. Background data of non-resource users

Ten non-resource user respondents were interviewed during the study. The youngest non-resource user respondent was 29 years, with about 50% in the 29-39 age range as seen in Table 1. The non-resource user respondents were mainly males (60.0%) (Table 2). The decreasing order of numerical importance of non-resource users is given as Academia/Research, NGO/CSO, Government and Traditional Authority (Table 3).

Table 1: Age of respondents of non-resource users.

		Frequency	Percent (%)
Valid	29-39	5	50.0
	40-50	3	30.0
	51 and above	2	20.0
	Total	10	100.0

Table 2: Sex of respondents of non-resource users.

		Frequency	Percent (%)
Valid	Male	6	60.0
	Female	4	40.0
	Total	10	100.0

Table 3: Stakeholder category of respondents of non-resource users.

		Frequency	Percent (%)
Valid	Government	2	20.0
	NGO/CSO	3	30.0
	Academia/Research	4	40.0
	Traditional Authority	1	10.0
	Total	10	100.0

Non-resource user respondents mainly (80.0%) had expertise in both mangroves and shellfisheries (see Appendix 3). Individuals in respondent's households numbered up to 10, with 10 persons per household having the highest percentage (43.48%) (Appendix 3). Households with 4 males accounted for the highest percentage (33.33%) of male non-resource users, while households with 6 females accounted for the highest percentage (54.54%) of female non-resource users (Appendix 3). The percentage of males and females in all the households (238) was 39.92% and 60.08%, respectively.

3. Status of Shellfisheries

3.1. Shellfish exploitation

The main coastal water bodies with or without mangrove systems that support commercial shellfisheries from the west to east coast of Ghana are Amanzule Estuary, Whin Estuary, Amissano Estuary, Narkwa Lagoon, Densu Delta, Volta Estuary (Tunu), Volta Estuary (Big Ada) and Keta Lagoon.

The shellfisheries comprise the exploitation of bivalves, gastropods, and crustaceans including crabs in the coastal lagoons and estuaries (Table 4).

Table 4: Shellfish species of commercial value across the selected water bodies/sites in Ghana.

Shellfish	Family	Species name	Common name
Bivalves	Ostreidae	*Crassostrea tulipa* (Lamarck, 1819)	West African mangrove oyster
	Arcidae	*Senilia senilis* (Linnaeus, 1758)	West African bloody cockle
	Donacidae	*Galatea paradoxa* (Born, 1778)	Volta clam; Freshwater clam
Gastropods	Pisaniidae	*Pugilina morio* (Kiener, 1834)	Whelk
	Potamididae	*Tympanotonus fuscatus* (Linnaeus, 1758)	West African mud creeper/periwinkle
	Littorinidae	*Littorina littorea*	Common periwinkle/winkle
Crabs	Gercarcinidae	*Cardisoma armatum* (Herklots, 1851)	African rainbow crab
	Ocypodidea	*Uca tangeri* (Eydoux, 1835)	West African Fiddler crab
	Portunidae	*Callinectes amnicola* (deRochebrune,1883)	Bigfisted swimcrab
Crustaceans	Penaeidae	*Penaeus monodon* (Fabricius, 1798)	Giant tiger prawn
	Penaeidae	*Parapenaeopsis atlantica* (Balss, 1914)	Guinea shrimp

3.1.1. Estimated number of shellfishers

Information on the number of shellfish harvesters in Ghana is largely not available. In this participatory assessment, the resource users indicated the number of shellfishers in their communities and/or harvesting areas. Conservative estimates are made with the assumption that each respondent represents exclusively one harvesting area/community to moderately compensate for the shellfish harvesting sites not visited, while averaging obvious duplications for communities with large numbers. The estimates provided in this report represent a combination of information gleaned from available literature sources deemed reasonable from the perspective of ground experience in the women-led shellfisheries sector as well as estimates from the participatory assessment conducted.

An estimated 4,333 persons, the majority of which are females, are engaged in shellfisheries livelihoods in Ghana.

An estimated 31,731 persons are direct household shellfisheries beneficiaries based on the findings of this study. Individuals in resource user respondents' households numbered up to 28, with

households of 6 members having the highest occurrence and accounting for 17.65% of respondents' household members (Table 5). The average number of members per household was 7.

Households with 2 males had the highest frequency and accounted for 29.47% of male members in the households of resource users in this survey, while households with 5 females had the highest frequency and accounted for 20.98% of resource users' female household members (see Table 6 and 7). The percentage of males and females among all households' members (total = 238) of resource users surveyed was 39.92% and 60.08%, respectively, indicating a dominance of females in households where shellfisheries provide livelihoods within coastal communities in Ghana.

Table 5: Number of individuals per household of resource users.

Number of individuals in household (x)		Frequency (f)	f(x)	Percent (%)
Valid	1	2	2	0.84
	2	1	2	0.84
	3	1	3	1.26
	4	5	20	8.40
	5	3	15	6.30
	6	7	42	17.65
	7	3	21	8.82
	8	5	40	16.81
	9	3	27	11.34
	10	1	10	4.20
	13	1	13	5.60
	15	1	15	6.30
	28	1	28	11.76
	Total	34	238	100.00

Table 6: Number of males per household of resource users.

	Number (x)	Frequency (f)	f(x)	Percent (%)
Valid	0	1	0	0.00
	1	5	5	5.26
	2	14	28	29.47
	3	6	18	18.95
	4	5	20	21.05
	6	1	6	6.32
	8	1	8	8.42
	10	1	10	10.53
	Total	34	95	100.0

Table 7: Number of females per household of resource users.

	Number (x)	Frequency (f)	f(x)	Percent (%)
Valid	0	3	0	0.00
	1	3	3	2.10
	2	5	10	6.99
	3	4	12	8.39
	4	5	20	13.99
	5	6	30	20.98
	6	4	24	16.78
	7	1	7	4.90
	8	1	8	5.59
	9	1	9	6.29
	20	1	20	13.99
	Total	34	143	100.0

The large majority (91%) of resource user respondents were above 29 years, while about 71% were 50 or under. This is important to note because women 15-49 years are considered as women of reproductive age, an important target age group for health and nutrition initiatives. About 29% were 51 years and above as seen in Table 8.

Table 8: Age of respondents of resource users.

		Frequency	Percent (%)
Valid	18-28	3	8.8
	29-39	10	29.4
	40-50	11	32.4
	51 and above	10	29.4
	Total	34	100.0

3.1.2. Insights on gender in shellfish exploitation

Eighty-eight percent (88%) of resource user respondents to this survey were women (Figure 8).

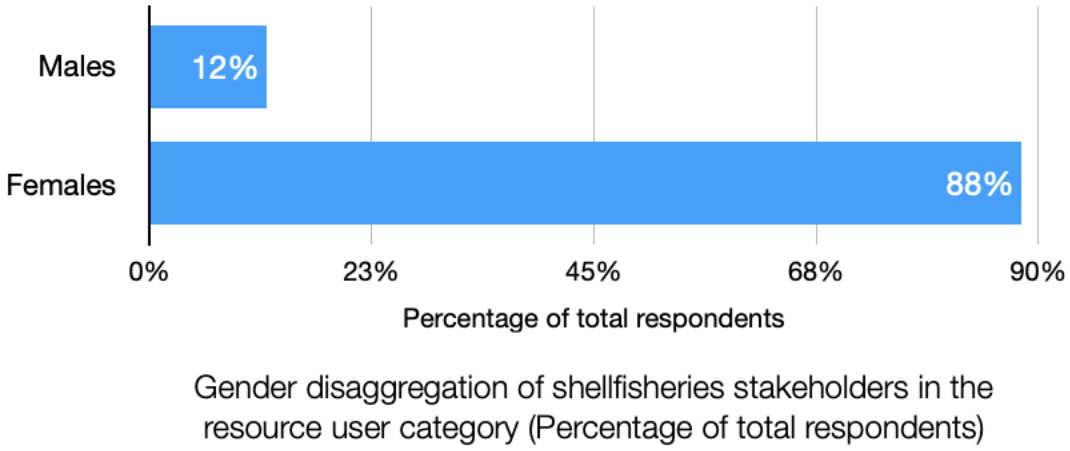

Figure 8: Gender distribution of shellfisheries resource users.

Women are extensively involved in the harvesting, processing, and trading of bivalves, gastropods, and crabs, while the men exploit shrimps. Except for the clam fishery where men mainly harvest the resource, women essentially carry out shellfish exploitation in Ghana. However, men are involved in the transportation of the shellfish harvesters using small non-motorized dugout canoes, which typically take up to four fishers, as well as the transportation of the Volta clam harvest to distant markets. Moreover, men are largely engaged in the practice of capture-based aquaculture of the Volta clam (*Galatea paradoxa*) in-situ to meet size demands for particular markets. In this form of open water aquaculture, the culturists collect and transplant wild clams to localized areas in the estuary and allow them to fatten before harvesting for sale.

3.1.3. Shellfishing as primary occupation

The exploitation of shellfishes has been the main occupation of women fishers. During the lean shellfish harvesting season some of the women switch to other forms of livelihoods like farming, petty-trading, food vending, sewing etc. The men in the coastal communities are largely involved in exploitation of finfish.

3.1.4. The shellfish value chain

Processing of shellfish is almost entirely carried out by women. Shellfish for consumption are thoroughly washed to get rid of soil particles and debris attached to the shells as in the case of bivalves and gastropods. Bivalves, gastropods, and crabs are boiled, meat shucked or dressed and used for stews, soups, or kebab (strung meat on sticks). Others process the meat (e.g., shrimp, bivalves) by frying. Bivalves for sale are processed by steaming, shucking, and packaging, as well as sold shell-on upon request. The gastropods, crabs and shrimp are washed and sold without further processing.

Shellfish are normally traded in the coastal communities. However, clams are transported throughout the country by middlemen and some fishers have contacts with hotels and restaurants. A few shellfishers engage in subsistence fishing only, while a larger number primarily, in addition to the subsistence, sell in the local community and in distant markets.

Aside from the use of shellfish as meat for consumption, fishers at the Volta Estuary (Tunu) use it as bait for trapping craps (*C. armatum*). The shells of coastal shellfish in Ghana are useful in the construction field: as fill for building foundations and muddy footpaths, making terrazzo, and mixing concrete; in paint production; in agriculture as a source of calcium for poultry feed and liming; and medicinally in powdery form for treating burns.

Although the resource users did not perceive any challenges with the consumption of shellfish, some of the non-resource users (government, academics, and NGOs) indicated that the increased pollution in the coastal waters of Ghana could serve as a potential source of heavy metals and other pollutants (e.g., fecal matter). These pollutants are likely to bioaccumulate in the filter-feeding shellfish (e.g., clams, oysters, and cockles) or render the meat unwholesome for consumption. However, it appeared the consumption of shellfish did not pose any health issues to consumers. As shown in Tables 9 and 10, all resource user respondents to this survey indicated that shellfish were consumed in their households and mainly on a daily (47.1%) and weekly (38.2%) basis.

Table 9: Consumption of shellfish by household of resource users.

		Frequency	Percent (%)
Valid	Yes	34	100.0

Table 10: Frequency of shellfish consumption by household of resource users.

		Frequency	Percent (%)
Valid	Daily	16	47.1
	Weekly	13	38.2
	Monthly	1	2.9
	Frequently	3	8.8
	when available	1	2.9
	Total	34	100.0

All the non-resource user respondents consumed shellfish in their household and mostly monthly (40%) and occasionally (20%) (Appendix 3).

About 76.5% or more of the respondents in this study (of which 88% were women) engaged in harvesting, processing, trading, and consumption (Fig. 9). This indicates a highly vertically integrated value chain with women harvesters dominant at every node and implies that value chain improvements at any node can directly benefit women harvesters and creates an opportunity to incentivize behavior change for sustainable resource management.

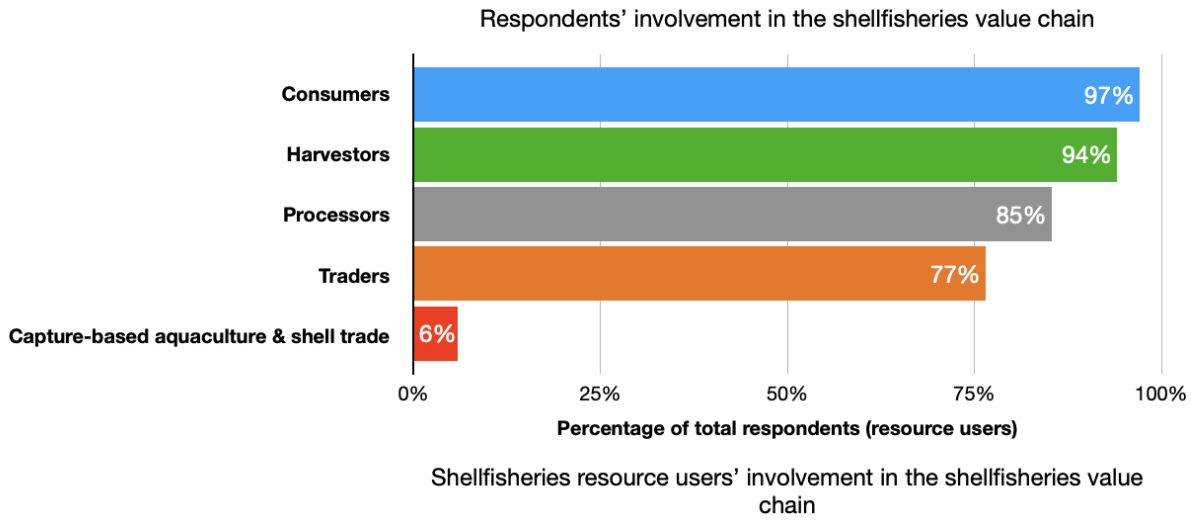

Figure 9: Value chain involvement of shellfisheries resource users.

About six percent of respondents did not engage in harvesting, processing, and trading of shellfish but rather practice capture-based aquaculture of clams and trading of its shells (Fig. 9).

3.1.5. Species harvested

The first three most commercially important shellfish species exploited in the various study sites with their local names are presented in Table 11. Though the order of importance by harvest varies among the sites, the most important species across the sites were *C. tulipa*, *T. fuscatus* and *P. morio.* Among the observed crab species, *C. armatum* is the most harvested while *G. paradoxa* is endemic to the Volta Estuary. All the shellfish species presented in Table 10 above are found in sand-mud substratum except for *Littorina littorea,* which prefers rocky substratum. *C. tulipa* also settles on red mangrove roots or any hard substratum like rocks (Table 11).

Table 11: *First three most commercially important shellfisheries exploited in each selected water body/site in Ghana.*

Water body/Site	Species name	Local name	Habitats
Amanzule Estuary	*Tympanotonus fuscatus*	Kosolonkpo (Nzema)	Sandy-mud substratum
	Pugilina morio	Tule (Nzema)	Sandy-mud substratum
	Crassostrea tulipa	Doble (Nzema)	Mangrove roots; Sandy-mud substratum Mangrove roots
Whin Estuary	*Crassostrea tulipa*	Alenti (Fante)	Sandy-mud substratum
	Pugilina morio	Nkokro (Fante)	Sandy-mud substratum
	Tympanotonus fuscatus	Aporfii (Fante)	Sandy-mud substratum
Amissano Estuary	*Tympanotonus fuscatus*	Aporfii (Fante)	Sandy-mud substratum Mangrove roots
	Crassostrea tulipa	Alenti (Fante)	Sandy-mud substratum
	Senilia senilis	Echi (Fante)	Sandy-mud substratum Mangrove roots
Narkwa Lagoon	*Crassostrea tulipa*	Alenti (Fante)	Sandy-mud substratum
	Senilia senilis	Echi (Fante)	Sandy-mud substratum
	Tympanotonus fuscatus	Aporfii (Fante)	Sandy-mud substratum
Densu Delta	*Crassostrea tulipa*	Kaklada (Ga)	Sandy-mud substratum
	Cardisoma armatum	Somo (Ga)	Sandy-mud substratum
	Tympanotonus fuscatus	Aporfii (Ga)	Sandy-mud substratum
Volta Estuary (Tunu)	*Crassostrea tulipa*	Adza (Ewe)	Mangrove roots Sandy-mud substratum
	Cardisoma armatum	Galalegi (Ewe)	Sandy-mud substratum
	Tympanotonus fuscatus	Tonkpledi/Aporfii (Ewe)	Sandy-mud substratum
Volta Estuary (Big Ada)	*Galatea paradoxa*	Afani (Ga-Adangbe)	Sandy-mud substratum
Keta lagoon	*Pugilina morio*	Borbor (Ewe)	Sandy-mud substratum
	Senilia senilis	Mikpa (Ewe)	Sandy-mud substratum
	Cardisoma armatum	Galalegi (Ewe)	Sandy-mud substratum

3.1.6. Harvesting methods

Unlike the clam fishery that essentially combines diving with handpicking in its exploitation (Adjei-Boateng, 2012; Abarike et al., 2015) mainly by men as found in this assessment, oyster, cockle, whelk, periwinkle, winkle, and crab are harvested by handpicking in shallow coastal water bodies by women who wear improvised foot protection gear (see Appendix 5) to avoid injury. This foot gear is usually made of old clothing such as trouser trunks severed, worn on feet, and tied firmly (Jahna et al., 2017; Chuku, 2019; Osei et al., 2020).

Adjei-Boateng et al. (2012) reported that men in the Volta clam fishery use motorized air compressors and hoses to supply air, as well as hauling nets, to aid in diving for and collecting clams. Men also deploy traps with bait in the exploitation of crabs (e.g., *C. armatum*) and use seine nets to fish for shrimps.

3.1.7. Harvest volumes and value

Across the study sites, a day, month, and season yield (shell-on) of *T. fuscatus*, *P. morio*, *S. senilis* and *C. armatum* per individual fisher as seen in Figure 10 to Figure 12 are less than 7 kg, 90 kg, and 450 kg, respectively, while *G. paradoxa* generates the highest yield of 320 kg, 5,120 kg and 40,960 kg, respectively. The *C. tulipa* fishery at Narkwa lagoon produces the second highest yield of 116 kg/person/day, 1,939 kg/person/month and 10,859 kg/person/season. An earlier study estimated the total annual oyster harvest in the Densu Delta to be 238,000 kg to 352,000 kg (Osei et al., 2020) as compared to the present study's findings of yield, up to 174.3 kg/person/day, 1,806 kg/person/month and 10,859 kg/person/season in Densu Delta (Fig. 10 – Fig. 12). The high yield in the *G. paradoxa* and *C. tulipa* fisheries could be ascribed to the high productivity of the species.

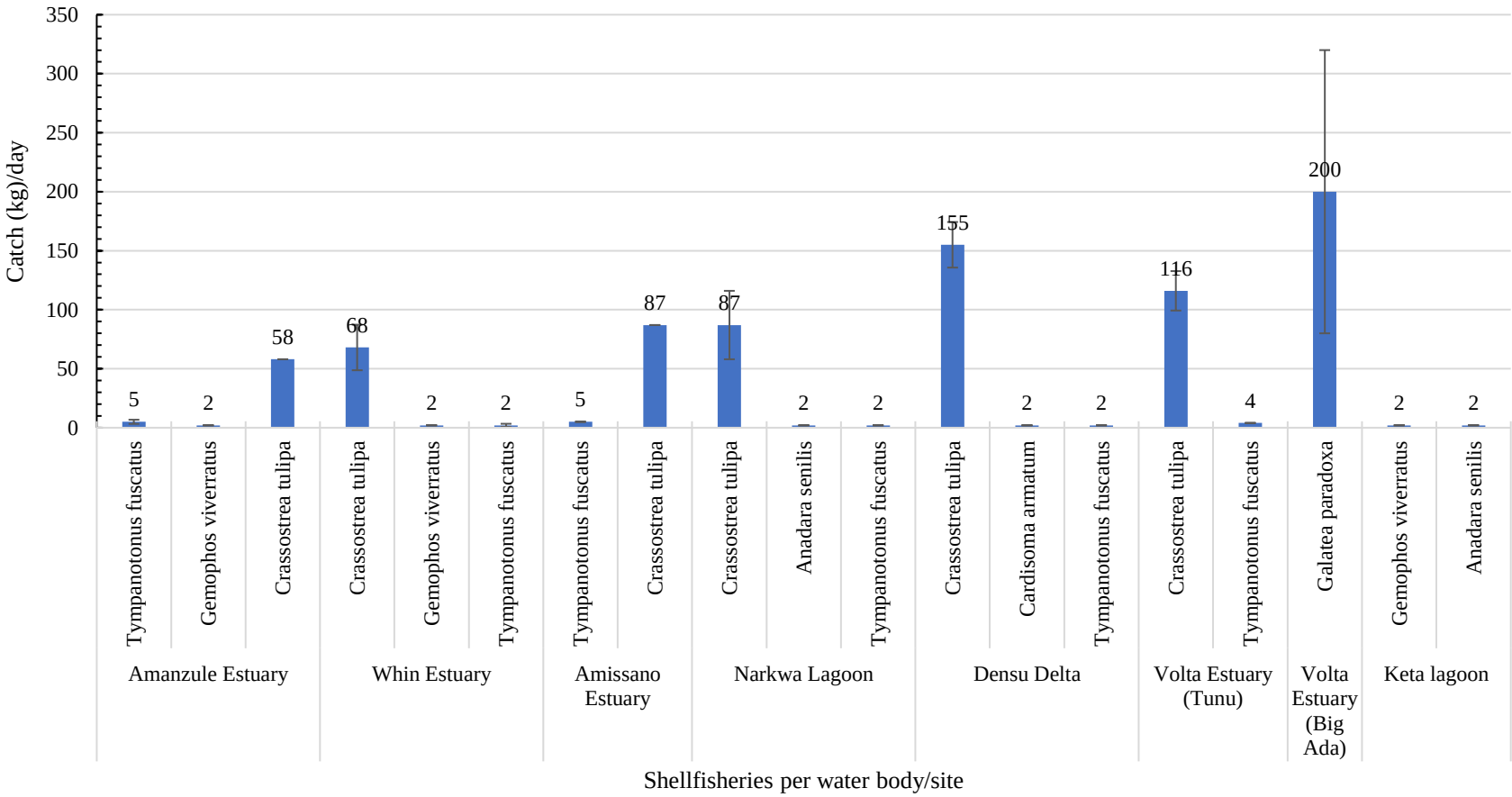

Figure 10: Distribution of catch (kg) per person or crew per day of key shellfisheries exploited in selected water bodies/sites in Ghana.

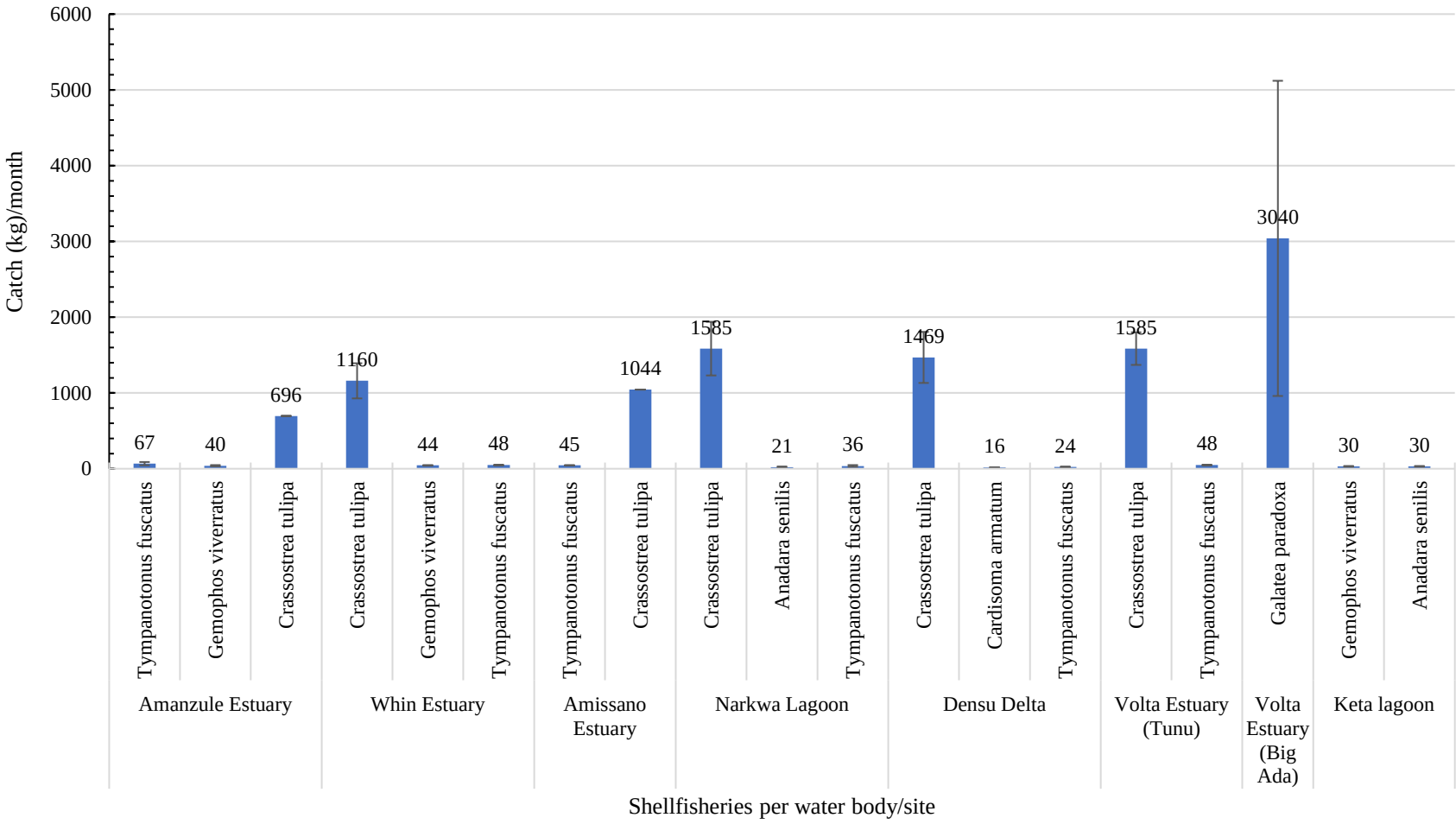

Figure 11: Distribution of catch (kg) per person or crew per month of key shellfisheries exploited in selected water bodies/sites in Ghana.

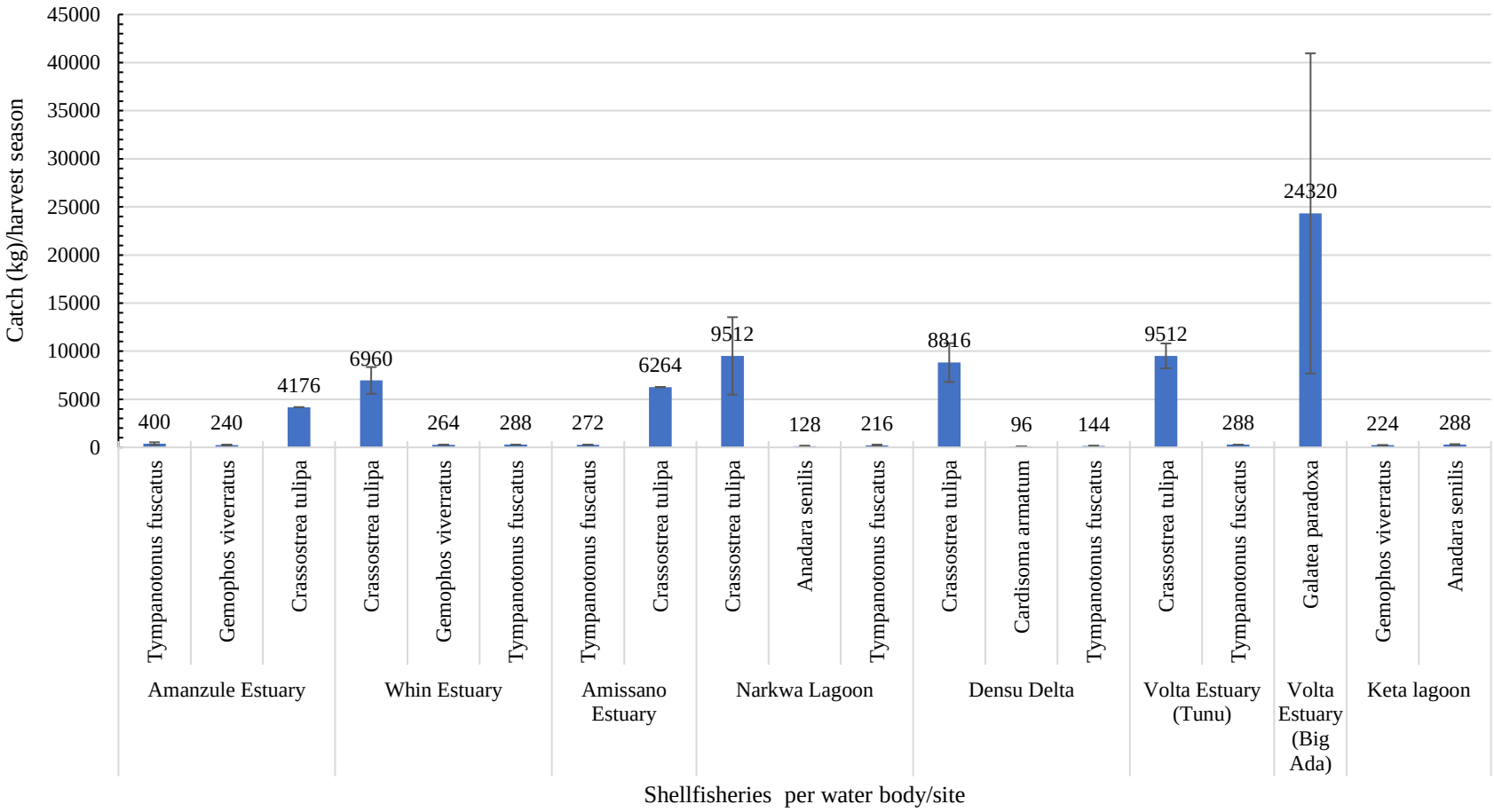

Figure 12: Distribution of catch (kg) per person or crew per harvest season of key shellfisheries exploited in selected water bodies/sites in Ghana.

The price per kilogram of shellfish varies within and among coastal communities. As seen in Figure 13, the highest priced women's shellfisheries per kilogram are *P. morio* (USD $8.40/kg) and *T. fuscatus* (USD $3.50/kg) both from Whin Estuary. In the Whin Estuary, *P. morio* is exploited at the estuarine portion of the water body, which the women described as a dangerous zone, hence its comparatively high price. The price could be influenced by the accessibility and seasonality (availability) of the shellfish. The Volta clam fishery generates the highest revenue of USD $1,106.90/month for a crew of clam harvesters. The oyster (*C. tulipa*) is the lowest priced across the sites with the lowest price in the Amanzule Estuary, where the species is less exploited because of its perceived difficulty in processing by the locals. Despite the low-priced oysters, the Whin Estuary oyster fishery had the second highest revenue (up to USD $626.30/month/harvester) followed by the Volta Estuary (Tunu) oyster fishery (USD $539.90/month/harvester) as presented in Figure 14.

Osei et al. (2020) reported a total annual cost of fishing, gross annual revenue, and total annual profit of the Densu Delta oyster fishery at USD $11,897, USD $39,993, and USD $28,097, respectively.

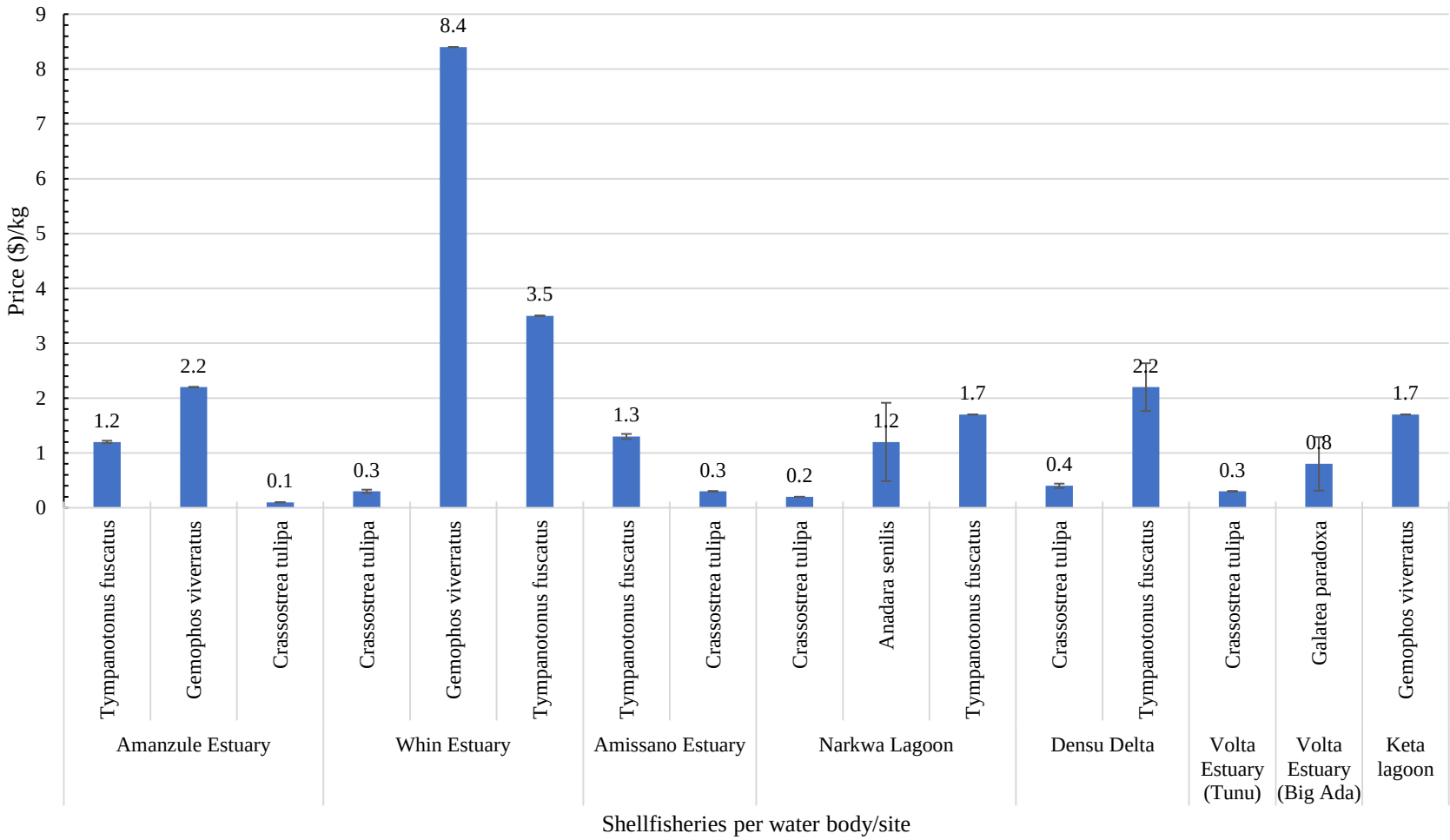

Figure 13: Distribution of price ($) per kilogram of key shellfisheries exploited in selected water bodies/sites in Ghana.

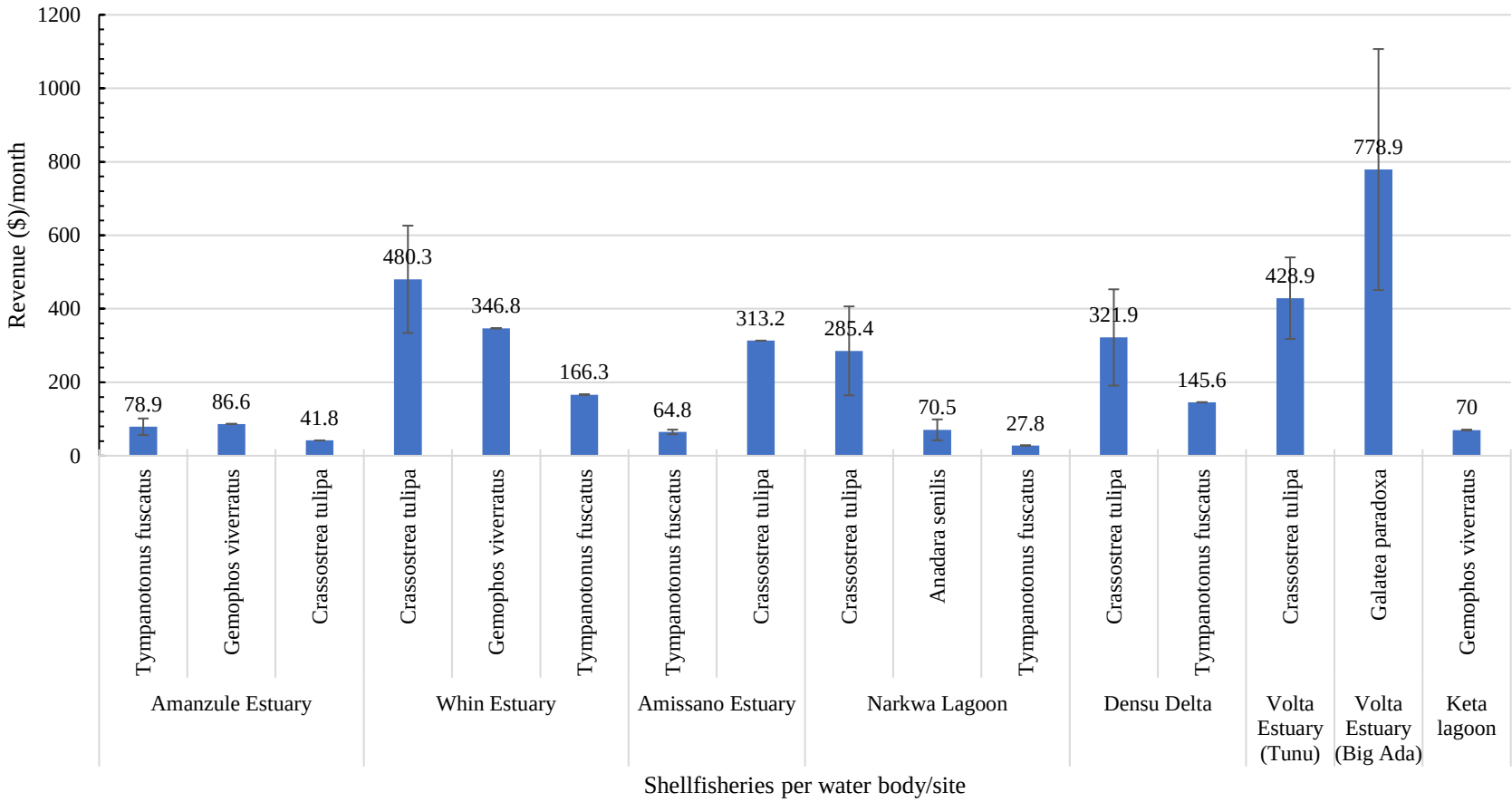

Figure 14: Distribution of revenue ($) per person or crew per month of key shellfisheries exploited in selected water bodies/sites in Ghana.

3.1.8. Seasonality of harvests

The seasonality of shellfisheries along the coastal water bodies/sites of Ghana is mainly influenced by rainfall, aside from the prevailing water conditions and availability of marketable sizes which is influenced by heavy exploitation. Most shellfisheries are active during the dry season from November to March/April (e.g., *P. morio* and *S. senilis*) depending on the month the rains start, while *T. fuscatus* is harvested year-round from most of the sites (Table 12). *C. tulipa* is harvested year-round in Whin Estuary, during the rainy periods in Densu Delta and Volta Estuary (Tunu), and in the dry season in the Amanzule Estuary, Amissano Estuary, and Narkwa Lagoon (Table 12).

For the Densu Delta oyster fishery, the couple of months long inundation of the wetland caused by the opening of the Weija Dam (to safeguard the integrity of the dam) during the rainy season results in high oyster mortality, even to the extent of losing about 90% of oyster biomass. The surviving oysters replenish the population during the ensuing dry season (i.e., the next six months, Osei et al. 2020), hence the harvesting in the rainy season. The Densu Delta oyster closed season is instituted to coincide with the dry season (recovery time of the fishery) to enable oysters to reach marketable sizes before the harvest begins. Unlike the Densu Delta oyster fishery, the Volta Estuary (Tunu) is not associated with dam spillage. However, shellfishers indicated that bigger oysters are sourced during the rainy season, hence their choice of harvesting oysters during that period. The oyster harvesting season ends with the unavailability of marketable sizes. It could be deduced that the seasonality of the resource is rainfall and exploitation driven.

In the clam (*G. paradoxa*) fishery, the resource is primarily exploited from December to March. However, clams are also made available on the market from culture farms managed by harvesters in the Volta Estuary (Big Ada) during the closed season. The bivalve and gastropod shellfisheries are harvested in relatively high quantities by the women as compared to the crabs (e.g., *C. armatum*), which are usually exploited year-round in the Densu Delta.

Table 12: Exploitation calendar for the most commercially important shellfisheries in the selected sites in Ghana.

Water body/Site	Species name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Amanzule Estuary	*Tympanotonus fuscatus*	■	■	■	▒							■	■
	Pugilina morio	■	■	■	▒							■	■
	Crassostrea tulipa	■	■	■	▒							■	■
Whin Estuary	*Crassostrea tulipa*	■	■	■	■	■	■	■	■	■	■	■	■
	Pugilina morio	■	■	■	▒							■	■
	Tympanotonus fuscatus	■	■	■	▒							■	■
Amissano Estuary	*Tympanotonus fuscatus*	■	■	■	■	■	■	■	■	■	■	■	■
	Crassostrea tulipa	■	■	■	▒							■	■
	Senilia senilis	■	■	■	▒							■	■
Narkwa Lagoon	*Crassostrea tulipa*	■	■	■	■	■	▒					▒	■
	Senilia senilis	■	■	■	▒							■	■
	Tympanotonus fuscatus	■	■	■	■	■	■	■	■	■	■	■	■
Densu Delta	*Crassostrea tulipa*					■	■	■	■	■	■		
	Cardisoma armatum	■	■	■	■	■	■	■	■	■	■	■	■
	Tympanotonus fuscatus	■	■	■	■	■	■	■	■	■	■	■	■
Volta Estuary (Tunu)	*Crassostrea tulipa*				■	■	■	■	■	■	■		
	Tympanotonus fuscatus	■	■	■	■	■	■	■	■	■	■	■	■
Volta Estuary (Big Ada)	*Galatea paradoxa*	■	■	■	▒	▒	▒	▒	▒	▒	▒	▒	■
Keta lagoon	*Pugilina morio*	■	■	■	▒							■	■
	Senilia senilis	■	■	■	▒							■	■

*Deeper shade = intensive harvest; light shade = partial harvest; white background = no harvest

3.2. Mangrove Ecosystem

Apart from the Volta River Estuary at Big Ada, which is void of mangroves seemingly because of the low salinity (nearing a freshwater condition) at the riverine portion, the other study sites had mangrove vegetation. The coverage of mangroves at the Amanzule Estuary, Whin Estuary, Amissano Estuary and Narkwa Lagoon is high to moderate, while that of Densu Delta and Keta lagoon is low. Recently, in the Densu Delta, DOPA members planted mangrove seedlings with support from Development Action Association (DAA) and funding from USAID under the Sustainable Fisheries Management Project (SFMP) to restore the depleted mangroves. Some level of mangrove exploitation occurs in all the study sites, however, shellfish harvesters at Amanzule and Densu Delta have been educated on the ecological importance of mangroves to fisheries in general.

Along the value chain of shellfisheries, mangroves support shellfisheries in production and processing by serving as a habitat and feeding ground for coastal shellfish to enhance growth and propagation. Also, mangroves are used as firewood in the processing of shellfish, which must be discouraged due to the numerous ecological functions of mangroves in the coastal ecosystem. Mangroves are also used in the construction of brush parks (Acadja) and building of sheds in the coastal communities. The exploitation of mangroves is primarily done by the men who earn direct income from trading in mangroves, particularly at Anyanui/Tunu near the Volta Estuary.

3.3. Governance/Management Regimes

The Densu Delta and Keta lagoon are the only wetlands/water bodies among the sites that are designated as Ramsar sites (i.e., wetlands of international importance under the Ramsar convention). However, these water bodies are not well managed. All the study sites support open access fisheries and most are unregulated (Appendix 1.6). The Densu Delta oyster fishery is regulated by a community-based fisheries management plan instituted by the Government of Ghana (MoFAD, 2020) with the support of DAA and USAID-SFMP. This plan was gazetted and signed in 2020 following approval by MoFAD of the National Co-Management Policy for the Fisheries Sector. The Densu plan delegates exclusive use rights to the oyster fishery resources in the Densu Delta to the Densu Oyster Picker's Association (DOPA) and it stipulates an annual 5 month closed season, among other management measures. This closed season was implemented for three consecutive years even before the plan was officially approved based on community consensus and voluntary compliance.

The Volta clam fishery is controlled by traditional management. The Volta clam fishery groups like the Kpomkpo Clam Women Association and Agorkpo Clam Fishers and Processors Association assist with enforcement of regulations. The Amanzule fishery appears to be managed by a community conservation committee, which is supported by a local NGO (Hen Mpoano). The shellfish harvesters in Amanzule Estuary, Densu Delta, and Volta Estuary (Tunu) harvest shellfish throughout the days in a week, while fishers in Volta Estuary (Big Ada), Whin Estuary, Amissano Estuary, and Narkwa Lagoon have a day off on Tuesdays, Wednesdays, Thursdays, and Saturdays, respectively (Appendix 8.5).

Interventions needed to improve shellfisheries livelihoods of women in Ghana as indicated by shellfishers are as follows: provision of soft loans, improved markets, harvesting equipment and

protective gears, regulation of the shellfisheries, diversification of livelihoods to support shellfishers during lean/off fishing season, cultivation of shellfish, and restoration and maintenance of mangrove vegetation.

3.4. Climate Risk Mitigation

The major climatic factor that influences seasonality of shellfisheries across the study sites is rainfall. The shellfishes in the coastal water bodies are largely marine, tolerating different salinity regimes with freshwater input. Of the shellfisheries encountered in the study, *C. tulipa* appears to have adapted best to the wide salinity range, which could explain its high yield. The livelihoods of resource users, as many as 500 in the Densu Delta (see Appendix 1.6), are lost during the unfavorable period of high flooding in the coastal areas for most of the shellfisheries (e.g. *C. tulipa*, *G. paradoxa*, and *S. senilis* fisheries, etc.) which then affects food (shellfish) security.

Shellfish (especially bivalves and gastropods) and mangrove systems are known to serve as carbon sinks thereby contributing to reduction in atmospheric carbon, which in turn affects the climate (Alongi, 2012; Filgueira et al., 2019; Nayak et al., 2014). Therefore, reduction in oyster biomass and mangroves may affect the climate.

4. Conclusion and Recommendations

4.1. Conclusion

The list of key resource user and non-resource user stakeholders of the Ghanaian shellfisheries and shellfisheries-based livelihoods is attached (see Appendix 7).

The Amanzule Estuary, Whin Estuary, Amissano Estuary, Narkwa Lagoon, Densu Delta, Volta Estuary (Tunu), Volta Estuary (Big Ada), and Keta Lagoon are coastal water bodies that support thriving shellfisheries in Ghana. Women are extensively involved in the harvesting, processing, and trading of shellfish, except for the clam (*G. paradoxa*) and shrimp fisheries where men dominate the harvesting. Shellfish are exploited by handpicking and diving, where necessary.

Exploitation of shellfish occurs mainly during the dry season from November to March/April and some *C. tulipa* fisheries are harvested during the rainy period, while *T. fuscatus* and *C. armatum* are mainly harvested year-round. The shellfish are processed by boiling after thorough washing to get rid of soil particles and debris and are traded shell-on (unprocessed) or shucked and processed. Shellfish are traded primarily in local communities and sometimes in distant markets or to customers in hotels and restaurants, especially in the clam fishery.

The most productive shellfisheries are *G. paradoxa* of the Volta Estuary (Big Ada) and *C. tulipa* of Narkwa Lagoon, producing a daily, monthly, and seasonal yield of 320 kg, 5,120 kg and 40,960 kg as well as 116 kg, 1,939 kg and 10,859 kg, respectively per harvester/crew. The highest priced women's shellfisheries per kilogram are *P. morio* (USD $8.40/kg), *T. fuscatus* (USD $3.50/kg), and *S. senilis* (USD $1.20/kg). The Volta clam fishery, Whin Estuary oyster fishery, and Volta Estuary (Tunu) produce the highest revenues USD $1,106.90/month, USD $626.30/month and USD $539.90/month, respectively.

Considering the insufficient supply of shellfish as opposed to the current apparent demand, a program to pilot and develop the farming of the various commercially important shellfish species identified in this assessment should be pursued. Such a program could enhance production and value and forge a wider market and industry to maximize the livelihood and food security potential of shellfisheries in Ghana. This effort should take a research and development approach with strong collaboration between academic, research, and government institutions in close partnership with the resource users. Preliminary research promoting oyster aquaculture has been piloted in various ecosystems by researchers at the University of Cape Coast.

There are some concerns about the health implications of shellfish on consumers as most shellfish are filter-feeders with the potential to bioaccumulate heavy metals and other pollutants. Although, there are no indications of complications emanating from shellfish consumption.

Mangroves are found in all the study sites except in the Volta River Estuary (Big Ada). Mangrove vegetation at Amanzule Estuary, Whin Estuary, Amissano Estuary, and Narkwa Lagoon are said to be high to moderate while that of the Densu Delta and Keta Lagoon are low. Mangroves are mainly exploited by men and used as firewood.

All the coastal water bodies in the study operate an open access fishery. Unlike the other water bodies/sites, the Densu Delta oyster fishery, the Volta clam fishery, and the Amanzule Estuary are managed by co-management plans, traditional management, and community conservation committee respectively. Rainfall is the main climatic factor that causes seasonality of shellfisheries along the coast of Ghana and thereby causing loss of livelihoods during the rainy months.

4.2. Recommendations

a. All commercial shellfisheries along the coast of Ghana should urgently be regulated to ensure their rational management, development, and sustainability.
b. A comprehensive program of action research should be developed to harness the aquaculture potential of Ghana's shellfisheries, as well as to expand the market and improve the value of shellfish through business models for the various species.
c. Education of shellfish harvesters on the ecological services provided by shellfish and mangrove systems should be prioritized to promote rational utilization of the resources.
d. The use of mangroves as firewood must be discouraged and degraded mangrove vegetation should be restored by replanting to maintain the ecological integrity of mangroves.
e. The general sanitation of coastal aquatic systems and their catchment areas should urgently be improved to produce high quality shellfish, which in turn would stimulate good health and make wild shellfish consumption more appealing.
f. Shellfish harvesters should be educated and trained in entrepreneurial skills to promote the construction of lucrative varied income sources to better the standard of living of resource users, particularly during the lean or off-season for shellfish harvesting.
g. Shellfish resource users should be equipped with skills in value addition to generate higher income, extend the shelf life of the product, and possibly penetrate high-value markets.

h. Shellfishers should be assisted with soft loans and protective gear (i.e., diving apparatus, shucking gloves, waders etc.) to enhance their businesses.

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Appendices

Appendix 1: Field interviews with key stakeholders

Figure 15: (a) a resource-user from Tunu (b) a resource-user from Amanzule (c) an official of non-governmental organization (d) a government personnel (e) a traditional authority from Bortianor.

Appendix 2: Vessels used for shellfish harvesting

Figure 16: (a) basin (Osei, 2020) and (b) bucket (Adjei-Boateng, 2012).

Appendix 3: Background data

Table 13: Stakeholder's field of work of non-resource users.

		Frequency	Percent (%)
Valid	Shellfish	2	20.0
	Both Mangroves and Shellfish	8	80.0
	Total	10	100.0

Table 14: Number of individuals per household of non-resource users.

Number (x)		Frequency (f)	f(x)	Percent (%)
Valid	1	1	1	4.35
	2	2	4	17.39
	3	1	3	13.04
	5	1	5	21.74
	10	1	10	43.48
	Total	6	23	100.0

Table 15: Number of males per household of non-resource users.

Number (x)		Frequency(f)	f(x)	Percent (%)
Valid	1	3	3	25.00
	2	1	2	16.7
	3	1	3	25.00
	4	1	4	33.33
	Total	6	12	100.0

Table 16: Number of females per household of non-resource users.

	Number (x)	Frequency (f)	f(x)	Percent (%)
Valid	0	1	0	0.00
	1	3	3	27.27
	2	1	2	18.18
	6	1	6	54.54
	Total	6	11	100.0

Table 17: Consumption of shellfish by respondents' household of non-resource users.

		Frequency	Percent (%)
Valid	Yes	10	100.0

Table 18: Frequency of shellfish consumption of non-resource users.

		Frequency	Percent (%)
Valid	Daily	1	10.0
	Weekly	1	10.0
	Monthly	4	40.0
	once in a while	2	20.0
	when available	1	10.0
	intermittently	1	10.0
	Total	10	100.0

Appendix 4: Commercially important shellfishes exploited in selected sites

Figure 17: (a) Crassostrea tulipa (b) Tympanotonus fuscatus (c) Pugilina morio (d) Cardisoma armatum (e) Senilia senilis (f) Galatea paradoxa.

Appendix 5: Exploitation of shellfishes

Figure 18: (a) women handpicking oysters at Densu Delta (b) a woman returning from shellfishing with a basin at Keta Lagoon (c) a woman with improvised footwear, red circled.

Appendix 6: Exploitation and management of shellfisheries

Table 19: Exploitation and management of shellfisheries.

Water body/Site	Approximate number of fishers	Harvesting Off-day	Shellfishery & Mangroves	Management Regime
Amanzule Estuary	200	No day off	Open access; partially regulated	Community Conservation Committee
Whin Estuary	150	Wednesday	Open access; Unregulated	No management
Amissano Estuary	100	Thursday	Open access; Unregulated	No management
Narkwa Lagoon	60	Saturday	Open access; Unregulated	No management
Densu Delta	500	No day off	Open access; regulated	Ramsar site; Oyster Co-management
Volta Estuary (Tunu)	10	No day off	Open access; Unregulated	No management
Volta Estuary (Big Ada)	250	Tuesday	Open access; partially regulated	Traditional Management
Keta lagoon	40	No day off	Open access; Unregulated	Ramsar site

∑ number of fishers = 1,310

Appendix 7: List of key stakeholders

(Spreadsheet)