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MANGROVE ECOSYSTEM RESOURCES: DEPENDENCE OF COASTAL COMMUNITIES IN THE SCARCIES RIVER ESTUARY, SIERRA LEONE

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ABSTRACT

The study was conducted in the Great Scarcies Estuary, North-Western Coast of Sierra Leone and it involved 200 respondents. Methods included Focused Group Discussion, Key Informant Interviews and transect walk. The article aimed at promoting initiatives for mangrove restoration and management in the Scarcies River Estuary. The objective of the study is to bridge a research gap by documenting specific mangrove products most utilized by locals for subsistence or commercial purposes. Results showed that mudskipper (84.5%), finfish (73%), littoral crabs (80.5%), river crabs (79.5%), littoral snails (84.5%) and pane aid shrimps (76.5%) attained higher values for subsistence use; whereas mangrove oyster (78%), cockle (76.5%) and mangrove wood (65%) largely attracted commercial interest. The African Manatee (*Trichechus senegalensis*) is non-target species. Mean frequencies for subsistence and commercial dependence ranged from 9.3±3.9–33.5±2.5 and 5.8±3.1–30.8±3.9 respectively, and the difference is insignificant (P>0.05).Rice farming is the dominant economic activity in the region. Chi Square test **(**ANOVA, *df.* = 4; α = 5%) confirms dependence of locals on direct mangrove tree products (oyster and wood) for income. Further research on the ecological integrity and values can improve the will of locals and managers to restore and conserve mangroves in this area

Keywords: Ecological integrity, Ecosystem, Littoral, Capture fishery, Subsistence, Commercial

INTRODUCTION

Estuaries are marine water bodies close to land and the most characteristic vegetation present in the estuarine region is mangrove (Dudani *et al*., 2017).The mangroves are woody plant communities situated in the intertidal zone of tropical and subtropical latitudes between 30° North and South of the equator (Alongi, 2009; Spalding *et al*., 2010; Das *et al*., 2014; Kerry *et al*., 2017).The global mangrove area estimate of 1, 59041.5Km^{2}is less than 1% and 0.4% of all tropical forests and total global forests estate respectively (Van Lavieren *et al*., 2012). African and Asian countries constitute most of the global mangroves followed by South and Central America (Kathiresan, 2010; Spalding *et al*., 2010; Saranraj and Sujitha, 2015).

Forest ecosystems support livelihood of poor households in developing countries, especially at times of economic hardship (Mojiol *et al*., 2016; Rasmussen *et al*., 2017). The mangrove ecosystem is sanctuary to enormous abiotic and biological resources and offers an array of ecosystem goods and services from which humanity benefits such as, supply of natural resources and food (Bidayani *et al.*, 2016; Kerry *et al*., 2017; Barua and Rahman, 2019); regulating services, that modify climate and hydrology (McIvor *et al*., 2013; Ansari *et al*., 2014; Barua and Rahman, 2019); mitigates atmospheric carbon levels worldwide (Donato *et al*., 2011; Chen *et al*., 2012; Van Lavieren *et al*., 2012; Banerjee *et al*., 2014; Mitra, 2015; Lopez, 2016; Pal *et al*., 2016; Chowdhury *et al*., 2017; Duncan, 2017); education, cultural and recreational services (Warren-Rhodes *et al.*, 2011; James *et al.*, 2013; Costanza *et al.*, 2014; Mukherjee *et al.*, 2014); protection against extreme weather events and rising sea levels (Kauffman *et al*., 2011; Mant *et al.*, 2014).The ecosystem houses important carbon stocks of key importance to the "blue carbon" trade (Chen *et al.*, 2012; Mant *et al.*, 2014; Zakaria *et al.*, 2017), and can store organic carbon 3-5 times higher than terrestrial forests, with greater longevity (Zakaria *et al.*, 2017). Mangrove ecosystems are among the most economically important ecosystems in the world (Hamilton and Collins, 2013). Earlier studies have estimated the economic returns from well preserved mangrove resources at billions United States Dollars per-year (Costanza *et al.*, 1997), $751, 368 per-hectare-years (Lewis, 1983) and $35,000 per-hectare per-year (IBIN, 2009).

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However, due to unsustainable management, there has been extreme threats worldwide on the ecological integrity and functional traits of such economically and biologically diverse ecosystem (Ward *et al.*, 2016; Richards and Friess, 2016; Shama, 2018), with a cascading effects on fisheries production and carbon sequestration potentials (Donato *et al.*, 2011; IPCC, 2014; Mant *et al*., 2014; Carrasquilla-Henao and Juanes, 2017; Sharma, 2018). The main threats are: Conversion to agriculture or aquaculture (Webb *et al.*, 2013; Richards and Friess, 2016; Trzaska *et al*., 2018); Pollution, hydrological changes and indirect disturbances (Pegg and Zabbey, 2013; IPCC, 2014); over exploitation (Feka and Ajonina, 2011; Trzaska *et al.*, 2018); climate change and extreme weather events (Gilman, 2008; Ward *et al.*, 2016). It has been postulated that the quest for socioeconomic sustainability favoured by mangroves is the fundamental driver of mangrove loss and degradation globally (UNEP, 2007).

In Sierra Leone, there has been scandalous degradation of the mangrove forest through widespread conversions to rice fields and salt pans in spite of its invaluable supports to local livelihood, and the highest depletion has been in the Scarcies River Estuary (Chong, 1987; Garnett and Mansaray, 2007; GoSL, 2016; Konoyima, 2019; Konoyima and Johnson, 2020; Trzaska *et al*., 2018).

The aim of the article is to foster mangrove restoration and management initiatives in the Scarcies River Estuary, the most mangrove degraded region of the Sierra Leone Coasts. The objective of the study is to bridge a research gap by providing evidence of specific mangrove products most utilized by the locals for subsistence or commercial purposes in the Scarcies Estuary. This emphasizes the level of dependence of locals on mangrove resources, and hence the need for management interventions through restoration and co-management in this area.

MATERIALS AND METHODS

Study Area: Five coastal communities were selected for the study in the Great Scarcies Estuary, North-Western Sierra Leone coast, Kambia District, situated on 9°10′N, 12°45′W. These are Rokupr, Mambolo, Kychom, Kassiri and Yeliboya Island (Figure 1).

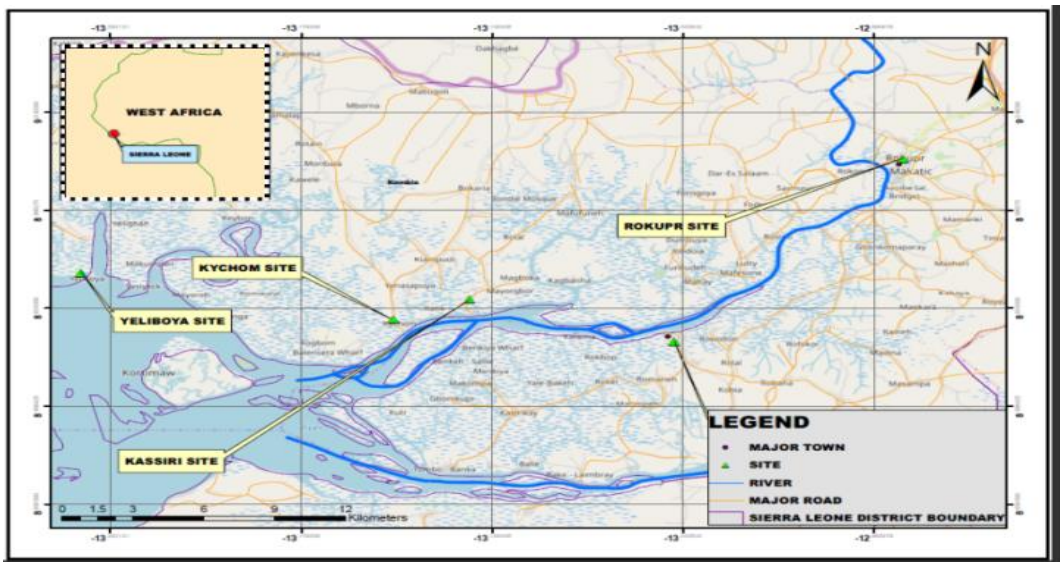

Figure 1. Map showing study locations

The district is the rice bowl of the country (Agyen-Sampong, 1999) with majorant farming populations compared to fishing activities (Agyen-Sampong, 1999; Konoyima, 2019; Trzaska *et al.*, 2018; Konoyima and Johnson, 2020). Existing records have revealed that the hydrology of the district mainly constitutes the Scarcies

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River Estuary formed by the Great and Little Scarcies, which merge towards their mouth before emptying into the Atlantic Ocean (Longhurst, 1962; Coutin, 1989). The Great Scarcies Estuary is tidal and during the rainy season rises to about 2.7 m; and is subject to significant seasonal changes caused by changes in atmospheric conditions (Ssentengo and Ansa-Emmin, 1986). The trade and monsoon winds are the main factors responsible for hydrological changes (Longhurst, 1962). However, the Great Scarcies Estuary contains most of the mangrove vegetation in this area (Ssentengo and Ansa-Emmin, 1986), and all species of mangrove reported for Sierra Leone have also been noted for the River Estuary (Chong 1987; Garnett and Mansaray, 2007; Turay and Kamara, 2010; IMBO, 2015;Trzaska *et al.,* 2018).This area hosts 7.6% of Sierra Leone mangroves, in large patches of compact mangroves; and extends inland 8-10 km and up to 15 km along the rivers (Trzaska *et al.,* 2018). Climate in this region is consistent with climatic conditions of the country, a tropical climate with distinct dry Season (November to April) and monsoonal rainy season which lasts from May-October (Coutin, 1989). The nature of sediment in the study areas is mainly sand/mud, and supports both sandy and muddy substrate littoral organisms (Aleem and Chaytor, 1980).

Sampling Technique: Respondents were selected through a stratification method where each community was imaginarily divided into 5 strata from a reference point (popular point such as mosque). This technique ensured a fair representation of the population in each settlement.

Research Design: Owing to grave constraints involved in accessing the study areas, **s**ampling was conducted intermittently and bi-monthly in 2017 in the five major coastal settlements along the Great Scarcies Estuary fringed with mangroves. A total population size of 200 respondents was targeted for the survey. As a strategy, the number of participants in focus group was limited to eight per-stratum per-community. This ensured efficiency in deliberations of issues relating to dependence on the mangrove ecosystem.

Data Collection: The study applied a qualitative approach in data collection using structured questionnaires. Participatory methods such as Focus Group Discussions (FGD), Key informant interviews (KII) and transect walk were overly essential in enhancing brevity in the data collection process. Transect walk included social and ecological transects. Ecological transects focused on observations on the status and aspects of conversion of the mangrove forest as well as mapping of fauna utilized for local livelihood as previously identified by participants, while social transect in market places confirmed alleged economic activities by respondents. Identification of mangrove fauna by respondents for subsistence and commercial purposes was achieved using finfish and shellfish guide by FAO (2010), while interviews were completed using structured questionnaires. These methods made certain of the brevity of information sought from participants, especially when it was impossible for the study to sample every individual in each settlement. Several authors have applied similar data collection approaches (Chambers, 1992; Townsley, 1996; Hahn *et al.,* 2009; Ellison, 2012; Trzaska *et al.,* 2018; Konoyima and Johnson, 2020).

Statistical Analysis: Student's *t*-test of significance and correlation were completed using the Microsoft (MS) Excel (ver. 2010) computer analysis package. Similarly, percentage means and standard errors (SE) were computed using descriptive statistics. A Chi-Square ($\chi 2$) test of independence (ANOVA) was used to test for dependence of locals on direct mangrove tree products for income, using:

$$\chi 2 = \sum (O-E)^2/E \quad \ldots\ldots(1)$$

Where, "*O"* represents the Observed Frequency. "*E"* is the 'Expected Frequency' under the null hypothesis. Graphical and tabular approaches were used to illustrate recorded data.

RESULTS

Subsistence and Commercial Dependence on Mangrove Products

Table 1 provides the essential mangrove products utilized for subsistence and commercial purposes. Unlike Yeliboya, participants in Rokupr, Mambolo, Kychom and Kassiri demonstrated high subsistence reliance on the intertidal substrate organisms (crabs, snails and mudfish)

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Table 1. Subsistence and commercial dependence on mangrove products (n=40)

	Rokupr		Mambolo		Kychom		Kassiri		Yeliboya		Mean±SE	
Mangrove Products	S	C	S	C	S	C	S	C	S	C	S	C
Mudskipper	35	5	31	9	28	12	36	4	39	1	33.5±2.5	6.5±2.5
Capture fish	35	5	38	2	36	4	33	7	10	30	29.3±6.5	10.8±6.5
Oyster	7	33	12	28	2	38	4	36	19	21	9.3±3.9	30.8±3.9
Cockle	10	30	19	21	3	37	3	37	12	28	9.3±3.9	30.8±3.9
Mud crabs	28	12	37	3	32	8	24	16	40	0	33.3±3.5	6.8±3.5
River crabs	38	2	36	4	35	5	37	3	13	27	30.3±5.8	9.8±5.8
Mud snails	32	8	38	2	26	14	33	7	40	0	34.3±3.1	5.8±3.1
Shrimps	37	3	32	8	38	2	34	6	12	28	29.0±5.8	11±5.8
Mangrove wood	14	26	18	22	4	36	9	31	25	15	14±4.7	26±4.7

*S=Subsistence dependence; C=Commercial dependence; SE=Standard error; N=Total sample size

Fish and Shellfish

Two groups of finfish were recorded. These are the macro-benthic fish, *Periopthalmus barbarous* (Mudskipper) and the estuarine capture fishes dominated by species belonging to the family Clupeidae. The subsistence use (84.5%) of the benthic fish surpassed its economic importance (15.5%). A similar trend in high subsistence dependence (73%) was recorded for the estuarine fishes.

The crustaceans were the mid-water species (Penaeid Shrimps and the Blue Crabs) and the littoral crabs. Species of shrimps were *Farfantepenaeusnotialis* (Farfante), *Parapenaeopsisatlantica* (Balss) and *Melicertuskerathurus* (Forskål). The estuarine crabs of key importance in the area were the "blue crabs" belonging to the genus *Callinectes* and include *Callinectespallidus* (Lineaus), *C. amnicola* (Lineaus) and *C. marginatus* (Lineaus). The littoral crabs comprised of *Ucatangeri* (Eydoux), *Ocypode cursor* (Linnaeus), *Ocypodeafricana* (De Man), *Perisesarmahuzardi* (Desmarest), *Goniopsispelii* (Herklots) *and Cardiosomaarmatum* (Herklots). Dependence on shrimps by locals for subsistence far outnumbered (76.5%) their commercial uses (23.5%). As with the penaeid shrimps, there was high subsistence use (80.5% and 79.5%) and low commercial dependence (19.5% and 20.5%) for the river and littoral crabs respectively.

The mangrove oyster, *Crasosstreatuliper* (Lamarck) and the cockle, *Seniliasenilis* (Linnaeus) are the important species of bivalves. Oyster (78%) and cockle (76.5%) are largely exploited for cash income, with only 22% and 23.5% showing no financial interest in the resources, respectively.

The gastropods consisted of *Pugilinamorio* (Linnaeus), *Hexaplex duplex* (Röding), *Thaiascoronata* (Lamarck) and *Tympanotonusfuscatus* (Linnaeus). These serve both subsistence (84.5%) and income (15.5%) needs of the people in the study areas.

Mangrove Wood

The mangrove wood is largely exploited for income (65%) than for subsistence purposes (35%).

Figure 2 provides a graphical illustration of the relationship between subsistence and commercially important mangrove products for the total respondents population (N=200). As oyster, cockle and mangrove wood attained higher peaks for commercial products, the littoral organisms (snails, crabs and mudskipper) as well as the estuarine species (finfish, shrimps and blue crabs) attained similar peaks for subsistence.

A Student's *t*-test (*t*) (Paired two sample for means), however provided a very weak correlation (-1) between subsistence and commercial dependence on mangrove products (df. 14; α = 0.05; Probability, P = 0.37; $t_{critical}$=2.36; $t_{stat.}$= 0.96; Equal 'n'; two tailed). Mean frequencies for subsistence and commercial products ranged from 9.3±3.9 to 33.5±2.5 and 5.8±3.1 to 30.8±3.9 respectively, and the difference is insignificant (P>0.05).

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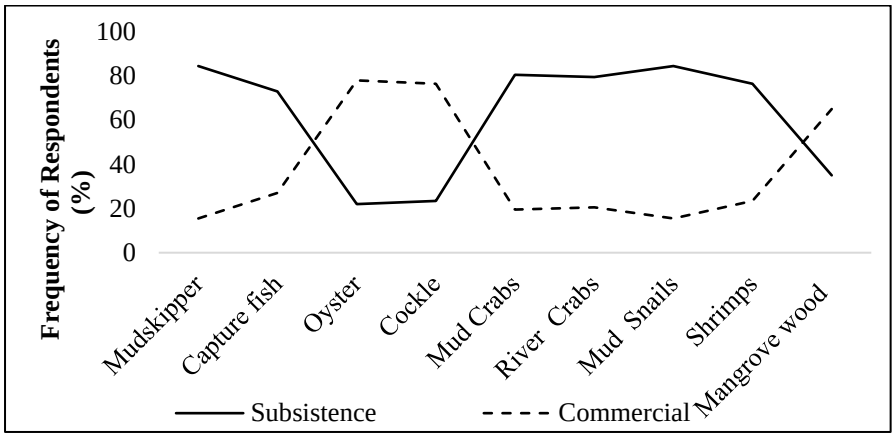

Figure 2: Trends of subsistence and commercially important products.

Marine Mammal-the African Manatee

Irrespective of its subsistence and commercial significance, the African Manatee, *Trichechus senegalensis* (*Link*), was consensually reported to be a non-target marine mammal by respondents in the study areas, which is why it is omitted from the target species in Table 1 and Figure 2. Amid its unscrupulous disturbances on fishing nets and destruction of rice crops, fishers and farmers refrain from targeting the marine mammal, and are encouraged to return the Sirenianto its habitat when caught alive as by-catch.

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Rice farming on mangrove soil remained the dominant economic activity in the study areas (38.5%). Fishing (27.5%), sales of mangrove tree products (12%), other mangrove trades (7.5%), and non-mangrove related commerce (12.5%) accounted for the rest of other economic activities. Mangrove swamp rice varieties included ROK5, ROK10, ROK21, WAR77, and CP4. 'Mangrove tree products' refer to mangrove wood and oyster resources; while 'Other mangrove trades' relate to such other activities as salt production, boat building and handicrafts

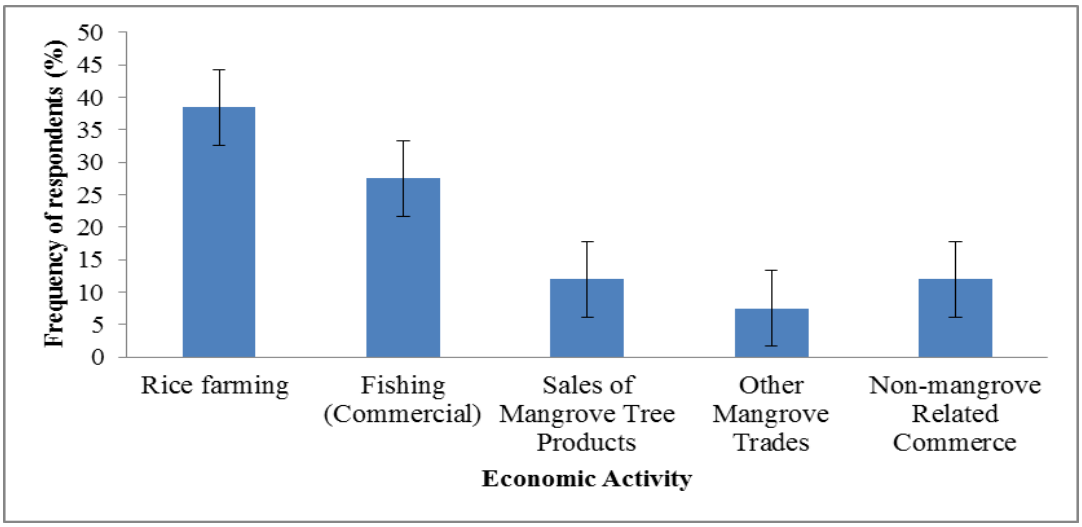

Figure 3: Mangrove Economic Activities

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Mangrove Economic Activities

A Chi Square ($\chi 2$) test statistic (Upper two-sided test) for the dependence of coastal communities on direct mangrove tree products (wood and mangrove oyster) for income gave a calculated value, 37.3 ($\chi 2_{cal}$) and the tabulated value ($\chi 2_{tab}$), 11.1 (ANOVA, *df.* = 4; α = 5%). There was a strong positive correlation (r=0.992) between the two commercial products. Minimum economic rent obtained for direct tree products was Le600, 000 (USD60) per-months. Profit margin exceeding the sum of Le1million (>USD100) is only common for rice farming, per farming-season. The high standard error bars validate the reliability of the data.

The proportion of female/male respondents engaged in mangrove related economic activities in the Scarcies River Estuary was 1:2.3.

DISCUSSION

The mangrove products identified in this study are categorized as fish (mudskipper and capture fish), shrimps, littoral organisms (Macro-benthic snails and crabs) and mangrove wood. Hamilton andCollins (2013) have shown thatmangrove forests serve as habitat to important traditional coastal seafood in the form of hundreds of species of fish, crabs, shrimps, bivalves, and gastropods.

From the mean values, the mangrove oyster, cockle and mangrove wood emerged quite significant commercial products in the study areas. It could be that prices offered by entrepreneurs are high to attract harvesters to go commercial for these resources.Not only-but, the outcome of the Chi-Square test statistic confirmthe commercial dependence of locals on the direct mangrove tree products (wood and oyster).This supports the philosophy that sensitizing the people well enough on the values of ecologically intact mangroves, could help foster positive attitudes towards mangrove restoration and conservation among local communities. Barbier (2006) concluded that the degree of mangrove dependent income is the most important positive influence for mangrove conservation.The minimum monthly economic rent from mangrove related trades for the study further emphasizes the importance of mangrove to local economy in the study areas.The economic value of mangrove has been noted by several authors (Lewis, 1983; Costanza *et al.*,1997; Sathirathai and Barbiar, 2001; Zabbey*et al.*, 2010; Hamilton andCollins, 2013).

Notwithstanding, the low commercial dependence obtained for the riverine species (capture fish, shrimps and river crabs) for the study is unexpected, as these are commercially important species in Sierra Leone (Thorpe *et al.*, 2009;Vakily *et al.*, 2012; Seto *et al.*, 2015; Akinjogunla and Moruf, 2018). The numerical superiority of farming communities in the survey (80%) may have resulted to such. It could also be that individuals in the study areas lack the capital to go commercial in the fishery industry. Pegg and Zabbey (2013) postulated that fishing activities may be feasible only for those with boats that can travel further afield, or for individuals who can afford the fuel. Thorpe *et al.* (2009) have asserted that the riverine fish required much fishing effort and highfinancial costs for exploitation in Sierra Leone.However, the high subsistence dependence on the littoral organisms (mud snails, mud crabs and mud fish) for the study is expected as these are 'shabby' species with little or no commercial value. Related studies have shown that littoral organisms are overly essential in providing alternative food provisioning functions for coastal communities (Crow and Carney, 2013; UNEP, 2014; Bidayani *et al.*, 2016; Kerry *et al.*, 2017; Barua and Rahman, 2019).

In addendum, sensitization programs by concerned ministries, department and agencies as well as non-governmental organizations (NGOs) and civil organizations (CBOs) are taking a toll in the protection of the 'African Manatee' in the study areas. The species was reported by participants to be non-target marine organism, probably owing to the fact that trade in the species is carefully monitored and terminated by international conventions such as the Convention for International Trades in Endangered Species (CITES; Powell and Kouadio, 2008; Encyclopedia of Life, 2015) and other international biodiversity conventions and treaties to protect the species, adopted by the countries in which it lives, including Sierra Leone. This emphasizes the power in awareness raising and stringent policies for effective conservation. However, frustrations from the destructive behaviour by the marine mammal as well as the inadequate livelihood options could debilitate the willingness of locals to protect the species.

Further, the difference in subsistence and commercial dependence on mangrove products was not significantat (P>0.05). This suggests a generally low return in the mangrove business enterprise, probably owing to the poor status of the mangrove forest in the area. Trzaska *et al.* (2018) have recorded a nationwide mangrove

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depletion of 25% since 1990, and 46% of such decline is in the Scarcies River Estuary, primarily due to widespread conversions to rice fields and salt production. Such degradation could have consequential effects on the ecological integrity and functions traits of the mangrove ecosystem and hence, the ecosystems goods and services for human wellbeing. Studies concur that mangrove degradation can affect the existence of the ecosystem and undermine the services offered to mankind (Din *et al.*, 2008; Auberto-Oropeza *et al.*, 2008; Pegg and Zabbey, 2013; Feka and Morrison, 2017). Feka and Ajonina (2011) further states that "as mangroves dwindle, the livelihoods and well-being of vulnerable coastal communities that directly or indirectly depend on their resources are at risk".Pragmatically, the productive potential of mangrove soil for various rice crops (Agyen-Sampong, 1999) coupled with the lack of capital for individuals to explore other income generating options, could be driving the incredulous conversions of mangrove forests to rice fields in the Scarcies Estuary. ROK5 is the most preferred rice variety in all the study areas not only for its high rate of salinity tolerance, but also for its high yielding, early maturing, white grain colour, long grain and sweet to eatattributes (Agyen-Sampong, 1999).

Finally, a female/male sex ratio, 1:2.3 suggests high involvement of men in mangrove related economic activities. Income activities of women are dominated by oyster and cockle trade while men are mostly engaged in all facet of trades including farming, fishing and logging of trees.

CONCLUSION

Farming is the dominant economic activity in the study areas. While the littoral organisms are being shunned by better-off households as well as individuals with access to quality fish in the fishing village of Yeliboya, these provide exceptional food provisioning functions in the farming communities. The mangrove tree products (wood and oyster) largely support local economy in the study areas. It could be that individuals in the farming communities lack vested interest in fishing or lack the capital to explore options in the fishing industry or other income generating activities, which may be driving incentives for rice farming, an easily accomplishable economic activity.

RECOMMENDATIONS

Research on the current ecological integrity and values of mangroves are necessary to improve public understanding of the ecosystem's goods and services. Alternative livelihood options should be considered in mangrove restoration and management plans. Oyster harvesting and wood cutting must be regulated through stringent law enforcement and new harvesting innovations.

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