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Vulnerability to coastal erosion in The Gambia: Empirical experience from Gunjur

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ABSTRACT

Coastal erosion is a major challenge along the coast of The Gambia besides the increasing pressure from climate change. This poses tremendous influences on physical and the socio-economic vulnerability of the coastal communities, in the form of negative impacts on lives and livelihoods. Therefore, there is a need to investigate the vulnerability of households to the impacts of coastal erosion. As a result, this study focused on the assessment and mapping of the social vulnerability of households to coastal erosion in Gunjur village. An interdisciplinary and mixed-method approaches were used in the study. The MOVE system-thinking framework was used to develop and select social vulnerability indicators. Geographic Information Systems technique was employed in data integration and mapping of the vulnerability of households. The outcome of the study revealed that 90% of the households were highly vulnerable to coastal erosion, however, women were perceived to be relatively more vulnerable. The study found high levels of exposure and susceptibility of the households to coastal erosion, given the limited adaptation capacity. It was found that 74% of the households do not have sustainable adaptation strategies to the impacts of coastal erosion. Integrating coastal protection measures into climate change adaptation and mitigation policy framework was a key recommendation towards reducing the impacts of human factors on coastal erosion. Alternative sources of livelihoods and mind building are required to build the resilience of households and enhance human security in the coastal communities of The Gambia.

1. Introduction

Coastal erosion in the past centuries was not considered as much of a challenging socioeconomic issue, due to the creeping nature of the erosion process and insignificant impacts on human factors [1]. In recent times, it became a major issue of discussion globally, due to the coupled impacts of climate change, through sea-level rise, and intensified anthropogenic activities [1–3]. The geology of the coastline has great influences on the nature and rate of erosion along most coastlines across the globe [4]. Coastal erosion is a global phenomenon as a result of multiple processes and environmental factors acting collectively on the morphology of the coastal environments [5]. The retreated shorelines, anthropogenic activities and global sea-level rise over the past are likely the underlying causes of coastal erosion [3,6,7].

Coastal erosion is a common morphological process in most coastal countries across the globe, however, the increasing dynamics in the erosion process has become a major concern in countries, where there is limited engineering capacity [5]. In Africa, most coastal communities have suffered tremendous economic losses, destruction of homes, livelihoods and cultural artifacts, through coastal erosion [8,9]. For example, Egypt, Ghana, Togo, The Gambia, and Benin have the most vulnerable coastal communities besides Nigeria [1,2,10,11]. There are various predictions (based on scenarios) of likely increase in coastal erosion and inundation of densely populated low-lying areas, such as the Victoria Island in Nigeria, the Nile delta in Egypt, and the Greater Banjul Area in The Gambia [1,11,12]. In Nigeria, the coastline erosion rate of approximately 30 m per year was observed in 2005, and relating this rate of erosion to the economic and cultural losses to the communities is

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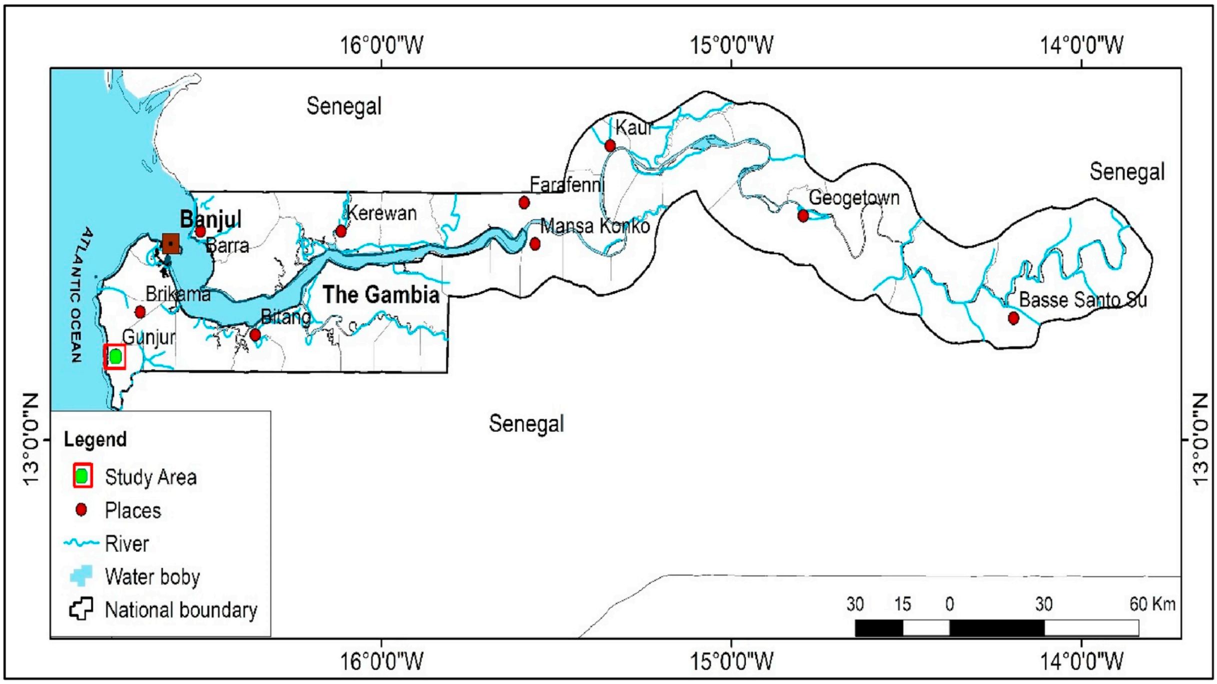

Fig. 1. Map of the study area.

alarming [13].

In most countries along the coastal belt of West Africa, large portions of the human population live along the coast, where various socioeconomic activities (tourism, fishing, real estate, etc.), which contributes to the Gross Domestic Product (GDP) exist. However, changes in nature of coastal erosion and deposition of sediments on coastal ridges pose serious threats to the natural resource base and livelihood activities of the coastal communities [2,14]. The risk associated with climate change hazards and the consequent impacts on the socio-economic development in coastal communities in The Gambia is increasing [2].

In addition, The Gambia is among the top ten (10) most vulnerable countries to coastal erosion and sea-level rise in the world, including the Nile delta in Egypt, mainly due to its geographic location, with some areas lying below sea level [8]. Besides the natural coastal erosion processes, beach sand mining is a remarkable threat to the coastal vegetation cover and marine biodiversity [11]. The rate of erosion of coastline in The Gambia, based on scenarios, ranges between 1 and 2 m per year, resulting in an average land loss of about 3 ha per year [8]. According to studies and model projections, by the year 2100, a 1.2 m rise in sea level will likely lead to total flooding of the capital city of The Gambia, Banjul [2,8]. However, these estimated rates of coastal erosion were observed to have doubled over the past years, due to climate change and anthropogenic activities. The coastal zone has been one of The Gambia's most valuable assets. Many commercial activities take place in the coastal zone, where fishing, tourism, and real estate development are the most important ones [7].

The contribution of the coastal communities to the GDP of The Gambia was reported as decreasing, due to the exacerbated cascading impacts of coastal erosion [2,15,16]. Gunjur, a coastal and fishing community in The Gambia contributes to the GDP, through agriculture and fishing [2,8,17]. It has the largest share of the fish supplies (86%), as reflected in its larger proportion of the Fish-Landing-Site (FLS) in the country, since 1999 [7]. However, the community loss part of its FLS to coastal erosion over the past years, which partly affected the fishing activities, and the income levels of the households [18].

The communities in The Gambia; for example, Gunjur, are already experiencing tremendous stress from poverty resulting from limited financial investment in education, commerce, and poor social networks among households [2]. The households' levels of vulnerability to coastal erosion is partly due to insufficient financial investment in improved fishing technology, however, the underlying driving forces of the financial constraints can be more complex than simple imaginations [2,19]. Therefore, exploring the driving factors of the social vulnerability to coastal hazards such as erosion is a crucial response through comprehensive and systematic investigations to develop sustainable solutions [8,20,21].

A vast number of online literature on coastal erosion focused largely on the climate science and the physical component of vulnerability (coastal sediment dynamics, and wave actions), climate, coastal vegetation cover, and land-use change [1,17,18]. Similarly, it is worth noting that the numerous research studies conducted along the coast of The Gambia focused largely on the physical processes of coastal erosion dynamics [17]. Recent attempts have been made to assess the impacts of coastal erosion on the livelihoods of communities in The Gambia, however, the approaches adopted did not delve into comprehensive characterization of the vulnerability components of the households, however, these vital details are important in human capacity and resilience building [2]. Furthermore, the combination of indicator-based approaches and Geographic Information System (GIS) techniques in investigating the social vulnerability in The Gambia was found missing in the scientific literature. The role of research and the dissemination of research outcomes to the global audience is crucial for human capacity building. As a result, the objective of the study was to examine the social vulnerability of households, given the historic and the current levels of coastal erosion in Gunjur, a coastal community in The Gambia, towards promoting disaster risk reduction and management.

2. Case study area

The study was conducted in Gunjur, a coastal community and a major Fish Landing Site (FLS) in the South-Western part of The Gambia (Fig. 1). The community is located in Kombo-South District in the West Coast Region. Gunjur has a population of about 21, 000, while the population of the entire country was about 1,882,450 as of 2013 [15]. The administrative center and capital city of The Gambia, Banjul, which is situated on an island on the southern bank and mouth of the River

Gambia, is found to be vulnerable to coastal erosion and sea-level rise [15]. About 50.8% of the population of the Gambia are female, while 49.2% are male. The population density is 174 persons per km^2, thus making it the 10th most densely populated country in Africa [15]. In addition, the 2013 census figures indicate an average household size of 8.4 persons, which is relatively high, compared to the global levels.

The land area of Gunjur is relatively small, likewise the country, and has no sharp physical characteristic, hence, the description of weather and climate is often done at the country scale. The Gambia is the smallest country (~11,300 km2) in Africa. It lies between latitude 13^0 N and 14^0 N, and 17^0 W and 1^0 W. It consists of a narrow band of land, which is about 400 km long and about 30 km wide on each side of the River Gambia. It shares borders to the north, east and south by the Republic of Senegal, and to the west by the Atlantic Ocean.

The country has a Sahelian climate pattern, characterized by an extended dry season from November to May, and a short wet season from the beginning of June to October [15]. Rainfall varieties from 850 mm to 1200 mm, and average range of temperatures from 18° to 33 °C with the mean temperature of about 25 °C [17,22]. The relative humidity in the country is about 68% along the coastal belt, which is relatively lower (41%) during the dry season in the inland. Generally, the relative humidity of over 70% is recorded across the country during the wet season [18].

The Gambia has three major landscapes, namely; the floodplain (lowland), the colluvial slopes (hydromorphic) and upland.The natural drainage is centered on the River Gambia and its tributaries. With its characteristic Sudan Savanna woodland vegetation, The Gambia has diverse ecosystem types ranging from forest, marine, inland water ecosystems to terrestrial ecosystems [22]. Almost 10% of the country is covered by the River Gambia and another 20% by swampy land and flood plains [17,22].

Economically, about 75% of the population of The Gambia depends on crops and livestock for livelihood. The main cash products are groundnuts, cotton, horticulture, livestock, and fisheries, while subsistence crops are made of cereals such as millet, sorghum, maize, and rice. Small-scale manufacturing activity features the processing of peanuts, fish, and hides [15]. As such, artisanal fisheries are well evident in the day to day lives of the people of Gunjur.

3. Materials and methods

This section discusses the sampling procedure, the sources of data, the material used for the data collection, and the methods employed in the social vulnerability assessment and mapping.

3.1. Sampling

The study adopted a random sampling technique for selecting a sample size for the study. A sample size of 100 households was obtained at a confidence level of 95% and a P-value of 0.05%, using simple random sampling procedure in equation (1) [23,24]. This approach allows the selection of a minimum presentative sample size of 100 households for the survey.

$$n = \frac{N}{1 + N(e)^2} \quad (1)$$

where $\boldsymbol{n}$ is the sample size, $\boldsymbol{N}$ is the population size and $\boldsymbol{e}$ is the level of precision.

As part of the study, three (3) Focus Group Discussions (FGD) were organized to further obtain a deeper understanding of the topical issues. The FGD was organized at the shared Fish Landing Site between Gunjur Kajaba and Madina Salam. Each FGD was made up of at least eighteen (18) participants, including women and men, and the opinion leaders of the community.

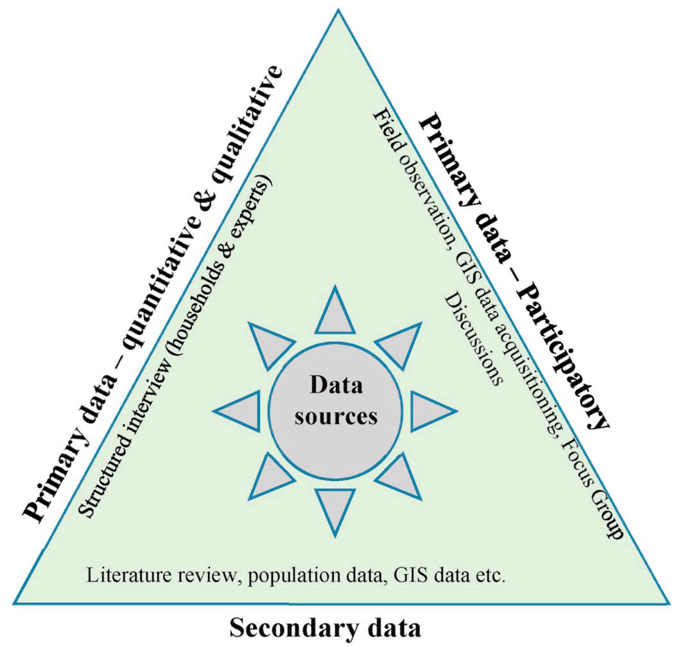

Fig. 2. Triangulation of methods for data acquisition.
Source: Inspired by Etzold [25] and Lauer [16].

3.2. Data sources/data collection

The study used both primary and secondary data sources. Using multiple sources of data is crucial for a mixed-method approach in research. The primary data such as socio-economic data of the households was obtained, using surveys and semi-structured interviews. To obtain the geographic coordinates of the building and key facilities in the community, a geographic positioning system (GPS) was used. Secondary data, such as the population and housing data, history of the community was obtained from the 2013 National Housing and Population Census report [15]. Literature from both published (online scientific libraries) and unpublished reports and documents from national and local government departments and the State of the Environment Reports for The Gambia were used as secondary data sources. The triangulation method (Fig. 2) was used to obtain data, as part of the mixed-method approach [16]. It allows the acquisition of data from various angles, while taking into account the scale of the research study.

3.3. Indicator-based approach for vulnerability assessment

Vulnerability has gained global attention due to its capability in combining the indicator-based with other approaches [21,26,27]. Adoption of the indicator-based approaches in vulnerability studies has been-well proven as an efficient approach to delve into the complexities of socio-ecological systems that explain the underlying dynamics of exposure and the susceptible elements in the communities [28]. However, this is done through the development of a framework or adoption of a suitable vulnerability framework [29,30]. As a result, indicator-based assessment involves the development and selection of a set of suitable and valid indicators, which are capable of providing information about the individual characteristics of a community, a household or a system. The MOVE (Methods for the Improvement of Vulnerability Assessment in Europe), was selected for this study in order to benefit from its advantages of flexibility and replicability [42,43]. It captures the most crucial aspects of vulnerability and could be easily modified to suit any kind of vulnerability investigation, at all scales. Hence, vulnerability could be expressed mathematically, as given in equation (Eq. (1)).

Table 1
Vulnerability indicators.

Vulnerability Component	Indicator	Justification	Functional relationship
Exposure	The distance of Household from the ocean/beach	Closure to shoreline means higher exposure	Increase (+)
	Location of the fish landing site	Closure to shoreline means higher exposure	Increase (+)
	Coastal protection	Protection reduces rate of erosion	Decrease (−)
	Vegetation cover (m)	Vegetation reduces the rate of erosion	Decrease (−)
Susceptibility	No. of children <5years	Children under 5years need extra care	Increase (+)
	No. of elderly >70years	Persons >70years are more dependent and prone to sickness	Increase (+)
	Families with physically challenged persons	They need extra care and aid	Increase (+)
	Female-headed households	Single mothers face many challenges in providing care	Increase (+)
Lack of Resilience	Roofing & Wall Materials (poor building materials)	Housing material depicts the economic status of the household	Increase (+)
	Livestock availability (no livestock)	Livestock serves as a form of animal banking	Increase (+)
	An alternative source of income	Gain support from alternative income	Decrease (−)
	Access to early warning systems	Access to early warning information allows planning	Decrease (−)
	Assets of the household	It allows quick recovery	Decrease (−)
	Past experiences of the hazard	Learning from experience aids in planning	Decrease (−)
	Participation in the resilience-building program	Mind building helps in building resilience	Decrease (−)

$$Vulnerability. = \frac{[(Exposure + Susceptibility)]}{Resilience} \tag{2}$$

3.3.1. The MOVE framework for vulnerability assessment

The MOVE framework was adopted to conceptualize the multi-faceted fashion of vulnerability, and to account for major causal factors such as the exposure, susceptibility, and resilience. The framework emphasizes that the occurrence of hazards is influenced by both natural and human-induced factors, while vulnerability by its nature is linked to human factors [31–33]. The key factors of this framework are linked to the exposure of a society or systems to a hazard or risk, the susceptibility of a system or a community, and its accessible and reliable adaptive capacity [31].

3.3.1.1. Components of the MOVE framework captured in the study. ***Exposure*** *(physical exposure)***:** in the context of coastal erosion in Gunjur, the study focused on the physical exposure of infrastructure and the households. The key indicators for the physical exposure included the distance of building from the shoreline, the location of Fish-landing-Sites, beach, and sand mining activities at the beach.

Susceptibility (*or fragility*)*:* as part of indicators for this study, the nature of building materials of houses, social networks, number of children under 5, number of elderly persons above 70 years in a household, number of persons living with diseases, and among others were developed and considered as susceptible to coastal erosion.

Resilience**:** this considered the monthly income, access to early warning systems, number of household members in active employment, sea-water related employment, participation in a resilience-building program, were the indicators developed for assessing the level of resilience of the households to coastal erosion in Gunjur.

The adaptation options**:** includes alternative sources of livelihoods, social networks, level of education, access to financial assistance, health and property insurance policy, and among others.

3.3.2. Development and selection of indicators for social vulnerability

The selection of indicators for the social vulnerability of households to coastal erosion is crucial. The development and selection of vulnerability indicators were guided by the works of Maanan et al. [26]; Birkmann et al. [31] and Fekete et al. [33]. The pre-selection of the indicators was done, through prior visits to the field, using FGDs, and consultation of experts for selection and validation of the final set of indicators. This was done by considering the various dimensions of vulnerability such as exposure, susceptibility, and resilience [31,43]. Socioeconomic aspects of the households and the physical attributes of the coastal zone were key factors of the vulnerability assessment, which likely influenced the capacity to cope or the ability of communities to adapt to coastal erosion [45,46]. Table 1 presents a summary of the final set of indicators developed and selected for the study.

3.3.3. Normalization of indicators using functional relationship

The normalization of indicators was done following the procedure outlined by the United Nations, [34]. This is done by identifying the functional relation between the indicators and vulnerability components. There exist two (2) functional relationships: positive and negative relationships. A positive relationship exists, when the indicator contributes to an increase in the level of vulnerability, while a negative relationship exists when the indicator tends to decrease the level of vulnerability [28, 34, 35]. The normalization was done, using the following expression (Equ. 3 and Equ. 4), when the variables have a positive functional relationship with vulnerability.

$$V_{ei} = \frac{Xei\ - MinXe}{MaxXe -\ MinXe} \tag{3}$$

When the variables have a negative functional relationship with vulnerability, the normalization is done, using the following expression (equ. 4):

$$V_{ei} = \frac{MaxXe -\ Xei}{MaxXe - MinXe} \tag{4}$$

where; V_{ei} refers to the standardized vulnerability score with regard to vulnerability component i, for community e; X_{ei} refers to the observed value of the same component for the same community;

$MaxX_e$ and $MinX_e$ are the maximum and minimum values of the observed range of values for the same vulnerability component, for all settlement of the index.

3.4. Mapping the levels of households social vulnerability

Maps are an integral part of decision support systems, which play crucial roles in disaster risk reduction and management. In this study, GIS was mainly used in data integration and mapping the social vulnerability of households to coastal erosion, following the guides outlined by Ntajal et al. [35] and, Krishnamurthy and Krishnamurthy [36]. The overall vulnerability of the households was calculated with the computed values for the capacity (resilience), exposure and susceptibility of the households, using the field calculator in ArcGIS. Calculating the exposure, susceptibility and resilience formed the initial stage of the process. Computing the overall vulnerability involved the addition of the exposure and the susceptibility components relative to the capacity of the households. The resultant vulnerability maps of the households were created and classified into four classes (Low, Medium, High and

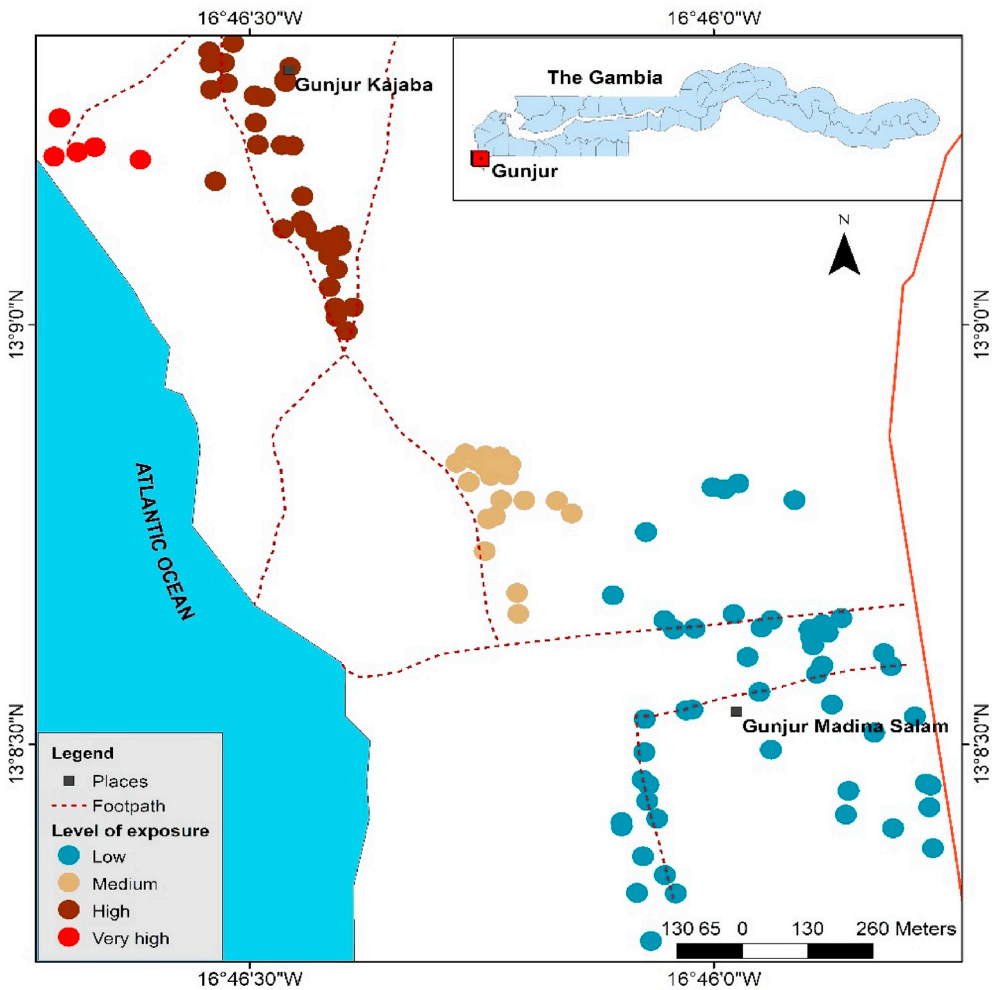

Fig. 3. Map of households' exposure to coastal erosion.

Very high).

4. Results and discussion

This section presents and discusses the results of the study. The study assessed the level of household vulnerability to coastal erosion in Gunjur village in The Gambia. It should be noted that the higher the exposure and susceptibility of households, the higher the vulnerability, while the high level of resilience translates into low vulnerability.

4.1. Demographic background

Regarding the level of education, 62% had some level of education and 38% are illiterate. Moreover, out of the 62% who are educated, 39% are male and female were 23%. Whereas, 38% who are illiterate, comprising males (14%) and females (24%). Observably, the percentage of literate males exceeds that of the female, while the percentage of illiterate females exceeds that of males. In addition, 51% had some form of employment, unemployed (48%) and unemployed (1%) because they were too old and were depending on the other members of the households. Given the impacts of coastal erosion, 94% of the residents revealed that they were not willing to leave the village to resettle elsewhere and thus, prefer to continue staying in the Gunjur village, due to the ancestral heritage, cultural ties, and established properties. The main source of livelihood is fishing, which could not be found in the potential new destinations, if relocated, without sustainable livelihood arrangements. The livelihoods are not only threatened by coastal erosion but also impacts of climate change, as highlighted in the report of Drammeh [17].

4.2. Causes of the coastal erosion in Gunjur

It was revealed that the factors, which have likely exacerbated the process of coastal erosion, were both natural and human-induced. According to the survey results, 23% of the respondents underscored that coastal erosion is a natural process. In addition, 19% linked it to sea-level rise, and 16% of them found sand mining as the major cause, which is similar to the findings of Ndour et al. [37] in Senegal and Benin, where sand mining for commercial purposes had been a huge contributing factor to coastal erosion. More relatedly, 13% of households perceived extreme high rainfall and stormwater runoff as part of the causative factors, 12% of them highlighted in a more broadly fashion that climate change is the great underlying factor. Deforestation (8%) was perceived as a factor; however, it is worth mentioning that about 9% of the households have no idea about the causes of coastal erosion in Gunjur.

Relatedly, similar studies in Italy revealed that coastal erosion between Paola and San Lucido was a natural process, which was accelerated by the impacts of climate change such as sea-level rise [38]. Although direct human activities such as sand mining were identified as a contributing factor to coastal erosion, however, Ndour et al. [37] argued that the most influential factor was the increasing power of the tidal actions due to sea rise in Togo. It is important to note that the phenomenon of coastal erosion in Gunjur is natural and has long existed

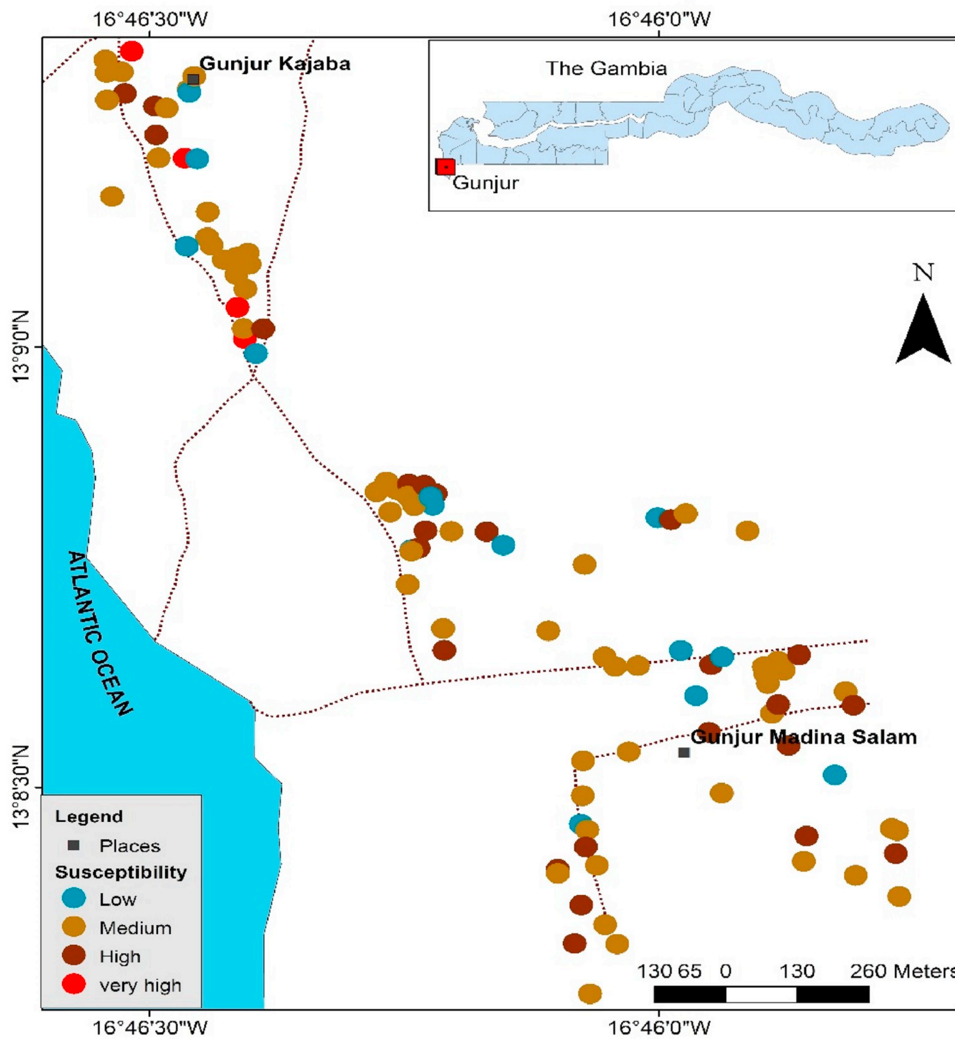

Fig. 4. Map of susceptibility.

before human habitation. However, the rate of erosion was exacerbated by anthropogenic activities. The influences of human actions in the process of coastal erosion make the situation more of a social problem.

In contrast to the findings in Croatia, the respondents in Gunjur could not agree on the specific factors as the main cause of coastal erosion, during the focus group discussion. However, the participants noted that the Fish-Landing-Site is gradually been washed away by erosion. The high level of research and high level of knowledge among the residents of the coastal communities in Croatia helped in identifying the causes and the best strategies to mitigate the menace [5]. Lack of understanding and low level of local knowledge on coastal erosion was explained by the low levels of education in Gunjur.

4.3. The level of exposure of households to coastal erosion

The results revealed the various levels of exposure of households to coastal erosion. Notwithstanding the characteristics of the households that predefined their levels of exposure, the location of public facilities such as school, market, mosque, roads, and the Fish Landing sites were taken into consideration (Fig. 3).

The location of human systems within the distance of 250 m from the shoreline found to have a very high level of exposure, 500 m (High), 750 m (Medium) and beyond 750 m was found in the area of a low level of exposure. Thus, the closer the households to the shoreline, the more exposed they are. Locations along the coast are more physically exposed to coastal erosion, while that inland is less physically exposed. Similar results were reported Tragaki et al. [39] in Peloponnese, southern Greece, where the physically exposed building was eroded off within a decade. Therefore, the exposure map (Fig. 3), it could be observed that households in Gunjur Kajaba have high level of exposure, where the households in Gunjur Medina Salam have medium to lower levels of exposure. Statistical analysis revealed that 44% of the households have a low level of exposure to coastal erosion, medium (25%), high (28%) and very high (3%). These levels of exposure should not be considered as safe, as devastating experiences reported in the findings of Escudero-Castillo et al. [40] in Cancun, Mexico, occurred following similar perception. In addition, the National Climate Change Policy of The Gambia [18] cautioned in its report that a 50 cm to 1 m rise in sea-level will result in the total inundation of the FLS in Gunjur and most part of Banjul, the capital city of The Gambia.

4.4. The level of the susceptibility

Mapping of the susceptibility of the households to coastal erosion gives a visual impression about levels of susceptibility in the area (Fig. 4).

As mapped in Fig. 4, households (14%) have low levels of susceptibility, medium (3.4%), high (82%), while 0.6% of the households have a very high level of susceptibility. Households with a higher number of children under 5 years, elderly above 70 years, and female-headed

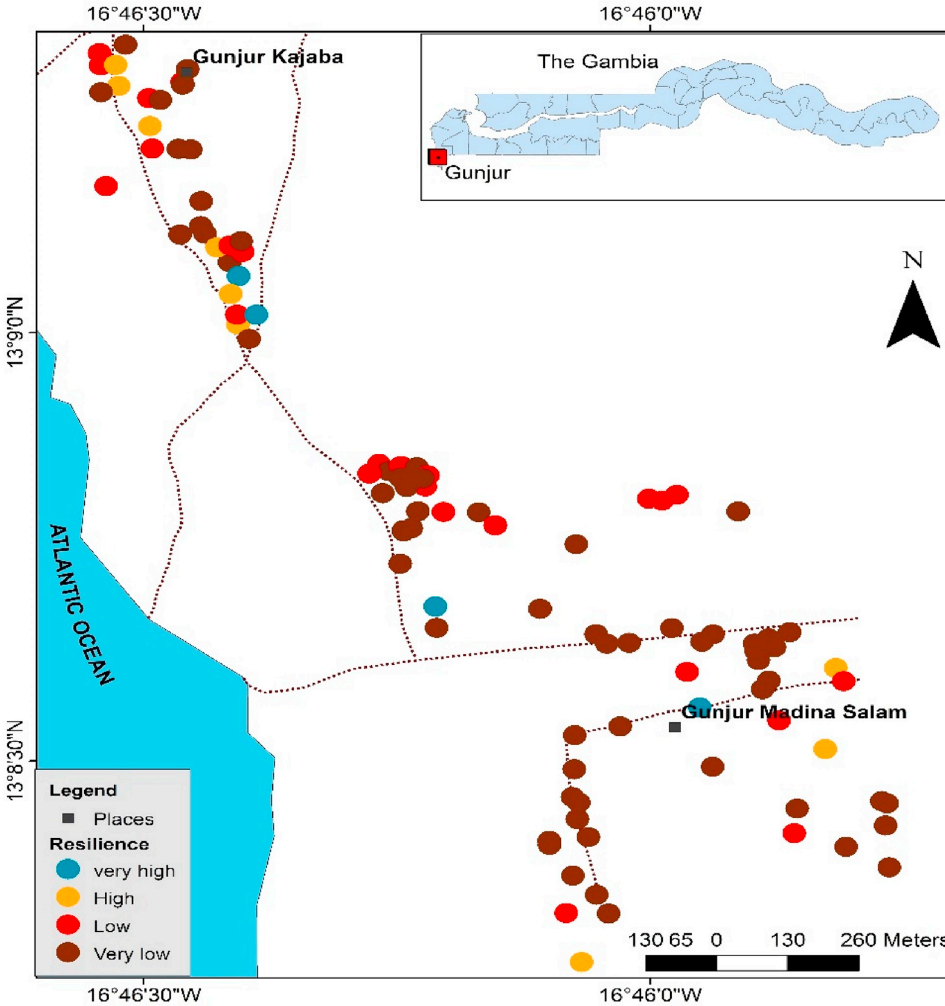

Fig. 5. The level of social resilience to coastal erosion.

households were found to be more susceptible to the impacts of coastal erosion. Children under 5 years are more prone to sickness (mal-nutrition) and therefore, require extra care, while the elderly persons above 70 years require extra care as they get older, and become more dependent on the family. The elderly persons in the household tend to spend much of the income on their health care. Tragaki et al. [39] reported similar cases, where the share of the dependent members of households are higher, leading to an increase in social vulnerability to coastal erosion in Peloponnese, southern Greece. Female-headed households were found to be an explanatory indicator to medium level of susceptibility. However, the underlying fact was that male-headed households were less vulnerable, compared to female-headed households, though this is not always the case, as some exceptions were discovered on the field, which further conforms to the report of Drammeh [17].

While, Wu et al. [14] acknowledged the need to empower women and the youth in Taiwan in order to build their capacity, and to reduce the level of susceptibility, which can reduce the fragility of their systems, households in Gunjur are entirely waiting on the government and other external aids to cope with the hazard. In Taiwan, the communities were ready to learn from past disasters and adopted various ways to build their resilience to bounce back better, should similar disaster strike their community [14].

4.5. The level of resilience

The resilience of the households is very crucial in adaptation to the impacts of a disaster or hazard. Households with a high level of resilience are able to recover and bounce back better and the opposite is true. The various levels of resilience are presented in Fig. 5.

It could be observed that the households in Gunjur village are not socially resilient against impacts of coastal erosion. Assessment from the field revealed that 44% of the households have a very low level of resilience, low level (42%), medium level (18%), high level (4%), and a very high level (2%) of resilience to the impacts of coastal erosion. The levels of resilience were determined by the building materials, availability of an alternative source of income and purchase of insurance policies. Households without any of these were found to have a very low level of resilience to the impacts of coastal erosion. To some extent, building materials portray an economic situation of a household. A more fortunate household will go for a house made of cement, roofed with zinc or concrete roof. Likewise, it was observed that 79% of the households live in clay/mud houses, not by choice but as a result of poverty. These findings were in contrast to the case of Southern Greece, where households have similar levels of exposure but the high standards of building and other infrastructure increased the level of resilience [39].

It was found that not only in Gunjur but also in many coastal communities in The Gambia, have low levels of adaptation capacity to coastal erosion. Similar findings were found in the reports of Drammeh [17] and Amuzu et al. [2] in the other parts of The Gambia, where households depend mostly on the government and external aid, during moments of disaster, including flooding and coastal erosion. The common livelihood alternative was livestock (e.g. goats & sheep), chicken

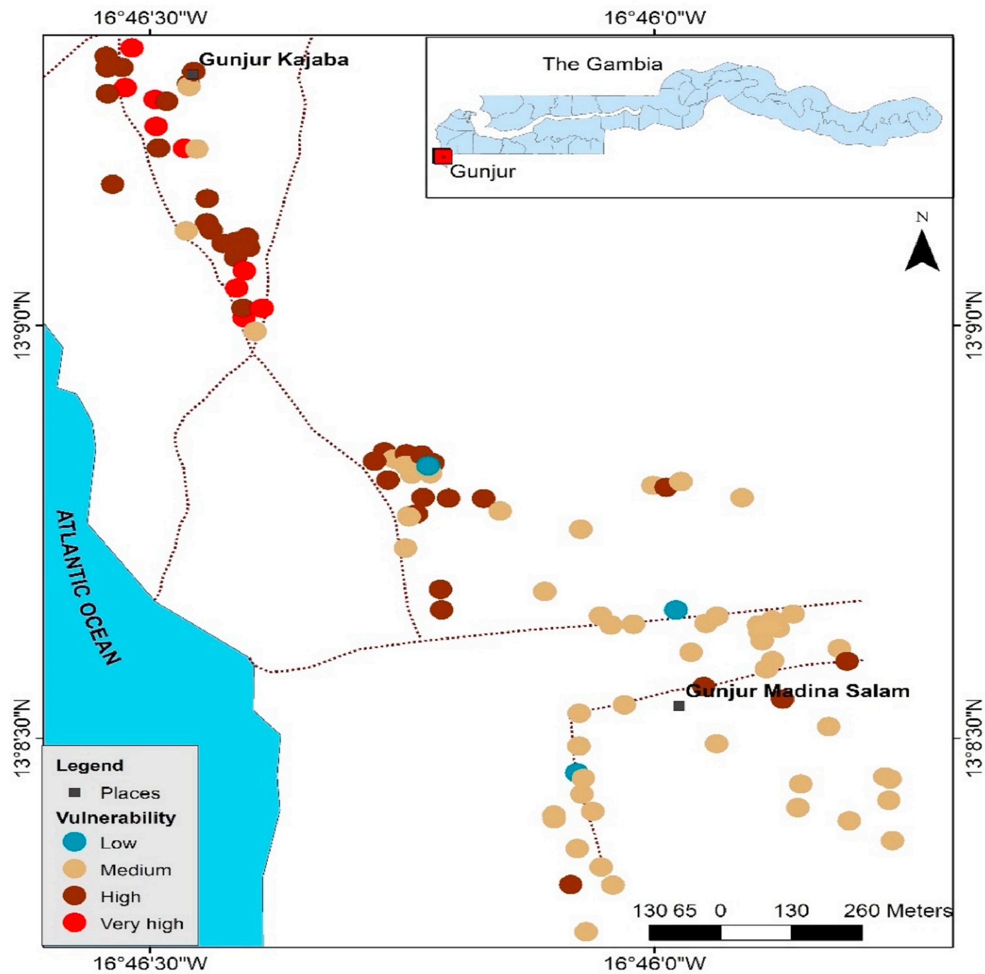

Fig. 6. The level of social vulnerability to coastal erosion.

(poultry) as it is a form of "animal banking" to cater and safeguard against coastal erosion. Such alternative sources of livelihood options are found among coastal communities in Ghana and the South-Western part of Togo [4,17].

4.6. The level of social vulnerability of households to coastal erosion

The overall vulnerability was computed by taking into account the various components such as exposure, susceptibility, and resilience of the households. The mapping of the vulnerability was found to be crucial for characterizing the nature of the impacts of coastal erosion at the household level in Gunjur (Fig. 6).

The households were challenged with medium to very high levels of vulnerability to the impacts of coastal erosion and observed in Fig. 6. The result of the statistical analysis revealed that 0.2% of the households have a low vulnerability, medium level (46%), high level (34%), while 19.8% of the households experienced a very high level of vulnerability. As dynamic as vulnerability, some households had a high level of resilience but were highly exposed to the hazard (coastal erosion), while households were susceptible and had very low levels of resilience. The source of the vulnerability of households was divergent. Thus from both the hazard and the social characteristics of the communities.

Moreover, the households in Gunjur Kajaba experienced high levels of exposure, which was explained by their proximity to the coastline. This result buttresses the recommendations in the report of UNEP [8]; to relocate these communities to relatively safer places. Gunjur Medina Salam experienced a medium level of vulnerability, due to the high level of susceptibility and lack of resilience though, the level of physical exposure to coastal erosion was relatively low. Through field observation, it was noticed that the vulnerability of the community could get worse in the following years without timely intervention from the government, the community itself, and the development partners. Therefore, households in Gunjur need alternative livelihood ventures and a strong intervention in the adaptation to coastal erosion.

The underlying factors of vulnerability to coastal erosion in The Gambia are not different from those of other places in developing countries, where women have limited access to resources, a higher share of dependent population (elderly above 70 years and children under 5 years), and a higher share of low level of education. Low level of education means limited access to information and available resources. Tragaki et al. [39] argued that higher levels of education translate into higher levels of access to information and decision, which aid in investment planning against disaster risk.

In addition, a critical factor, which further explains the levels of vulnerability was the lack of insurance, due to high levels of premiums. The affordability and efficiency of the health insurance policies could be an interesting issue for detail investigations, as recommended in the report of Amuzu et al. [2] to understand the underlying challenges. Purchasing insurance policies is a good strategy to secure one's health when sickness engulfs the household.

4.7. The proposed coastal management initiatives in Gunjur

Regarding the coastal management strategies in the community, the

Table 2
Community coastal erosion management strategies in Gunjur.

Management practice	Percentage share (%)
Sandbags/rocks	31
Tree planting	24
Stop/fine culprits of sand mining	17
wood barrier	15
Beach nourishment	9
Concrete walls	4
Total	100

results from the Focus Group Discussion (FGD) proposed potential strategies that could be adopted at the community level for managing coastal erosion. These included strategies such as placing sandbags parallel to the shoreline at marked areas to reduce the rate of erosion. The results are summarized in Table 2.

At the community level, it was proposed that sandbags or rocks, which represented 31% of the total share of the initiatives as a management strategy to reduce the rate of coastal erosion, through community participatory initiative. Again, it was mentioned that planting trees, building concrete walls and punishing the culprits of sand mining along the coast were other potential strategies, wich could be adopted to reduce coastal erosion. Given the proposed initiatives for coastal erosion management during the FGD in Gunjur, experiences from different studies identified some related shortcomings of such intiatives. The use of sandbags was reported as unsustainable and rather exacerbate the rate of erosion [1,17,37,41]. Konko et al. [41] argued that coastal management requires high levels of skill, technology and financial investment as the risk of poor management could be devastating. The reports of poor coastal erosion management at Aného in Togo, which already experienced an annual erosion rate of 1.8 m, demonstrated that sandbags can redirect the energy of the waves, thereby increasing the erosive power of the waves, [1,41].

At the government and private institutional level, many strategies, including both hard and soft engineering have been adopted to reduce erosion along the coastline of The Gambia, especially, in areas where important infrastructure (Harbor, hotels, etc.) are found. Sandbags have been established offshore at the Senegambia hotel to check erosion. However, these strategies are not implemented in Gunjur by the government. The government has been involved in discussions with the UNEP and the World Bank research group on the implementation of Integrated Coastline Management in the country, where sustainable coastal ecosystems approach will be adopted[44]. This will highlight the potentials of soft engineering measures such as beach nourishment and, mangrove planting and rejuvenation, for all vulnerable coastal communities in The Gambia. Integrating coastal protection measures (hard and soft engineering) into climate change adaptation and mitigation policy framework is a sustainable option for the government of The Gambia to reconsider.

5. Conclusion

Assessing the vulnerability to hazards is a key step to effective disaster risk reduction and resilience building. Generally, it was found that the households in Gunjur were physically exposed to different levels of coastal erosion, given the already existing threats posed by climate change. It could be generally stated that 90% of the households were relatively vulnerable to coastal erosion, which is influenced by both natural and human factors. The vulnerability of the households is explained by the levels of exposure, susceptibility, and the limited adaptation capacity. It should be noted that the vulnerability of the community was not entirely dependent on the physical characteristics of the hazard but also the socio-economic status (poverty levels) of the households, and the community at large. Therefore, to contribute towards sustainable and integrated coastal erosion management in Gunjur and The Gambia, the following recommended strategies in Table 3 should be considered.

Table 3
Recommended strategies for integrated coastal erosion management in Gunjur and the Gambia.

Strategy	Activity	Stakeholders	Timeline
Beach nourishment	Using soft engineering methods to nourish the eroded part of the country's coast	Government. Development partners, e.g. Global Environment Facility (GEF)	Medium
Constructing breakwaters & groins	Construction of breakwaters & groins (hard engineering) to reduce the rate of coastal erosion	Government Development partners, e.g. GEF	Medium
Coastal Research & monitoring	Monitoring & evaluation of coastal erosion and research to address the situation	Government, e.g. National Environment Agency (NEA) Development partners, e.g. UNDP	Long-term
Policy on climate change, integrated coastal zone management, wetlands, and mangrove conservation	Review and/or develop policy on climate change, coastal zone management, wetlands, and mangrove conservation	Government, e.g. NEA, Department of Forestry (DOF), Department of Water Resources (DWR), & Department of Parks and Wildlife Management (DPWM)	Short-term
SMART and well-integrated Natural Resource Management (NRM) policies	Formulation & implementation of SMART and well-integrated policies to ensure efficient management of natural resources to enhance adaptation and resilience	Government, e.g. Ministry of Environment, NEA, DPWM, DOF, Fisheries, Department of Agriculture (DOA), etc.	Long-term
Massive awareness on environmental protection & Climate change	Sensitization on environmental protection & Climate change	Government, e.g. Ministry of Environment & NEA, NGOs Traditional oral communicators, e.g. Griots, Community Radio	Long term
Tree planting & mangrove planted	Planting of trees, e.g. coconut trees along the coast	Government, e.g. Department of Forestry (DOF) NGO's & Community Based Organizations (CBO's)	Medium

Author contributions

The research design and the methodology was developed by Muhammad L. A. Gomez and O. J. Adelegan. Muhammad L. A. Gomez conducted the fieldwork in the Gambia under the supervision of O. J. Adelegan and Dodou Trawally. Joshua Ntajal and Muhammad L. A. Gomez analyzed the data and drafted the manuscript. The manuscript was edited and fine-tuned by Muhammad L. A. Gomez, Dodou Trawally and Joshua Ntajal.

Declaration of competing interest

The authors of this paper declare no conflict of interest.

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