



Knowledge of Climate Change and the Perception of Nigeria's Coastal Communities on the Occurrence of *Sargassum natans* and *Sargassum fluitans*

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Abstract

Climate change effects threaten life on earth especially economically poor areas. Among them is noticed the shifting of the algae species *Sargassum natans* and *Sargassum fluitans* seaweeds from the Brazilian coast to new areas along the West African coastline. Their occurrence along the Nigerian coast and their effect on livelihood are necessary subjects because of their link to coastal dwellers' food security and economic activities. This study aims to evaluate the perception of coastal residents on the occurrence of *Sargassum* on the banks and their notion of climate change effects. 206 household heads were interviewed using a structured questionnaire over eleven areas. The coastal population knowledge about climate change and the reason of the occurrence of *Sargassum* species, is limited due to low education level and information access limitations. Also, the population complained about the occurrence of another species identified as *Eichhornia crassipes* which disturbs fishery and boats displacements. Moreover, changes in weather conditions particularly temperature have various consequences on the respondents' livelihood by affecting their health, welfare, feeding and incomes. The population lamented about challenges of climate change and occurrence of *Sargassum fluitans* affecting fishery as they have no any adaptation measures to cope with these situations.

Subject Areas

Anthropology, Environmental Sciences, Environmental Sciences, Marine Biology, Oceanology

Keywords

Climate Change, Coastal Communities Perceptions, *Sargassum* Shifts

1. Introduction

The oceans regulate the weather at all scales but ocean activities are altered by the changes in climate [1]. Changes in ocean temperatures and currents brought about by climate change will lead to alterations in climate patterns which have consequences on marine ecosystem. Their habitats, specific behaviors and distributions are modified to adapt to changes in environmental conditions. Thus, it can affect the productivity of species and the way they behave, which directly, lead to shifts in the size structure, spatial and seasonal abundance of aquatic species. Moreover, climate change as well as modified ocean circulation will induce physiological responses of organisms represented by shifts in abundance, annual recurring events and dispersion of marine species [2]. Widespread biogeographical range shifts are associated with changing climatic conditions in marine environments [3]. Warming oceans have resulted in many aquatic organisms shifting their distribution towards favorable environments. Climate related distribution shifts contribute to observed modifications in composition and biodiversity of many systems and organisms communities [2].

Thus, since 2011, unprecedented masses of brown seaweed have been floating and transported ashore of different coastal and brackish water areas along the West African coast. The seaweeds affect tourism and fishing activities [4]. These species were distinguished as *Sargassum natans* and *Sargassum fluitans* from Phaeophyceae family which shifted from the Northern Brazilian coast to the West African coast [5]. According to [6] huge magnitude of the algae was washed up on beaches making them ugly and less attractive. Beaching was unknown in West Africa before 2011 and could be a response to the climate change effects. Also, in 2010, before the first influxes of the brown algae, scientists noted an unusual high temperatures and ocean currents in the Atlantic which could have furthered the motions of the species. These irregularities associated with the enrichment in nutrients such as nitrogen, phosphorus and iron from the African rivers would allow *Sargassum natans* and *Sargassum fluitans* to thrive. Nine (9) West African coast space spanning from Senegal to Nigeria across the Atlantic coastline were invaded. The coast of Nigerian has been disturbed by the presence of these algae. The quantity and frequency of occurrence of *Sargassum* species in the water and in the beaches induced various problems for ecology, tourism and fishery in several regions of the coast [4]. Moreover, [7] advocated

that in Ondo State, Nigeria, measures have to be in place. The occurrences of *Sargassum natans* and *Sargassum fluitans* offshore were noticed in July 2012 because of the damage they cause to the fishery sector and the human health. The *Sargassum* species spatio-temporal influxes were also observed offshore using color satellite methods [8] [9]. According to them, the real reasons for this shift were unknown and scientists are working to explain the causes of this new distribution. Although, the distribution of species can be attributed to natural or to unknown drivers but changes in ocean patterns due to global warming and the increasing discharge of nutrients (which promote algae growth) from land in the ocean [10] have also been implicated in this trend. Therefore, changes in climate pose a threat to marine species while the new coastal dispersion of the *Sargassum* species constitute a real problem for the future of the shores, and local livelihoods of the coastal residents. Moreover, the coastal populations depending on the coast for their activities such as fisheries are impacted and threaten the food security and communities' incomes.

Evaluation of the coastal population perceptions of climate change effects on the occurrence of aquatic species is necessary in order to help the decisions makers for anticipatory actions and to prepare coastal communities to cope with the climate change challenges. The aim of this study was to find out what is the perception of coastal population about the beaching of *Sargassum natans* and *Sargassum fluitans* and their notion about climate change. The objectives tackled included to: 1) Determine the socioeconomic characteristics of the respondents across the study locations, 2) Examine the awareness of the coastal communities on the impact of climate change, 3) Determine communities perception on *Sargassum natans* and *Sargassum fluitans* occurrence, 4) Identify the perceived consequences of climate change, *Sargassum* species occurrence and livelihood challenges, 5) Determine the existence of any adaptation measures about climate change and *Sargassum* occurrence implemented by the communities.

2. Materials and Methods

2.1. Study Area

Sargassum natans and *Sargassum fluitans* have been found offshore/onshore on the Nigerian coast [4]. According to [11], located between 3° and 14° East Longitude and 4° and 14° North Latitude, the Federal Republic of Nigeria is defined with an area of 923,769 square kilometers with 13,879 square kilometres of water area. The Nigerian coast measures 853 km long, extends across seven Southern States listed as: Lagos, Ondo, Delta, Bayelsa, Rivers, Akwa Ibom and Cross Rivers bordering the Atlantic Ocean and lies between longitude 2°45'E to 8°35'E and latitude 4°10'N to 6°20'N (See **Figure 1**). We considered three coastal states which are Lagos, Ondo, Ogun State. Each state consists of several Local Government Areas (LGAs) randomly chosen as followed:

Lagos State: Apapa, Badagry, Eti-Osa, Ibeju-Lekki, Ojo.

Ogun State: Ado-odo and Ondo State: Ilaje Ese odo.

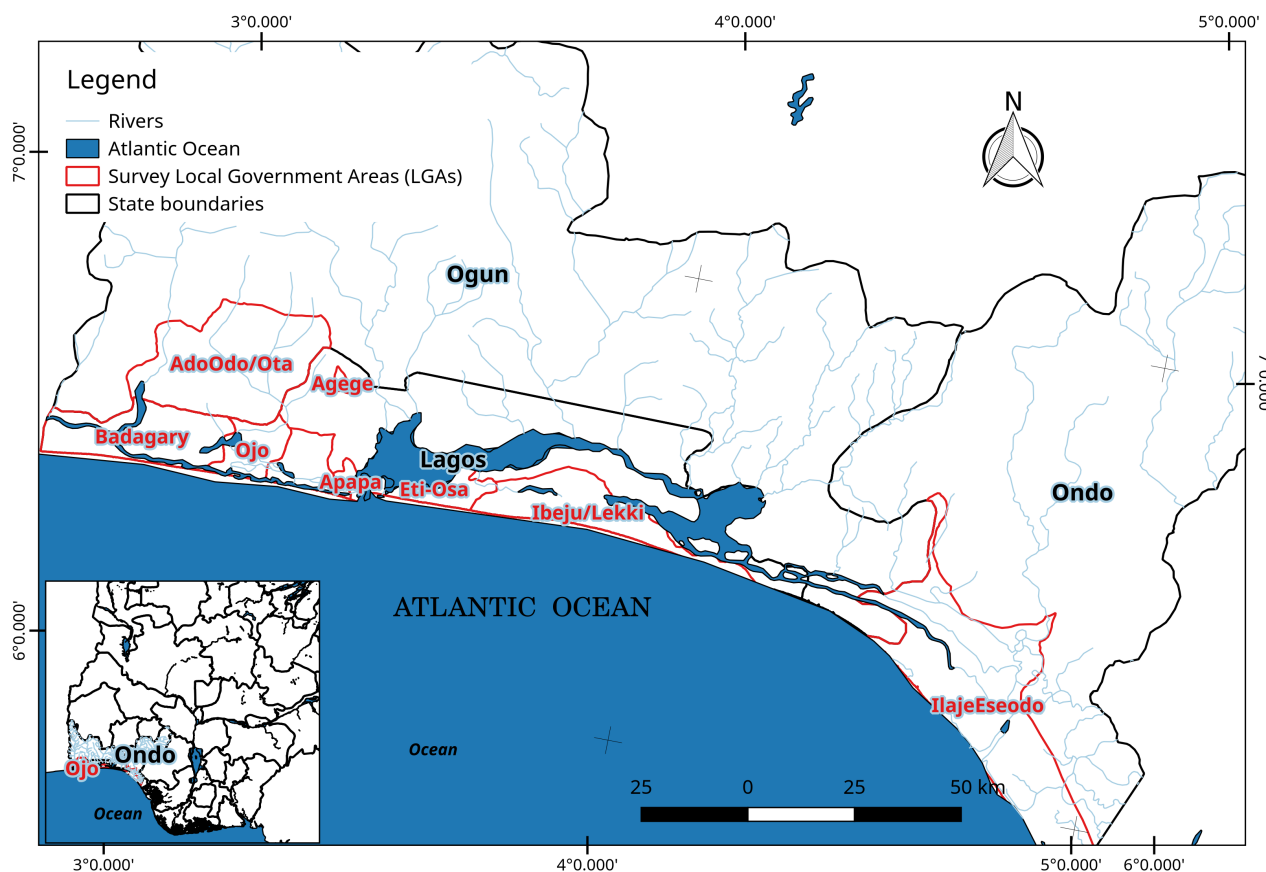


Figure 1. Coastal map of the study area. Author, 2017.

Nigerian coastal regions have several activities which contribute to the communities development and economy. Among these activities are cultural activity, coastal tourism, fishing associated with collection of shrimps, crabs, and other palatable sea organisms [12], aquaculture, boats transport and so on [13].

2.2. Survey Method

To depict the perception of coastal residents on the presence of *Sargassum* on the banks and their knowledge about climate change, a descriptive research (survey) was used, whereby quantitative and qualitative information were collected from two hundred and six (206) households heads or from persons who can answer the questions on behalf of the household's head. Based on a random sampling, the household survey was conducted in eleven (11) communities over three different states (See Table 1). For the calculation of the simple random sample size, the following formula was used:

$$N = p (1 - p) z^2 / e^2$$

where:

p : The assumed population under study

z : The confidence level value 95% (standard value of 1.96)

e : The maximum absolute error

Table 1. Shows a summary of the household sample and the sample locations.

State	Local Government Areas (LGAs)	Community	Number of household respondents	Percent (%)	
Ogun	Ado-odo	Olorunleke	26	12.6	
Ondo	} Ilaje	Araromi	29	14.1	
		Igbokoda	Larada	23	11.2
		} Ilaje	Zion pepe	20	9.7
			} Ojo/Otto-awori	Egan-oromi	25
Etegbin	18	8.7			
Igboja	8	3.9			
Lagos	} Badagry/Olohunda	Okogbo/Olohi	14	6.8	
		} Agege/Ilado-odo	Sea-beach, Idi-mango	16	7.8
			} Apapa/Amunwo odofin	Igbologun (Snake island)	13
		Ibeju-Lekki		Eleko Beach	14
		Total			206

Sample size have been adjusted (n_a) according to the size of the study population (N), as follows:

$$n_a = n / (1 + n/N)$$

where:

n : The sample size calculated for an infinite population.

N : The size of the population under study.

Questionnaire was used as data collection tool. By asking a set of questions, the surveys were made to allow comparisons across several susceptible vulnerable areas to the *Sargassum* upcoming and between diverse households' feelings. The questionnaire was structured in five (5) sections which covered each of the five study objectives. Section A provided a view of the socioeconomic status and household characteristics of the respondents in order to describe and compare households across case study locations. Section B focused on awareness and perceptions of the impacts of climate change. Section C was aimed at the communities' perception on *Sargassum natans* and *Sargassum fluitans* occurrence to find out the extent to which households are affected. Section D sought the consequences of climate change and *Sargassum* species occurrence and livelihood challenges. Then, Section E focused on the existence of any adaptation measures about climate change and *Sargassum* occurrence implemented by the households communities.

The survey's locations were selected because of their location near the coast or near lagoons and streams to ascertain the presence of *Sargassum natans*, *Sargas-*

sum fluitans in those areas. In each survey's location, the households respondents were identified and interviewed. Moreover, the questionnaire was based on both closed and open-ended questions in order to get precise, simple, logical and easy responses. It began with easy questions that raised interest of the respondent. The questions explored how livelihoods had been impacted and how communities evaluate the surrounding changes, the signs of climate change in terms of productivity of their activities. Also, the population considered for this study occupied mainly fishing, trading, farming, sell-fishing activities as principal occupation. GPS coordinates of the considered locations and some photographs were taken in order to enhance the efficiency of the observation process. Survey study period began in the middle of May 2017 and was ended in July 2017, during rainy season. This period was covered with several trips to the survey sites.

2.3. Data Analysis

After the data collection answers from the questionnaire were processed in a statistical software using the standard statistical program Libre Office Calculator version 5.1.6.2 in Ubuntu exploitation system which is similar to Microsoft Excel 2010 in Windows exploitation system for the data preparation and coding (then, transferred in R software for analysis). The qualitative data were processed and analyzed in the statistical software Rstudio Version 1.0.143 integrated development environment through the package 'R-based Qualitative Data Analysis package called "RQDA" (Huang, 2014) cited by [14]. RQDA is a new open source with computer-assisted qualitative data analysis capabilities which allow for thematic analyses of survey information. Throughout the interviews and whilst examining the obtained transcripts, several words or phrases were identified as being important. These words were coded and allowed a commonality of the words in order to evaluate the relationship between them. Then, the significant portions of the quantitative data were statistically analysed to assess the different points of view of the participants within the three states [14]. RQDA analyses were performed according to the steps presented by [15].

3. Results

3.1. Socio-Economic Characteristics of the Respondents

Table 2 presents the socio-economic characteristics of the interviewed households heads which influence respondents view point. From the 206 interviewed households, the percentage of household heads was of 52.4% at Lagos, 12.6% at Ogun and 35% at Ondo. Out of the 206 respondents, there were more male headed households than females headed households and the majority of the respondents were aged between 30 and 40 years (33%). Demographically, **Table 2** shows also that majority of the respondents (36.4%) had a family size of 4 - 6 persons. It can be noted that most of the household heads (42.2% which summarized the percent of respondents that selected the specific proposition and subtract

Table 2. Summary of the respondent's characteristics.

Household characteristics (n = 206)	Frequency	Percent (%)
Household head State		
Lagos	108	52.4
Ogun	26	12.6
Ondo	72	35.0
		100%
Gender		
Male	145	70.4
Female	61	29.6
		100%
Age		
<20	5	2.4
20 - 30	62	30.1
30 - 40	68	33
40 - 50	41	19.9
>50	30	14.6
		100%
Household size		
<4	68	33.0
4 - 6	75	36.4
7 - 9	45	21.8
10 - 12	7	3.4
13 - 15	5	2.4
16 - 18	1	0.5
<18	5	2.4
		100%
Education level		
No formal education	26	12.6
Primary school	87	42.2
Secondary school	60	29.1
Tertiary education	33	16.0
		100%

the number that selected the other propositions) attained only primary school education since less than 50% of the population had no access to tertiary education. Lagos and Ondo States accounted for the majority of the respondents who had no access to primary school education. Similarly, they also accounted majorly for those who attained only primary school with the educational distribution for the two states in a similar trend. Furthermore, compared to Ogun State, Lagos and Ondo also had the lowest literacy level. The number of respondents with at least tertiary education certificates for the three states was highest for

Ogun State. The interview also revealed that fishing, trading, farming, and fish selling were the major occupations of the respondents.

3.2. Communities' Awareness of Climate Change

Efforts were made through the administration of questionnaires to the different households ascertain their level of awareness to climate change and their general perception of the topic. The result is as shown in **Table 3**. 69.9% of the respondents were not aware of climate change while 30.1% were aware. About the source where the respondents got information or heard about climate change, the result also showed that 41.7% of the respondents were aware of these changes through personal experiences (what they feel, see, and experience). The respondents (19.9%) who have not heard about the topic did not choose any of the propositions presented by the questionnaire. Apart from them, the respondents heard about climate change principally through media (18.9%). Some heard about it through several ways such as their own observation, through a visit to a weather station (3.9%), the media and some courses attended in school (1%), the media and a visit to a weather station (1%), then only from media (0.5%), weather station (0.5%) and researchers (0.5%).

Moreover, 57.3% of the respondents thought that climate change is principally due to a natural variability. 33.5% affirmed that the real cause of the climate change was the human activities, while 9.2% affirmed that both natural variability and human activity were the probable causes of climate change. In Ogun State, majority of respondents affirmed that the human activities which contribute to the environment degradation were the reason for all the occurring change in the climate. In Lagos and Ondo States the majority of respondents affirmed that the main cause of climate change is the natural variability. According to one of the respondents "weather change always, it a normal phenomena". For them, the changes linked to the climate change are just normal mechanisms which assure the maintenance of the weather cycle. The result of the respondents' understanding of "climate change" meaning showed that larger percentage 41.7% of the total respondents perceived climate change as mainly a Change in Weather conditions and Change in Temperature (CTW). 16.0% saw it as Change in Weather conditions (CW) while 15.5% believed that climate change is

Table 3. Households' awareness of climate change.

Items	Frequency	Percent (%)
Awareness about climate change		
No	144	69.9
Yes	62	30.1
Cause of climate change		
Both	19	9.2
Human activity	69	33.5
Natural variability	118	57.3

a Change in Weather conditions, Temperature and in the Environment (CTEW). Moreover, 6.8% of the respondents perceived climate change as Change in the Environment (CE) and 6.3% were of the opinion that climate change is simply a Change in Temperature and in the Environment (CTE).

Furthermore, greater percentage of the respondents in Lagos and Ondo States saw climate change as a Change in Weather conditions and Change in Temperature (CTW). In Ogun State, Change in Weather conditions, Temperature and in the Environment (CTEW) were majorly seen by the respondents as being the same as climate change.

The perceived impacts of climate change as stated by the participants in the sites sampled were: increase in the sea level, 48.1%, increase in the occurrence of disease, 45.1%, increase of the difficulty of navigation, 63.1%, recurrence of flooding, 69.9%, increase in rainfall intensity, 78.2%, increase in the wind speed, 80.1%, increase of the sea pollution, 46.6% and occurrence of rainfall shift, 57.8%. Only, drought frequency with, 41.7% and coastal erosion, 60.7% have been qualified constant according to the respondents. Moreover, the population of Ogun State complained about the occurrence of strong winds recently that destroyed their farms and houses by removing the roofs and making trees to fall on them inducing financial challenges. Respondents in Lagos and Ondo added that the strong winds disturbed the boat transport and on some occasions led to accidents. They also observed that the fishermen navigated with difficulty. Also, the respondents in the 3 states complained about the lack of power which makes vain their efforts to tackle constant extreme heat which induces human skin diseases, suffocation and catarrh. The work also reported increment in sea pollution and a shift in the seasonal rainfall which has affected sowing time.

The result of respondents perception about the impact of climate change demonstrates that the role of climate change on the overall health and population of aquatic species can never be over emphasized. As a result of change in climate, the products of the fishery and the crop yield have decreased and that affects the household income and the welfare of their families. According to the respondents, the shrimps, crabs products have all increased while fishes are reduced. Also, the distance covered by the fishermen during fishing has increased. The distance to fishing is now longer in their fish quest and the fishermen encounter more difficulty in navigating in the tumultuous waters due to the recurrent strong wind.

3.3. Perception of the People on *Sargassum* Occurrence

The findings on the coastal population perception about *Sargassum* occurrence reveal that 71.4% of the respondents noticed the occurrence of *Sargassum* species in their areas. Furthermore, 39.8% of respondents affirmed that *Sargassum* species occurrence is not linked to climate change but more linked to the level of sea pollution while 32.5% agreed that *Sargassum* species occurrence is linked to climate change. However, in Olorunleke (Ogun State) the respondents reported

that they have not noticed the presence of *Sargassum* species in their streams. The same observation was also made of their water body at Egan oromi and Igboja (Lagos State). However, at Egan oromi, Snake island and Igboja (Lagos State), the respondents revealed the presence of another weed specie identified as being *Eichhornia crassipes*, which disturbs the movement of boat, the spreading of the nests and make the rivers and surroundings dirty. *Eichhornia crassipes* invades the water surface and dries up and within five (5) hours the water changes state and becomes salty. Its presence was also observed on the Araromi shore, together with the *Sargassum* species, helped by the waves motions.

Also, a larger number of respondents have noticed the presence of *Sargassum* species over a period less than five (5) years, a portion of the respondents agreed that *Sargassum* species occurred for more than ten (10) years. Furthermore, most of the respondents said that *Sargassum* occurred mostly during rainy season. Some affirmed that *Sargassum* occurred in abundance during both seasons (dry and rainy seasons). For the period of the field survey, we observed the presence of *Sargassum* at Lagos and Ondo States, precisely on the sea, the shores and the beaches. The species identified corresponded to *Sargassum fluitans* characterized by floats without spines according to the description by [16] [17] [18]. The species were observed at several locations along the western Nigerian coast on the 16th May 2017, 10th and 12th June 2017 (See **Table 4**).

According to the respondents, *Sargassum* presence disturbs fishing, disturbs nests, disturb boat transport and make sea and beaches dirty. Quite a negligible number of respondents talked about odour due to the decomposition and the presence of insects. Some fishermen affirmed that the fishes run away when they feel the presence of *Sargassum* which makes difficult their activity. Sometimes, the fishermen's nests catch mass of *Sargassum*. When they realise that the *Sargassum* rafts trapped fishes sometimes already dead, they are not disturbed, instead the fishers spend time to sort the contents of the nets. Thus, according to

Table 4. Locations coordinates of the observed *Sargassum* species.

Local Government Areas (LGAs)	Beaches	Coordinates GPS
Ojo	Abese beach	06°25'21.3"N/06°25'19.9"N 003°26'31.8"E/003°26'32.5"E
	Olomenta beach	06°24'01.9"N/06°24'01.6"N 003°06'27.3"E/003°06'14.2"E
	Igboja kekere beach	06°24'01.6"N/06°24'01.9"N 003°06'07.0"E/003°05'56.9"E
Eti-osa	Private beach-victoria island	06°26'59.09"N/06°26'59.99"N 003°23'58.02"E/003°23'59.99"E
Ibeju-lekki	Eleko beach	06°26'18.2"N/06°26'19.8"N 003°51'08.2"E/003°51'18.2"E
Ilaje	Araromi	06°19'23.6"N/06°19'55.5"N 004°29'15.9"E/004°29'36.7"E

the household heads the most affected people by these species invasion are the fishermen, fish sellers, and coastal population.

3.4. Consequences of Climate Change and Sargassum Species Occurrence on Livelihood

The majority of the respondents acknowledged that their activities, income, feeding, welfare and health have been affected by the effects of the climate change. Also, the majority of the respondents claimed that they are not affected by the occurrence of *Sargassum* species. Only 37.9% of them responded that their activities have been affected, 32% their incomes, 39.3% their feeding, 2.4% their welfare and 1.5% their health have been impacted by the presence of *Sargassum fluitans*. Therefore, *Sargassum* events could become a worrying problem for the areas where aquaculture plays important role in food production.

3.5. Adaptation Measures to Climate Change and Sargassum Occurrence

From the questions asked “do you have adaptation measures to climate change?” and “do you have adaptation measures to algae species occurrence? yes, no”, the majority of the household heads 87.4% responded that they do not have adaptation measures against climate change while 12.6% answered yes they have. Some of them strove against the heat by planting trees in their compound. Others turned on their generator to refresh the air. 84.5% of the respondents affirmed that they do not have adaptation measures against the presence of *Sargassum* while 15.5% answered yes they have by removing the algae from the nests or tried to take off the algae at the water surface.

4. Discussion

The socio-economic characteristics of the respondents showed that men were more in charge of family sustainability than women in respect of the life law which stipulate that men are the family chiefs. Also, the respondents were majorly aged which is an indication of their maturity to respond to the survey questions, with a small size family. This result implies that each household is likely to get or to share information about climate change from or with their fellow members as presented by [19]. Less respondents secondary and tertiary education degree implying that majority of the respondents were not really educated. This may make them more vulnerable and reduce their opportunities to access information apart from the basics ones they get from their immediate environment. In addition, it could influence the way the respondents perceive climate change and its impacts. The findings revealed trading, farming, fishing and fish selling were the respondents’ main activities. Through the fishing and fish selling experience, the respondents were able to show a clearer, concrete comprehension of *Sargassum* occurrence, and on any oceanographic change because they are more familiar with the ocean environment and they are likely to have no-

ticed the hazards linked to *Sargassum* event and to perceive directly the changes which occur over the sea. Their answers were correlated with the ones collected from the other respondents in order to get a general overview. Some of the respondents had more than one occupation. This according to them is to augment their income.

The level of awareness to climate change and their general perception revealed that the respondents were not aware of climate change. In contrast of this, 92.5% of the respondents in Umuahia South Area of Abia State, Nigeria were aware of climate change, while 7.5% of them were not aware of climate change. That is due to the fact that the majority attended tertiary institution according to [19]. The respondents lack of awareness of the climate change situation could be explained by their low literacy level. Their knowledge about climate change, its variability and its repercussions is low and limited. Climate change has been seen as a principal consequence of natural variability. These findings were corroborated by [20] research in Vietnam found. Several previous studies on perception and awareness of climate change have pointed out that a greater number of respondents are aware of climate change. Even though, they experience it on daily basis, most of those who are aware of climate change are mostly the educated ones with easy access to information through internet, media, newspapers. Similarly, [21] in Yenagoa, Bayelsa State, Nigeria demonstrated that the major sources of people' information about climate change were mainly based on their personal experiences. In addition, the respondents understood "climate change" as being the Change in Weather conditions and Change in Temperature (CTW) which is in accordance with the IPCC assessment findings; the global temperature is changing with several repercussions on the immediate weather conditions over time. The respondents expressed what they knew about the different impacts of climate change and which of them mostly affect their community. Their answers were similar to [22] results who found out that most of the climate change impacts are negative and strongly related to effects of strong winds and occurrence of excessive rains in Eastern Saloum, Senegal. Also, [23] reported that fishermen in the fishing villages in Bagamoyo District, Tanzania noticed strong winds and irregular tides which interfered with their fishing activities.

Respondents stated in addition of the aforementioned, the appearance of diseases which is in agreement with the work of [24] which reported that strong winds and stormy weather were perceived by the communities and has led to occurrence of many diseases which affected both adults and children who are most vulnerable. Furthermore, the study of [25] in Bangladesh also revealed an unusual increment and unpredictability in the rainfall pattern. About 81% of the adult and 61% of the juvenile respondents declared that frequent occurrences of cyclones were affecting more and more their coast. That was also corroborated by [26] in Pakistan where the respondents were troubled about the negative impact of climate change (76.3%) as a result of flooding and diseases. In the sites sampled the respondents complained about the increase of mosquitoes which

has also resulted in malaria prevalence in the area, the recurrence of heat rashes and catarrh due to the sudden temperature variability from hot to cold or *vice versa*.

Moreover, aquaculture, fishery and crop production have been affected over time. Similarly, [27] noted that climate change had negatively impacted crop production in south western Zimbabwe and [28] reported that in Alaska, climate change affects fishermen and fisheries through saltwater intrusion, storm surge, coastal erosion, and other oceanographic events. The atmospheric and ocean temperature variability and the shifts in ocean currents induced a great decrease in the fishes' productivity. Indeed, *Sargassum* species were absent in the streams and lagoons in the sampled sites. In contrast with the finding of [29] which reported presence of *Sargassum* species in the marginal-coastal environments (lagoons, rivers). Instead of *Sargassum*, *Eichhornia crassipes* was the specie present in those areas. The presence of this specie shows the degree to which the water body is polluted and furthering its proliferation. The respondents stated that presence of *Sargassum* over a period less than 5 years were corroborated by [10] who reported that since 2011 Caribbean islands and West African countries shores have been inundated by a mass of *Sargassum*. That could be explained by all those disturbances in the ocean environment such as increase in sea temperature, changes in global water cycle, changes in salinity which affect sea currents and marine life. Wind also affects currents which influence the transport and distribution of floating seaweeds according to [30]. These oceanic parameters are linked in such a way that any disturbance to one induces immediate imbalance in the others. However, in contrast of this, [31] findings in Texas demonstrated that the most recent period of heavy *Sargassum* landings have been between 1999 and 2007 on Galveston's beaches. *Sargassum* species occurred mainly during rainy season as reported in Côte d'Ivoire by [29] who explained that *Sargassum* species invaded coastal marine waters, beaches and lagoons around April-May-June, then begin to die during the tornado season and disappeared completely during major rainy seasons, May to July, when winds are strong, thereafter during June-July rains, the algae disappeared totally from the waters. Also, [4] emphasized on the aforementioned by reporting that *Sargassum* species occurred principally during the rainy season (May-August) in the south-western region of the coast of Nigerian. Moreover, during the field work, only *Sargassum fluitans* were observed. That could be due to the fact that when the observation was made the conditions that lead to *Sargassum natans* development and growth were not present at the time. As reported by [32] *Sargassum fluitans* is more sensitive than *Sargassum natans* meaning that any temperature disturbance which brings the sea surface temperature below or above 24°C - 30°C could affect the growth and lifetime of *Sargassum fluitans*. *Sargassum fluitans* could have been in adequate growth conditions to proliferate more than *Sargassum natans* and strands along the shores.

Moreover, each of the waves discharged the species and as a result they covered the shores where they were amassed in *Sargassum*' clod. Those which have

not been piled up were coated by the sea sand. When the decomposition starts, it attracts insects and releases a nauseous odour. *Sargassum* species disturbs marine activities as found in Nigeria by [4] who reported that fishing gears and nests have been clogged by the floating mass of *Sargassum*. This results in *Sargassum* clinging on the fishing nets thereby making preparations for fishing trips more time wasting. Thus, the beneficiaries from the marine activities products are the most touched by this event as confirmed by [10] and [4] who noted that the fishermen reported a low fish productivity and also the fishermen designated the shores, sea, and beaches as the areas most affected. Climate change affects various respondents life' levels. In a similar study, [33] found that 62.5% out of the total number of respondents interviewed agreed that the consequences of the climate change were becoming harsh in Nigeria and causing famine, socioeconomic difficulties, occurrence of diseases, rise in environmental problems and decline in natural resources in coastal communities in Nigeria. Also, [34] reported that in Ethiopia, the communities were impacted by the climate change, principally their incomes as a function of their occupations. Similar study in UK coast by [35] suggested that climate change affects coastal communities' health due to flooding and heatwaves. *Sargassum* occurrence constitutes also a source of problems for the coastal residents. As reported by [35] and [36] in Caribbean, massive influx of *Sargassum* disturbs coastal marine life (dead fish), impact socioeconomic livelihood of the coastal household. The mass of this algae affects the quantity of fishes normally caught which could be reverberated on the households whose feeding is principally based on fisheries products. Similarly, [4] and [10] work have shown that the recent influxes of *Sargassum* in Caribbean and Nigeria affect the operations of fishing, the fishermen health and disrupted coastal fishing communities. Also, the beaches in Lagos State (areas of tourism and recreation) may be affected by the accumulation of *Sargassum* species which make the places dirty and not attractive. As argued by [5] tourism was impacted by the continual intrusions of *Sargassum* into beaches followed by decomposition and the releasing of associated odors containing poisonous hydrogen sulphide which can induce fish mortality but it does not affect too much human health [36] in the study areas. Coastal populations are really vulnerable to climate change and its repercussions such as the occurrence of *Sargassum* species because of their lack of adaptation measures to cope and need help and assistance to adapt.

5. Conclusions

In summary, the quantitative analysis corroborated with qualitative analysis demonstrates the relationship between climate change, the occurrence of *Sargassum natans* and the vulnerability of the population through the qualitative network analysis based on the codes and codes categories. The most commonly repeated themes in the ensemble of the interviews administered over the sampled locations defined the relationship between each of the reported themes

which represent the different perceptions of the respondents.

The coastal population in the sites sampled, perceive the change in the climate and the presence of *Sargassum fluitans* along their coast on the water, beaches and shores, but not in the lagoons where another specie *Eichhornia crassipes* was identified. The respondents have little knowledge about both phenomena because of their low educational level and their limited information access. For the majority, climate change is just a natural variability and it is seen as a change in weather conditions and in temperature which have several consequences on the respondents' livelihood and activities. In addition, the population complained about several challenges of climate change and occurrence of *Sargassum natans* on their daily life, such as, flooding, strong wind, diseases recurrence, long distance browse by the fishermen and fishing disturbance, but they do not have any adaptation measures to cope with these events. Thus, the following recommendations are proposed:

- 1) Implementing measures to inform, to educate, and to sensitize population about climate change reality is needed;
- 2) Awareness campaign should be launched in order to assist the coastal communities in the identification of *Sargassum* species' stranding;
- 3) Sensitization and efforts should be geared towards the determination of the population vulnerability and degree to climate change with a view to providing support for them;
- 4) *Sargassum* species threatens food security, thus, a realistic evaluation of the threats through monitoring of wind and currents circulation over West-Africa in order to predict and to manage *Sargassum natans* and *Sargassum fluitans* potential should be organized;
- 5) Removal of *Sargassum* species from the open water should be carried out to address the challenges which these species pose to fishermen and their fishing activities;
- 6) Provision of assistance to the fishermen to help them adapt better to any future climate threats especially to their occupation should implemented;
- 7) As several papers praise the chemical benefits of *Sargassum natans* and *Sargassum fluitans*, the removed species could be integrated into agricultural projects as liquids or biochar fertilizers or integrated into medical projects based on their properties.

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