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ORIGINAL RESEARCH PAPER

Social vulnerability of small scale coastal fisher's livelihood to climate change

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ABSTRACT: Fisheries support livelihood of over half a billion of people globally. Many of these people live in coastal regions of developing countries; and have limited capacity to adapt and build resilience in the face of climate change. This research assesses the biophysical and socioeconomic characteristics of fishers in four coastal communities, Komenda, Elmina, Cape coast and Morree, in Ghana. Structured questionnaire based on selected indicators that serve as proxy for components of the vulnerability were administered randomly to 237 fishers through face-to-face survey. Descriptive statistics was used to determine the socio-demographic characteristics profile of fishermen and how it will affect their susceptibility to climate change. There were slight differences in the socio-demographic characteristics of the four communities, probably because of their similar physical locations and occupation. A theoretically-derived vulnerability index was used to determine their vulnerability which was based on the components of vulnerability identified from 1IPCC and capital assets identified from sustainable livelihood framework. The vulnerability index score in Morre was found to be the highest (0.64) while that of Elimina was the lowest (0.30). The size and activities in Elmina and Moree artisanal landing site did not play any role in the vulnerability of fishers in these communities rather better access to basic amenities and livelihood strategies affected their vulnerability. Since vulnerability and adaptations are highly specific to a particular people or location, this study will be used to examine the fishers' vulnerability to climate change and to target adaptation interventions in these communities.

KEYWORDS: *Coastal communities; Fishers; Livelihood; Vulnerability index*

INTRODUCTION

The role of fisheries sector is of great importance, in ensuring adequate protein intake and as a source of economic and social growth for the rural coastal communities (FAO, 2014). A great deal is at stake on the effects of natural and manmade disasters on fisheries especially in Africa. The effects of climate change may not only alter the biophysical processes of aquatic organisms, productivity of aquatic habitats and species distribution but will threaten livelihoods that are dependent on aquatic ecosystem. Vulnerability analysis provides a good tool to study and understand the impacts of climate change on fishers' livelihood. It is necessary to study the physical and human conditions that could create vulnerability to climate change.

While there are studies on effects of climate change on the production and distribution of individual fisheries (Drinkwater, 2005; Lehodey *et al*., 2006; Brander 2007, Allison *et al*., 2009), little attention has been given to the consequences of changing fisheries ecosystems on fishers, particularly to those of small scale fishers in coastal areas of developing countries who are among the most vulnerable to climate change.

Coastal communities in West Africa are characterized of high populations with extensive concentration of

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residential, industrial, commercial and other human activities. Their proximity to the ocean has exposed the coastal dweller to effects of climate change which include sea-level rise and floods arising from increasing frequency of storm surges, increased frequency and intensity of extreme weather events, saltwater intrusion and heavy rainfall of long duration or high intensity. Brander (2007) stated that sustainable fisheries will depend on efficient management of fishing activity, because of the interaction between the impacts of fishing and effects of climate change. Fishing causes changes in the distribution, demography, and stock structure of individual species which in turn affect their resilience and ability to adapt to climate change, and other pressures. This study has been carried out in four coastal communities in Ghana from October 2015 to January 2016.

Concept of vulnerability

Vulnerability has been defined differently in the various scientific areas in which it has been used (Füssel, 2010). Vulnerability assessment methodology is dependent on the conceptual framework chosen, the intended use of the assessment results and the population size (Vincent and Cull, 2010). Using IPCC (2007) definition of vulnerability to climate change as the degree to which a system is susceptible to and unable to cope with adverse effects of climate variability and climate change. This implies that vulnerability is a function of exposure, sensitivity, and adaptive capacity (Fig. 1) and is as a result of combination of prevailing geographical or ecological, socio-cultural and political conditions (Allison *et al*., 2005). Therefore, vulnerability and adaptations are highly specific to a particular people or location and are influenced by their biophysical conditions, socio-economic situations at household and community levels and institutional provisions available to them (DFID, 1999).

Vulnerability is not confined to only the devastations caused by disaster to the physical environment, but also the impact on the social, economic, and political environments which varies based on the activities of people (United Nations Office for Disaster Risk Reduction (UNISDR), 2004). This study determines a theoretically-derived index of community level social vulnerability to climate change, which is based on the three components of vulnerability identified in the sustainable livelihood framework developed by DFID, (1999) and Ellis, (2000); (Fig. 2).

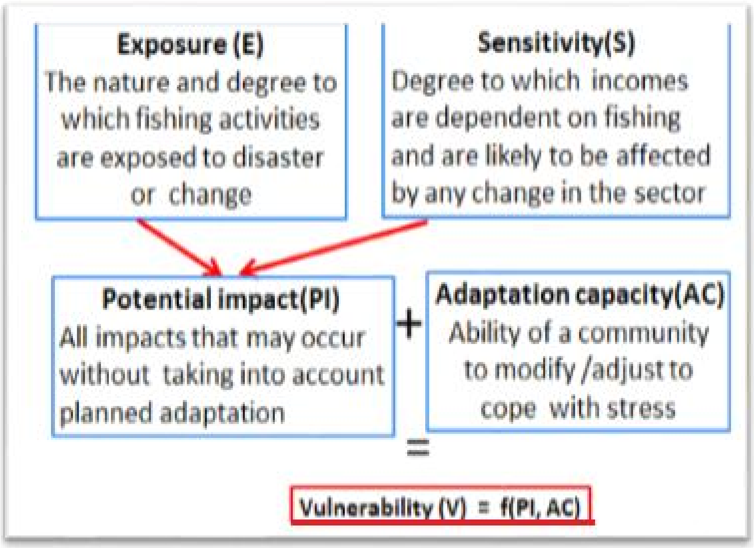

Fig. 1: Conceptual model of vulnerability of fishers; adapted from Allison *et al.* (2005)

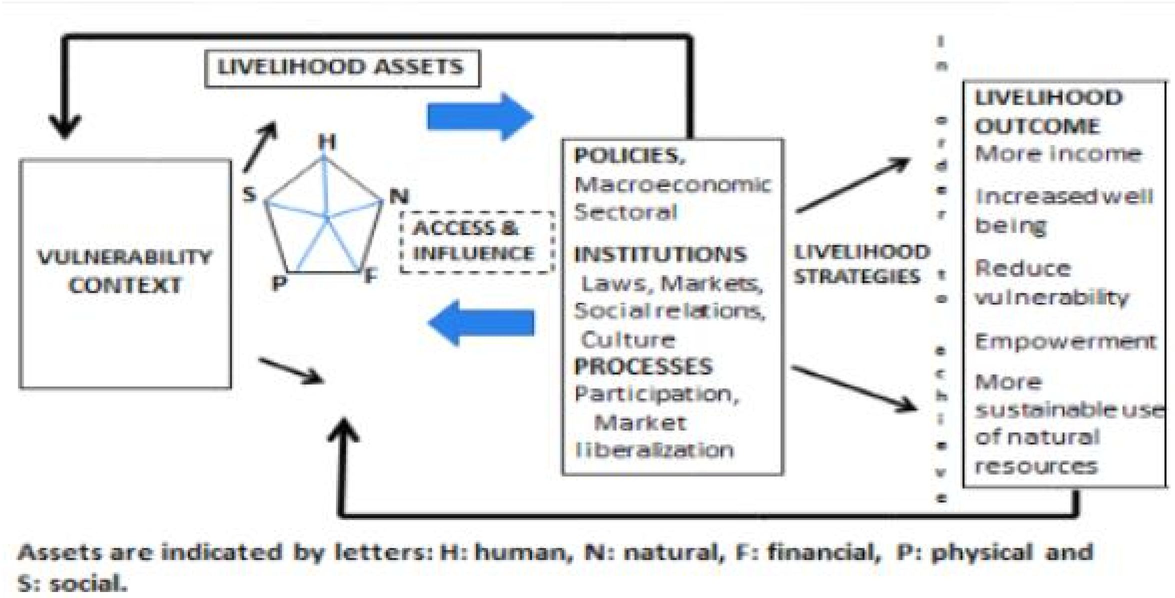

Fig. 2: Sustainability livelihood framework developed by DFID (1999)

MATERIALS AND METHODS

The study was conducted at four adjoining coastal communities in Ghana: Komenda and Elmina, Cape coast and Morree within three administrative districts: Komenda-Edina-Egyafo-Abirem, Cape Coast and Abura-Asebu-Kwamankese (Ghana Statistical Service, 2012). The study area (Fig. 3) has a coastline length of about 25 km; Komenda (Latitude 05°03ꞌ50.0ºN and Longitude 001°28ꞌ58.8ºW) and Moree (Latitude 05°13ꞌ91.2ºN and Longitude 001°19ꞌ07.4ºW) represents the western and eastern limits of the study coast. A set of structured questionnaire were administered randomly to 237 fishers, in Elmina (n = 81), Cape Coast (n = 68), Moree (n = 48) and Komenda (n = 40). Data was collected from October 2015 – January 2016. Elmina and Moree operate as artisanal landing sites while komenda and Cape Coast as landing beaches. The information on the questionnaire was obtained through face-to-face survey; the questions were based on selected indicators that serve as proxy for components of the vulnerability as shown in Table 1.

Apart from the demographic data, indicators for each of the key factors (Exposure, sensitivity, and adaptive capacity) were used in determining vulnerability. The sustainable livelihood approach was used to understand the state and dynamics of livelihood vulnerability through assessing the adaptive capacities and status of five capital assets (financial, human, social, physical and natural resources) and activities required for means of living (Vincent and Cull, 2010).

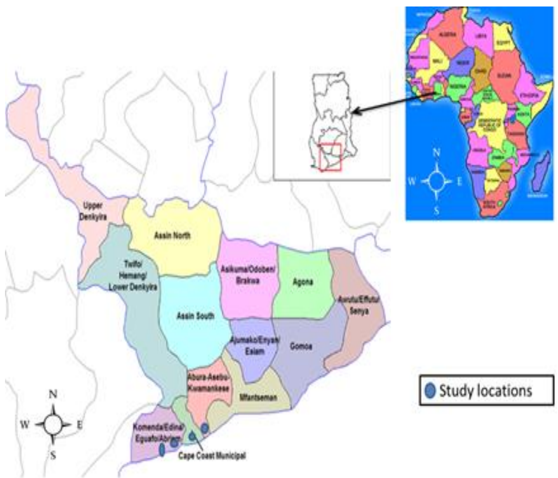

Fig. 3: Map of Africa, indicating study communities in Ghana

Data analysis

Data analysis was done using descriptive statistics such as frequency distributions and analysis of variance to determine differences at P>0.05.Vulnerability was assessed by constructing a 'vulnerability index' which was based on several set of indicators that resulted in vulnerability of the communities. The relevance of these criteria used depends on the relationship between the indicators and the supposed conditions to measure (Table 1). To measure exposures as a component of vulnerability, changes in climate variables such as temperature and precipitation (E1 - E4) were used.

Table 1: Component of vulnerability and description of component Indicators

Component of vulnerability	Description of component Indicator	FR*
Exposure **(E)** Change in Climate variables (1985-2012)	Average annual temperature **(E)**	↑
	Variance in annual temperature **(E)**	↑
	Average annual precipitation **(E)**	↑
	Variance in annual precipitation **(E)**	↑
Sensitivity **(S)**	Fishers with good source of drinking water **(S)**	↓
	% of small scale fishers in the area	↑
	Number of days in a week spent on fishing **(S)**	↑
	% of fishers dependent solely on fishing**(S)**	↑
	Average years of fishing experience **(S)**	↑
Adaptation capacity (AC)		
Social	% of fishers with family member working in a city	↓
	% of fishers that have access to climate information **(AC)**	↓
	% of fishers that participate in village meeting	↓
	% of fishers that are members of organized group **(AC)**	↓
	% of fishers that receive support from organized group **(AC)**	↓
	% of fishers that receive support from relatives outside	↓
Financial	% of fishers that give support to relatives	↑
	% of fishers that have quick mobility(car, bicycle, motorbike)	↓
	% of fishers with diversified income **(AC)**	↓
	Average amount of monthly income	↓
	Average amount of major expenses	↑
	% of fishers that have access to fund	↓
	% of fishers that have savings **(AC)**	↓
Health/human	% of fishers that own properties(boats, house, fishing equipment) **(AC)**	↓
	% of fishers with members under 15 and over 65 years	↑
	Average time and distance to health facility	↑
	% of fishers with sick family member	↑
	Average amount of money spent on sickness	↑
	% of fishers with at least two prevailing illness	↑
	% of fishers with good cooking and toilet facilities **(AC)**	↑
	% of fishers eating at least two major meals **(AC)**	↓
	% of fishers with formal education **(AC)**	↓
Physical	Average time and distance to school	↑
	Average time and distance to government facility(district headquarters, police station)	↑
	% of fishers with electricity **(AC)**	↓
	Presence and Types of Government / NGO interventions	↓
	% of fishers with good quality house **(AC)**	↓
	% of fishers with access to market **(AC)**	↓
	% of fishers that have access to government support **(AC)**	↓

Sensitivity of the fishers was captured using human conditions that could affect the change or activate an impact such as source of drinking water, time spent in fishing and depending on fishing only (S1 – S4). The Adaptive capacities (AC1 – AC15) that reduce or avert effects of potential impacts and to build up their assets were used. Vulnerability index was calculated from the weighted aggregation of 6 composite sub-components, formed from three or more indicators that are sensitive enough to detect variations (Yohe and Tol 2002, Vincent, 2007). The final aggregate scores were normalized across the range of data to permit averaging using equations 1 and 2. The method used took into account the functional relationship between the variable and vulnerability (UNDP, 2006). When vulnerability increases with increase in the value of the indicator, the variables have increasing (↑) functional relationship and the normalization is done using the Eq. 1. When vulnerability decreases with increase in value of indicator, the variable will have decreasing (↓) functional relationship with vulnerability and Eq. 2 is used. Vulnerability index is calculated by summation of sub-indicators and dividing by the number of sub indicators. The vulnerability score were scaled between 0 (not vulnerable) and 1 (high vulnerability). Community with highest index is said to be most vulnerable and it is given the rank 1, the region with next highest index is assigned rank 2 and so on.

(actual value - minimum value)/(maximum value - minimum value) (1)

(maximum value- actual value)/(maximum value - minimum value) (2)

RESULTS AND DISCUSSION

Socio-demographic characteristics profile of fishermen

The socio characteristics of respondents in artisanal landing sites and landing beaches were obtained to determine whether it will affect their susceptibility to climate change. The interviewed fishers in the four communities were all males, and 75.3, 64.7, 68.8 and 90% of respondents in Elmina, Cape Coast, Moree and Komenda respectively were head of their family. The respondents had a mean age of 43.04 years; majority (72.4%) of them was in the age range between 20 - 50 years; 16.2% was between 51 - 60 years and only 8.3% were above 60 years. This implies that the fishers are still in their active age and are productive. The Family size of the fishermen was categories into small family (0-4), medium family (5-9) and large family (above 10). The highest percentage was obtained in the medium family (54%) and the lowest percentage was obtained in large family (4%). Interestingly, the respondents' family size (75.4%), number of dependents (93.7%) and number of rooms (86.1%) respectively were less than 10. Among the interviewed fishers, 22.6%, 34.6%, 23.9 % had 10, 20 and 30 years fishing experience respectively while the married fishers in the Elmina, Cape coast, Morre and Komenda were 78%, 92.6, 93.3 and 92.5 respectively. Family type was classified into two types: nuclear family- married couples with children and extended family- couples with group of people related by blood or by law. It was found that 44.2%, 44.8%, 79.2% and 32.5% of the people lived in extended families in Elmina, Cape Coast, Moree and Komenda respectively. In an attempt to examine the assets the respondents have in the face of climate change; they were asked relevant questions which has been summarized as shown in Table 2. Fishers vulnerability differs based on their capacity to absorb and cope with climate change.

Access to assets and resources varies across the communities; thus impact of climate change on the fishers in different communities may differ. Most respondents had no formal education; with more indicating finishing primary as compared to lower or higher secondary school. Respondents that had formal educational were 67.5%, 41.8 %, 33.3%, and 15.3% for Elmina, Cape Coast, Moree and Komenda respectively. These values were significantly different from each other. Concrete building with galvanized roof is an indication of good quality housing while water closet and running tap water indicate good sanitary condition. Elmina had higher values in all the components except in support from government, access to electricity and fund, and adequate meal which Komenda recorded higher values.

Scores of the components of vulnerability (exposure and sensitivity) for the four communities are reported in Table 3. Exposure is computed from the four sub-components: average annual temperature (E_1); variance in annual temperature (E_2); average annual precipitation (E_3); and variance in annual precipitation (E_4). Sensitivity was computed from percentage (%) of Fishers with good source of drinking water (S_1); Number of days in a week spent on fishing (S_2); % of fishers that depend solely on fishing (S_3); and average years of fishing experience (S_4). From the result, Moree is more exposed to climate variability but the differences in values were not significant for all the communities. Sensitivity of fishers in Komenda is highest indicating that effect of climate variability is felt more on the fishers from this community while it is low in Elmina. However, the number of days spent fishing and average years of fishing experience differ for the communities.

Adaptive capacity and scores of the components of vulnerability (social and financial assets) for the four communities are reported in Tables 4 and 5. The Social assets were computed from the four sub-components; % of fishers that have access to climate information (AC_1); % of fishers that are members of organized group (AC_2); % of fishers that receive support from an organized group (AC_3); % of fishers that own properties (boats, fishing equipment) (AC_4); and financial assets

Table 2: Values of indicators of vulnerability for the four communities

Components	Elmina	Communities Cape coast	Moree	Komenda
Formal education	67.5a	41.8b	33.3b	15.3c
Good quality housing	95.7a	83.8a	92.7a	92.5a
Good cooking place	28.4a	13.2a c	16.7a c	23.1a b
Good toilet facility	13a	12.5b	8.1c	8.0b
Good source of water	98.8a	92.6a b	93.8a	84.2b
Access to climate information	93.8a	100a	100a	100a
Access to electricity	98.8a	92.6a b	92.7a	100a b
Access to market	100a	98.5a	100a	100a
Own properties	63a	75a	89.5a b	80a
Own communication gadgets	95.1a	94.1a	87.5a	82.4a
Have diverse income	17.3a	7.4a	6.2a	5.0c
Have Government support	58a	58.8a b	39b	70c
Have adequate meal	58a	60.3a	52.1a	67.5a
Have savings	65.4a	72a	60.5a b	72a c
Access to fund	24.7a	22.1a	27.1a	42.5c
Member of support group	49.4a	52.9a	58.3a b	42.5a c
Receive support from group	32a	17.6a	31.1a	12.5a

Notes: Values in each row with the same alphabets are not significantly different at $p < 0.05$

Table 3: Scores of exposure and sensitivity for the four communities

Communities	Exposure					Sensitivity				
	E_1	E_2	E_3	E_4	Total	S_1	S_2	S_3	S_4	Total
Elmina	0.75	0.67	0.57	0.46	0.61	0	0	0	0	0
Cape Coast	0.5	0.67	1	0.12	0.57	0.42	1	1	0.45	0.71
Moree	1	1a	0.57	0	0.64	0.34	1	1	0.55	0.72
Komenda	0	0a	0	1	0.25	1	0	1	1	0.75

from % of fishers with diversified income(AC_5); % of fishers that have access to fund (AC_6); % of fishers that have savings (AC_7) (Table 4). Fishers in Moree and Komenda had better social and financial assets respectively. Fishers in Morre belong to organized group and have properties which can be assets to fall back on if fishing fails or it can be a liability if it is not utilized. Scores of the components of vulnerability (health/ human and physical assets) for the four communities are reported in Table 5. The Health/human is computed from the five sub-components: % of fishers with good cooking facilities (AC8); % of fishers with good toilet facilities (AC9); % of fishers eating at least two major meals a day (AC10); % of fishers with formal education (AC11); while Physical assets are from % of fishers using electricity (AC12); % of fishers with good quality house (AC13); % of fishers with access to market(AC14); % of fishers that have access to government support (AC15). In terms of health and physical assets, fishers in Elmina and Komenda have the lowest scores respectively, which imply that they have better assets to copy in face of any climate change or disaster.

The sub-components of vulnerability were used to calculate the vulnerability index and presented in Table 6. The vulnerability index score in Morre was found to be the highest (0.64) which is next to Cape Coast (0.63) while Elmina has the lowest score of 0.3.

Fishers are threatened by changes in climate conditions that are ultimately driven by rising global atmospheric temperatures, precipitation fluctuation and increased frequency and severity of extreme weather condition. There were slight differences in the socio-demographic characteristics of the four communities, probably because of their similar physical locations and occupation. The interviewed fishers in the four communities were all males in their productive age. This shows that some occupations in Africa are gender skewed which could be attributed to cultural inclinations and risk associated with fishing in ocean. The men usually go out to fish on sea, while the women purchase, process and market the fish when the boats land. Most of the fishers were married with extended family members and medium family size which is typical of African culture of having communal living.

Table 4: Score of adaptation using social and financial capital assets

	Social					Financial			
	AC_1	AC_2	AC_3	AC_4	Total	AC_5	AC_6	AC_7	Total
Elmina	0	0.56	0	1	0.39	0	0.87a	0.57	0.48
Cape Coast	0.08	0.34	0.74	0.55	0.43	0.8	1	0	0.60
Moree	0.6	0	0.04	0	0.16	0.9	0.75	1	0.88
Komenda	1	1	1	0.36	0.84	1	0	0	0.03

Table 5: Score of adaptation using health and physical assets

Communities	Health					Physical				
	AC_8	AC_9	AC_{10}	AC_{11}	Total	AC_{12}	AC_{13}	AC_{14}	AC_{15}	Total
Elmina	0	0	0.62	0	0.16	0.16	0	0	0.36	0.13
Cape Coast	1	0.1	0.47	0.49	0.52	1	1	1	0.39	0.85
Moree	0.78	0.98	1	0.66	0.86	0.32	0.25	0	1	0.39
Komenda	0.35	1	0	1	0.59	0	0.27	0	0	0.06

Table 6: Vulnerability index score of the communities

Communities	Exposure	Sensitivity	Adaptations	Index	Rank
Elmina	0.61	0	0.29	0.3	4
Cape Coast	0.57	0.71	0.60	0.63	2
Moree	0.64	0.72	0.57	0.64	1
Komenda	0.25	0.75	0.45	0.48	3

Fishing is the main occupation of the coastal communities which have been practiced by their fathers and passed on to the children because most of them have 10-30 years fishing experience. In each community, formal education is based on those that attended primary, lower secondary or upper secondary. No formal education indicates that time spent away from school was used in fishing. Majority of the respondents had no alternative means of livelihood which implies that any major climate change event will affect their livelihood.

Exposure to impact of climate change in these communities did not differ significantly because they are along the coast and experience similar climate conditions. Adaptive capacity and access to assets varies across the fishers in these communities hence their vulnerability differs.

This induced disparity in impact of climate change on the fishers in different communities is caused by reduced susceptibility and ability to cope with adverse effects of climate variability. Therefore, Vulnerability index is a readily available method to determine the communities with the highest relative vulnerability for adaptation intervention. The slight changes in adaptive capacity between the communities may be attributed to the socio-demographic profile, level of education and livelihood strategy. Identifying the fishers socio-demographic is important in vulnerability assessment and effectiveness to cope with disaster (Lavell, 1999).

The varied socio-demographic response was due to the high family size and high proportion of young people in the fishing business. Livelihood strategies such as; when income is derived from more than one source, any risk will be distributed among the sources. Access to fund and financial assistance from government were other major livelihood strategies that helped these communities to face climate impacts. Sensitivity of fishers in Komenda has been attributed to the work experiences they had and the number of days they spent fishing.

The longer the time spent on fishing, the more the effect of the change on them. However their access to fund and savings made them have better ability to cope. Elmina was found to be the least vulnerable because of better access to basic amenities and livelihood strategies, whilst Moree was found to be highly vulnerable in respect to high sensitivity and less adaptive strategy. Correlation study revealed that level of education increases with better access to good drinking water and proper sanitary conditions, access to climate information and lesser time spent on fishing. The variations in values of adaptive asset indicators between the larger and smaller fish landing sites were not significant. The size and activities in Elmina and Moree artisanal landing sites did not play any role in the vulnerability of fishers in these communities and they ranked the lowest and highest respectively.

CONCLUSION

Since vulnerability and adaptations are highly specific to a particular people or location, a better understanding of the vulnerability of fishers in these communities will help in fisheries management and to target adaptation interventions to the highest relative vulnerable communities.

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CONFLICT OF INTEREST

The authors declare that there are no conflicts of interest regarding the publication of this manuscript.

REFERENCES

Allison, E. H.; Adger, W. N.; Badjeck, M. C.; Brown, K.; Conway, D.; Dulvy, N. K.; Halls, A.; Perry, A.; Reynolds, J.D., (2005). Effects of climate change on the sustainability of capture and enhancement fisheries important to the poor: analysis of the vulnerability and adaptability of fisher folk living in poverty. London, Fisheries Management Science, Programme MRAG/DFID, Project no. R4778J. Final technical report. 164.

Allison, E.H.; Perry, A.L.; Badjeck, M.C.; Neil Adger, W.; Brown, K.; Conway, D.; Halls, A.S.; Pilling, G.M.; Reynolds, J.D.; Andrew, N.L.; Dulvy, N.K., (2009). Vulnerability of national economies to the impacts of climate change on fisheries. Fish and Fisheries, 10(2): 173-196 (**24 pages**).

Brander, K.M., (2007). Global fish production and climate change. Proceedings of the National Academy of Sciences, 104(50): 19709-19714 (**6 pages**).

Drinkwater, K.F., (2005). The response of Atlantic cod (Gadus morhua) to future climate change. ICES J. Marine Sci., 62(7): 1327-1337 (**11 pages**).

Department for International Development (DFID), (1999). Sustainable livelihoods guidance sheets. London: DFID.

Ellis, F., (2000). Rural livelihoods and diversity in developing countries. Oxford: Oxford University Press.

Food and Agriculture Organization (FAO), (2014). The State of World Fisheries and Aquaculture 2014 FAO Fisheries and Aquaculture Department, Food and Agriculture Organization of the United Nations, Rome, (**223 pages**).

Füssel, H.M., (2010). Review and quantitative analysis of indices of climate change exposure, adaptive capacity, sensitivity, and impacts. Background note to the world development report, World Bank, Washington, DC. (**34 pages**).

Ghana Statistical Service, (2012). 2010 population and housing census: Summary report of final results. Accra: Ghana Statistical Service. (11pages).

IPCC, (2007). Climate Change Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Eds M.L. Parry, O.F.

Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson,., Cambridge University Press, Cambridge, UK, (**976 pages**).

Lavell, A., (1999). Environmental degradation, risk and urban disasters. issues and concepts: Towards the definition of a research agenda', in M.A. Fernandez (ed.), Cities at risk: Environmental degradation urban risks and Disasters in latin America, LA RED, The Network for social studies on disaster, Lima, Peru, 19–58 (**40 pages**).

Lehodey, P.; Alheit, J.; Barange, M.; Baumgartner, T.; Beaugrand, G.; Drinkwater, K.; Fromentin, J.M.; Hare, S.R.; Ottersen, G.; Perry, R.I.; Roy, C., (2006). Climate variability, fish, and fisheries. J. Climate, 19(20): 5009-5030 (**22 pages**).

United Nations Office for Disaster Risk Reduction (UNISDR), (2004). Living with risk: A global review of disaster reduction initiatives, UNISDR, Geneva.

United Nations Development Programme (UNDP), (2006). Human development report, United Nations Development Program.

Vincent, K., (2007). Uncertainty in adaptive capacity and the importance of scale. Global Environmental Change, 17(1): 12-24 (**13 pages**).

Vincent, K.; Cull, T., (2010). A household social vulnerability index (HSVI) for evaluating adaptation projects in developing countries. In PEGNet Conference 2010: Policies to foster and sustain equitable development in times of crises. Midrand, 16: 2-3 (**2 pages**).

Yohe, G.; Tol, R.S., (2002). Indicators for social and economic coping capacity—moving toward a working definition of adaptive capacity. Global Environ. Change, 12(1): 25-40 (**16 pages**).