Climate Variability, Coastal Vulnerability and Resilience: Mainstreaming Climate Adaptation in the Dangme East District of Ghana

Authors: Margaret Appiah, Aaron K. Christian, Yaw D. Atiglo and Joseph Intsiful

Introduction:

The coastal zone and its eco-system provide numerous benefits to mankind. An increase in the intensity of climatic extremes precipitated by climate change threatens the sustainability of coastal resources and livelihoods (Wu et al., 2002; IPCC, 2011; Burkett et al, 2012). The coastal communities in the Dangme East and West Districts in the Volta Delta of Ghana, which largely depend on natural resources for livelihoods and general sustenance, are susceptible to the vagaries of climate variability and change.

The rise in sea level, rise in sea surface temperature, coastal flooding and intensification of tropical cyclones induced by climate variability and change affect human life in diverse ways; including health (infectious diseases, food security) and livelihoods. The observed changes also cause damage to coastal infrastructure, saltwater intrusion into coastal freshwater resources, damage to coastal ecosystems, coral reefs and coastal fisheries, as well as population displacement (Nicholls et al. 2007, Harley et al. 2006). With a climate dependent economy, the Dangme East District is faces unique changes in climate variability has diverse economic consequences. The sea is an important economic resource for the people in Dangme East. The inhabitants in the district depend on the sea as well as the River Volta for fish, a source of nutrition and income. Salt mined or harvested from the sea provide additional income for the populace. The coastline with its flora and fauna and historical monuments provide beautiful scenery for thriving tourism industry. Aside the economic value of the sea and the Volta River,

they also have recreational purposes such swimming and outdoor games.

The coastal stretch of the Dangme East District is prone to sea erosion resulting from multiple factors including; sea-level rise (SLR), sand winning and depletion of mangrove vegetation. Although the impact of climate-related hazards are largely due to the physical characteristics such as low lying and low sloped, it is acknowledged that assessment of how the hazards interact with socioeconomic factors is key in identifying vulnerabilities (Cutter et al. 2000; Wu et al.2002; Preston et al. 2008). This study therefore assesses the pattern and trend of climatic conditions (rainfall and temperature) as well as physical and social conditions in the Dangme East District and how they exacerbate vulnerability of the communities and its implication for adaptation.

Objective:

The main objective of the study is to examine the climatic patterns and vulnerability of the coastal the coastal communities in the Dangme East District and its implication for adaptation.

Specifically, the study seeks to;

- Assess/characterize the baseline (1970 - 2010) agro-climate and hydro-climate in the Dangme East District of Ghana.
- Examine the impact of the climatic patterns on key socio-economic sectors
- Identify the potential strategies for building resilience.

Methodology:

The setting

The Dangme East District is located in the South Eastern part of the Greater Accra Region of Ghana. Major settlements in the district include Big Ada, Kasseh, Got, Anyamam, Lolonya, Akplabanya, Wokumagbe, Koluedor and Ada Foah, which is the administrative district capital and the only synoptic station in the district where climatic events are recorded. It is predominantly rural (69.2%) district with a population size of 130,795. It has the highest average household size (4.7). It has the highest dependency ratio in the Greater Accra Region, a situation which is likely due to a youthful population of (age 0-14 is 40.3%) and relatively large proportion of the elderly (5.5%) (GSS, 2013). High rate of out-migration and the potential remittances provide additional source of income for households. It is predominantly rural (69.2%). The main economic activities are salt mining, tourism, with highest proportion of people skilled in agricultural, forestry and fishery (37.1%), which are climate dependent. The district is important for the cultivation of fruits and vegetables for Accra, the capital of Ghana.

Data and analytic tools:

Secondary source of data were largely used as well as field observation. Temperature and precipitation data between 1970 and 2010 from the Ada synoptic station in Dangme East District were collected from the Ghana Meteorological Agency (GMA). The analytical tools used for the analyses of the climate data were RClimdex and the NewLoclim. The errors in the data were cleaned using quality control checks embedded in the RClimdex tool. The quality checks showed errors in Min and Max temperatures (Max: Feb 5 1970 and Feb 14 1976; Min 1985 as well as outliers. Corrections were made based on expert judgement. While NewLoclim provides description of climate of a location, RClimdex tool provides analysis of temperature and rainfall trends over the time. The information used for physical and social vulnerability assessments were obtained from existing documents; Wiafe et al. (2013) and Ghana Statistical

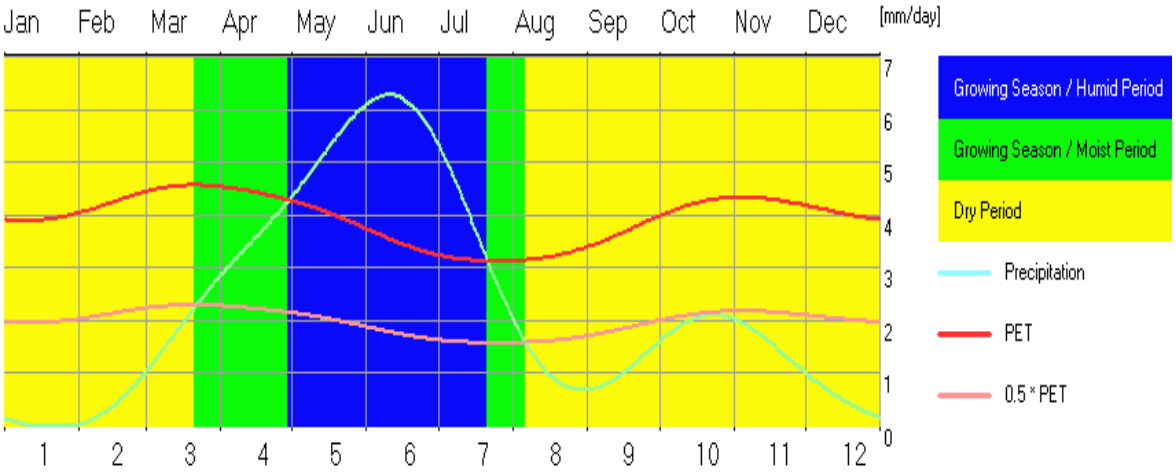
Service (2013) respectively. The index was computed using Z-scores. The results from both the physical and social vulnerability were put together and categorised as very high, high, moderate and low vulnerabilities. The primary source of information including the impact of sea erosion was through field observation.

Result:

Rainfall Pattern:

The area falls within the arid climate with precipitation characterised by hot conditions and deficit in precipitation. The area is characterised by uni-modal rainfall pattern, which occurs between late April and mid-July, which peaks in June, as shown in Figure 1. Rainfall total fluctuated over the period. The highest total rainfall was recorded in the early 1970s and late 1990s. Although the rainfall pattern shows a declining trend, there is no significant change in the trend observed. It has relatively short growing season (between late March and early August) and extended dry season, spanning from early August to late March. Precipitation peaks in June which experienced 16 rainy days, representing the peak of the humid period. The radiative index of dryness (the ratio of local radiation balance and the energy needed to evaporate all precipitation) is 2.111. Compared with Accra Metropolitan Assembly, the Dangme East District has a high radiative index, hence dryer than Accra. This is largely due to the high evaporation ratio resulting in the loss of about ninety percent of rainfall received in the area. The depletion of vegetation cover could partly be accountable for the high evaporation rate experienced in the area. The evaporation and runoff ratio in the area is 90.2 and 9.8mm per year respectively. The moisture index is -42%, an indication of excessive dry conditions in the area.

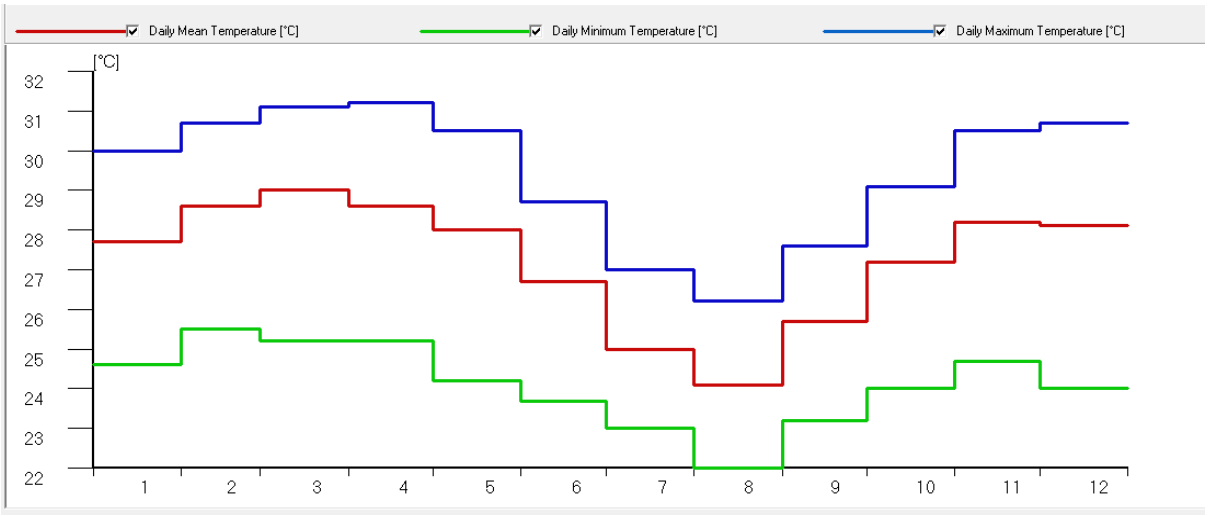
Figure 1: The pattern of precipitation in the study area



Source: Computed using GMA data, 2012

Temperature pattern: Temperatures are highest in the months March and April (31.10 and 31.20, respectively) with a mean of 29 degrees Celsius as shown in Figure 2. Temperature shows increasing trend with wide variability observed in the diurnal temperature range (DTR) with no significant change over time. However, temperature in the warm nights, indicated by the percentage of days when minimum temperature is greater than 90th percentile has seen a significant upward trend. Again, warm spells indicator (WSDI) i.e. the number of days when maximum temperature (TX) > 90 percentile (at least 6 consecutive days) has also increased significantly. The monthly minimum value of daily minimum temperature and the monthly maximum value of daily minimum temp (TNX) have all increased significantly.

Figure 2: Pattern of Daily Temperature



Source: Computed using GMA data, 2012

The significant rise in temperatures have affected the cool days and nights. Cool nights and days, that is the percentage of nights and days respectively when maximum temperature (TX) is less than tenth percentile, have seen a significant downward trend, an indication of warmer days and nights.

Physical vulnerability:

The Dangme East is sandy and geologically characterised by alluvial sand, silt, and clay. Elevation range between > 5 and <10 with erosion rate of 3.2 meters per year. In comparison with other districts along the coast of Ghana, physical assessment of the district shows very high physical vulnerability as shown in Figure 3 and Table 1.

Figure 3: .Physical vulnerability of Ghana's Coast

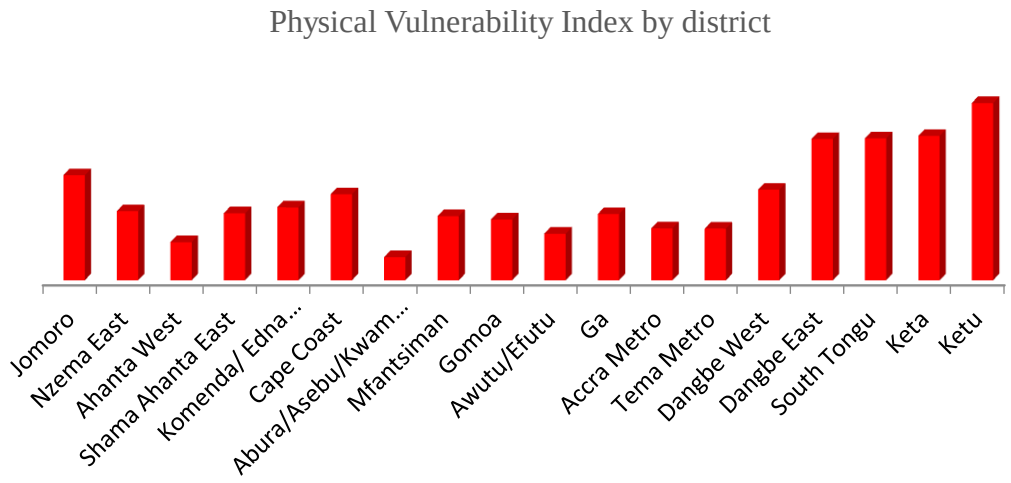


Table1: Vulnerability index by coastal districts in Ghana

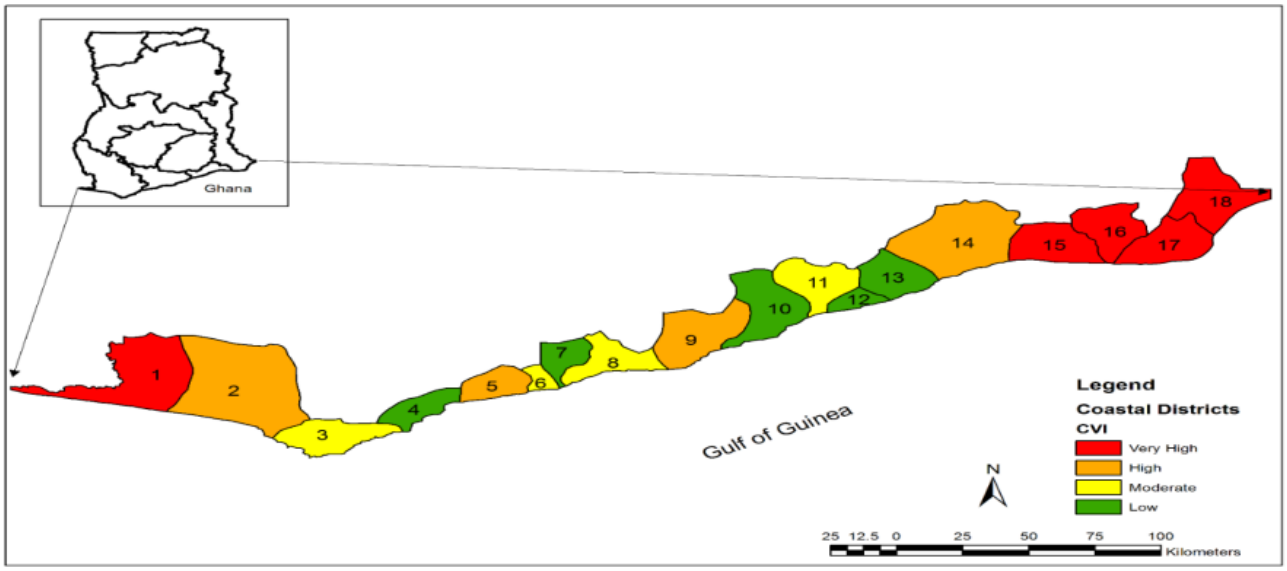
District	SV Index	PV Index	CVI
Jomoro	0.749	0.530	1.279
Nzema East	0.2749	-0.343	-0.068
Ahanta West	0.189	-1.093	-0.904
Shama Ahanta East	-0.871	-0.393	-1.264
Komeda Edna Eguafo Abire	0.103	-0.251	-0.148
Cape Coast	-0.876	0.067	-0.808
Abura Asebu Kwanmankese	0.132	-1.456	-1.324
Mfanatsiman	-0.165	-0.463	-0.628
Awutu Efutu	-0.198	-0.889	-1.087
Ga	-0358	-0.411	-0.769
Accra Metro	-1.068	-0.760	1.827
Tema Metro	-0.5125	-0.7650	-1.278
Dangme West	0.3941	0.1781	0.5572
Dangme East	0.8875	1.4066	2.294
South Tongu	0.3242	1.4826	1.748
Keta	0.5068	1.4826	1.989
Ketu	0.3784	2.2797	2.658

Source: computed with data from GSS (2010) and Wiafe et al. (2013)

Social Vulnerability:

The vulnerability of communities to climate induced outcomes is determined by number of factors, including social and economic factors. It has been observed that significant risk of climate change occurs when large groups of people with high social vulnerability are exposed to climate-related hazards (Cooley et al. 2012). Social vulnerability index provide the means to compare overall vulnerability of across and within geographical boundaries. Social vulnerability among coastal districts along the coast of Ghana was measured using nine indicators of vulnerability. Population density, population in agricultural employment, Household with no toilet facility, houses with weak building materials, household using unsafe source of drinking water, illiterate household heads, dependency, doctor population ratio and households with no electricity. With a Z- score of 0.8875, the Dangme East District was the district with the highest social vulnerability. The Dangme East District, which is the fifteenth district on the map in Figure 4 is among the districts with very high vulnerability (both physical and social vulnerabilities).

Figure 4: Cumulative vulnerability among coastal districts in Ghana



Discussion:

Temperature has direct impact on sea surface temperature which influences fish availability and fish catch, that is, both fishing in the river and the sea. Sea surface temperature causes the activity levels of fish to increase or decrease, affects the direction of movement, feeding and reproductive activity. Evidence shows that climate directly affects the productivity and fish catch. Lower catch rates of Round Sardinella fish is correlated with higher sea surface temperatures (SST) in contrasts with the anchovy, which has lower catch rates in higher SST (Dontwi et al. nd.).

Fish are unable to regulate their body temperature, so they are influenced by the temperature around them. When the water is warm, fish metabolism accelerates, feeding and respiration increases, and there is a general increase in movement. If the water is cooler, fish become lethargic and tend to be inactive. Sudden changes in temperature could also trigger fish

migration ((DFID, 2007; Fish Research, 2009).

Fish provide valuable complement to the starchy diet of the global poor. The direct human consumption fish reached an estimated 103 million tons in 2003. Increasing temperatures observed in the study area, coupled with a decline in the number of cold nights negatively affects the fishing industry as well as the nutritional requirements of the communities that depend on it. Some fishermen have lost their livelihood as a result of poor fish catch while others have found other sources of livelihood. In other instances, some fishermen have moved to neighbouring towns and countries for fishing.

Sea erosion has had heavy toll on the social and economic life of the people. Dwelling units, burial places and key infrastructures such as school buildings, churches, and shrines have been inundated by sea erosion. The washing away of burial places has both health and spiritual implications. Exposure of tombs can potentially contaminate water bodies. The tourism industry also suffers from the loss of historical monuments due to sea erosion.

Climate dependent economic activities such as farming, fishing and salt mining are affected by both dry conditions and rise in temperature. The long dry period is generally not favourable for crops with long gestation period. The salt mining industry require adequate sunshine for evaporation, which is critical in the mining of salt, hence increasing temperatures have favourable influence on the salt mining industry. Salt water intrusion can arise as a result of sea erosion and can compromise on the quality of water sources for domestic use in the area.

The hot and humid weather conditions coupled with poor housing conditions promote the development heat rashes, vector borne and other infectious diseases.

The dumping of refuse as means of land reclamation and open defecation as used by households as coping strategies for sea erosion facilitate the breeding of mosquitoes resulting

in negative health consequences.

Conclusion

Climate variability and change presents both opportunities and challenges for the Dangme East District. Major sectors of development such as livelihoods, health and health care delivery, infrastructure and food production in the area are all sensitive to climate impacts. In addition the physical characteristics, including the topography, location and susceptibility to erosion, the district also have high social vulnerability. The implications of these on adaptation of the communities in the area are numerous. The communities in the district have comparable lower capacity to adapt to their vulnerabilities. Some of the strategies adopted for coping such a the use of refuse for land reclamation are weak and heightens their vulnerabilities.

To adapt to the prevailing climatic conditions in the area require mainstreaming climate adaptation in the short, medium and long term development plans in all sectors of the district. It is acknowledged however that an effective climate adaptation hinges on community participation and decision making. A cross sector analyses is therefore proposed for a participatory selection of appropriate adaptation strategies with optimum benefits that would not conflict with each other or result in mal-adaptation. Future assessment requires an analysis of knowledge and perceptions on climate change and its consequences on the wellbeing of the people as well as the adaptation options.

Reference:

Burkett, V.R. and Davidson, M.A. [Eds.], (2012). Coastal Impacts, Adaptation and

Vulnerability: A Technical Input to the 2012 National Climate Assessment. Cooperative Report to the 2013 National Climate Assessment, pp. 150.

Cooley H., Moore E., Heberger M., Allen L. (2012). Study Maps Social Vulnerability to Climate Change in California and Identifies Need for Adaptation Planning. http://pacinst.org/publication/study-maps-social-vulnerability-to-climate-change-in-california-and-identifies-need-for-adaptation-planning/

Cutter, S.L., Mitchell, J.T. and Scott, M.S., (2000). Revealing the vulnerability of people and places: A case study of Georgetown County, South Carolina, Annals of the Association of American Geographers, 90 (4): 713-737.

DFID (2007). The threat to Fisheries and Aquaculture from Climate Change, World Fish Center. http://www.worldfishcenter.org/resource_centre/ClimateChange2.pdf.

Dontwi J., Dontwi I.K., Buabeng F.N., Ashong S. (nd). Vulnerability and Adaptation Assessment for Climate Change Impacts on Fisheries: Vulnerability and Adaptation Assessment under the Netherlands Climate Assistance Programme (NCAP).

http://www.nlcap.net/fileadmin/NCAP/Countries/Ghana/FISHERIES_DRAFT_FINAL_REPORT.pdf

Fish Research (2009). Sea Surface Temperature. http://www.fishresearch.org/sea-surfacetemperature/

Harley, C.D.G., Hughes, A. R., Hultgren, K. M., Miner, B. G., Sorte C. J.B., Thornber, C. S., Rodriguez, L. F., Tomanek, L., and Williams S. L. (2006). "The impacts of climate change in coastal marine systems." *Ecology letters* no. 9 (2):228-241.

IPCC (Intergovernmental Panel on Climate Change), (2001). Technical summary: climate

change 2001: impacts, adaptation, and vulnerability, A Report of Working Group II of the Intergovernmental Panel on Climate Change. URL:http://www.grida.no/climate/ipcc_tar/wg2/pdf/wg2TARtechsum.pdf.

Nicholls, Robert J, Poh P. W., Burkett V.R., Codignotto J.O., Hay J.E., McLean R.F., Ragoonaden S., and Woodroffe C.D. (2007). "Climate change and Coastal systems.pdf Climate Change 2007: Impacts, Adaptation and Vulnerability."In Original edition, Cambridge University Press, Cambridge, UK, 315-356.

Preston, B.L., Smith, T.F., Brooke, C., Gorddard, R., Measham, T.G., Withycombe, G., McInnes, K., Abbs, D., Beveridge, B. and Morrison, C., (2008). Mapping Climate Change Vulnerability in the Sydney Coastal Council Group. Prepared for the Sydney Coastal Council Group and the Australian Government Department of Climate Change.

Wu, S., Yarnal, B., Fisher, A., (2002). Vulnerability of coastal communities to sea level rise: a case study of Cape May County, New Jersey, USA. *Climate Research* no. 22 (3):255270.