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ORIGINAL ARTICLE

Accommodation of climate change in coastal areas of Cameroon: selection of household-level protection options

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Abstract Coastal areas are threatened under climate change because of factors related to vulnerability of society and sensitivity of the environment. Protection and adaptation may mitigate the adverse consequences. This research reviews and assesses the options of protection by homeowners in the coastal zone in the southwest region of Cameroon. The coastal zone of Cameroon is studied because of the observed deleterious effect of recent extreme climatic events. From a research sample of 400 *households,* the house types and protection strategies - which are of two main types: *reactive measures* and *preventive measures* taken to offset adverse effects on property, are studied. A multinomial logit function reveals that income, education, age and gender are significant factors determining household's probability on the selection of protection measures. The study concludes that there are strong implications for adaptation to future climate change, and the ability of homeowners to extensively respond will have to be reinforced not only by communal and public works projects but also through an active government policy to promote climate change adaptation.

Keywords Climate change · Coastal residents · Protection options

1 Introduction

The Fourth Assessment Report of the Intergovernmental Panel on Climate Change generally posits increases in the amount of precipitation in high-latitudes, and decreases in most subtropical land regions, with associated potential for increased frequency for hot extremes, heat waves, and heavy precipitation events (IPCC 2007). In the face of a warming climate, it is likely that future tropical cyclones (typhoons and hurricanes) will become more intense, with larger peak wind speeds and more heavy precipitation

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associated with ongoing increases of tropical sea surface temperatures (Emanuel 2005; Mann et al. 2007). Coastal areas will bear the brunt of any impact (Mimura 1999). With population growth exacerbating and increasing developments in coastal areas there is potential for increased loss of life and property in coastal regions. El Raey et al. (1998) estimate that beach areas are severely affected, up to US$ 2,126 million for a 0.5 m sea level rise. As growth and development continue, the damages caused by severe weather will increase regardless of global warming (Jallow et al. 1999). It stands to reason that climate change, namely increases in tropical storm activity and sea level rise would exacerbate the damage as global warming continues.[1] Despite conclusive assertions in the literature, most empirical work to date has focused on the industrial countries. Although experts have extrapolated the results of their findings world wide, little research has focused specifically on developing countries, and Africa seems neglected. The findings of some studies indicate that global warming and consequent climate change will have disparate impact on households in different regions in Africa (Kurukulasuriya et al. 2006; Molua 2002).

At 475,442 square kilometres, Cameroon on the west of Central Africa on the Bight of Bonny, part of the Gulf of Guinea and the Atlantic Ocean, faces diverse climatic threats along the 360 km coastline. The coastal plain which extends 150 km inland with an average elevation of 90 m.a.s.l (Neba 1999), is hot and humid with a short dry season. The densely forested coastal region includes some of the wettest places on earth (e.g. Debunsdscha's average wet season rainfall is 5,000 mm). The large rivers of Ntem, Nyong, Sanaga, and Wouri flowing southwestward directly into the Gulf of Guinea further define the ecological assets and environmental challenges in the region. While the drier northern regions in Cameroon may be threatened by increased warming and drought, the humid southern region is expected to be impacted by increasing warmth and wetness that promote the proliferation of pests, diseases, crop stress and livestock strain (Molua 2006). Prolonged and intensive rain storms account for most floods in southern Cameroon. The coastal areas are particularly subject to damages caused by storm-related flooding and tidal surges, making landfalls in the Littoral and Southwestern regions of the coast. The storm disaster and accompanying floods in 2001 led to loss of lives, livestock, crops, agricultural income and structural impacts. The UNEP/GEF (2000) study on Cameroon which examined both the southern coastal and the northern Sudano-Sahelian zones, currently affected by extreme events including floods and droughts, revealed from the IPCC IS92a emission scenario that average changes in annual temperatures will range from 1.58°C to 3.33°C with a mid-value of 2.31°C for the coastal zone. Temperature increases are projected in northern Cameroon from 2.13°C to 4.53°C. For precipitation changes, the results fall within present-day variability, albeit with increasing climate sensitivity. These climatic changes are expected to have sectoral impacts on Cameroon's agrarian economy (Molua 2008).

The foregoing problem set raise some broad questions and illustrate the path of future research in the region, pertaining to the response to changing climatic conditions: (i) How do homeowners in the coastal region protect their property against climatic extremes? (ii) What socioeconomic factors influence the selection of options for protection? This research

[1] In the North Atlantic there has been a clear increase in the number and intensity of tropical storms and major hurricanes. From 1850–1990, the overall average number of tropical storms was 10, including 5 hurricanes. Since 1995, the 10-year average has risen dramatically, with the 1997–2006 average at 14 tropical storms, including 8 hurricanes (IPCC 2007). This increase in frequency correlates strongly with the rise in North Atlantic sea surface temperature, and recent studies link this temperature increase to global warming (Keim and Robbins, 2006).

therefore assesses the factors that influence the selection of private protection in the face of climate variation and change.

2 Theoretical framework

The physical threat on coastal areas by current climate variation and future climate change has been documented to have diverse structural and socioeconomic consequences (Jallow et al. (1999); El Raey et al. (1999); Mimura (1999); Keim and Robbins (2006) and Donnelly and Woodruff (2007). Donnelly and Woodruff (2007) demonstrate that El Niño and the West African monsoon influence Atlantic hurricane intensity over time scales of centuries to millennia and also observe that on a timescale of hundreds to thousands of years, periods of intense Atlantic hurricanes tended to coincide with El Niños and periods of high rainfall in tropical West Africa. This corroborates Emanuel (2005) who examined 55 years of data from the North Atlantic and North Pacific and found a correlation between sea surface temperatures and the destructive potential of hurricanes. Emanuel (*ibid.*) analysis showed that the destructive potential of hurricanes—defined by a storm's wind speed and duration—has approximately doubled over the past 30 years. In both ocean regions, there is a close relationship between water temperatures and hurricane strength. In other words, when sea surface temperatures were cooler, hurricanes had less destructive potential; when sea surface temperatures were warmer, hurricanes had greater destructive potential. Starting in about 1975, sea surface temperatures in the North Atlantic and North Pacific began to increase dramatically, and the destructive potential of hurricanes followed suit.

According to Keim and Robbins (2006), every storm in the 2005 hurricane season occurred earlier than comparable storms in previous seasons; confirming that hurricane seasons are more severe when sea surface temperatures are high. Webster et al. (2005) results further strengthen the link between global warming and hurricane intensity in all of the world's hurricane basins. Mann et al. (2007) demonstrates that even with uncertainties in early Atlantic hurricane records, there is a connection between sea surface warming and Atlantic hurricane activity.[2]

Climate change is therefore expected to exacerbate already existing environmental problems e.g. coastal erosion, subsidence, pollution, land use pressures, and deterioration of ecosystems. Jallow et al. (1999); El Raey et al (1999) and Mimura (1999) examined the vulnerability of island states, coastal cities in Africa, the Mediterranean and human settlements along River Nile. A combination of experience based and scientific methods were employed to reveal the overall vulnerability and possible impacts on the coastal zone sectors. Inundation and flooding are the common threats to islands because of their low-lying setting; the problem is exacerbated by the social trends of population growth and migration to main islands, in particular to the capital cities.

The strength of the threats on infrastructure and coastal society and the associated cost of protection given expected damage to property will depend on the levels of vulnerability of the underlying population. Vulnerable households, i.e. those with assets and livelihoods exposed and sensitive to climatic risks and who have weak risk management capacity, tend

[2] Whilst wind speed and duration are important, the impact of recent Hurricanes on the northern Gulf Coast of the United States show that storm size too is important, causing a larger funneling effect that override wind speed and duration thus causing large impact in some cases (Resio and Westerink 2008).

to find that their assets and livelihoods are highly exposed and sensitive to the direct and indirect risks associated with climate variation and change (Heltberg et al. 2008). Such vulnerability is reinforced if households lack access to formal and informal risk management arrangements (Sen 1981; Ellis 1998). Two social groups are particularly at risk: the extreme poor, who live in extremely fragile conditions; and those who have improved their housing through their own efforts. The risk of loss and damage to housing could increase if homeowners do apply the basic rules of storm resistant construction—using materials and structures that are easily destroyed.

Box 1: Developing in a Changing Climate: Risk of Intensified Storm Surges and Floods Anecdotal Evidence

'50 homeless after storms!' is the screaming banner headline, reporting that almost 50 people, including children, were left without a roof over their heads, due to heavy storms which hit the North West region of South Africa (SAPA 2007). 'North West Department of Local Government and Housing Spokesperson Lesida Kgwele said families who were affected were mostly from rural areas.' According to the SAPA (2007) news report, 'Dozens of mud houses collapsed and the roofs of others were blown away by the storms'. 'In Middleton B village livestock was killed and most electricity infrastructure in the area damaged'.

Cameroon Tribune (2009) reports 'hundreds injured in floods and inundation in Douala Cameroon's economic capital.' 'I have never seen this much rain since I lived in Douala,' asserted a resident. In the neighbourhoods of Bonanjo, Bali, New Bell and Nganguè are repeated tales of flooded homes and streets.

'Around 88,000 people displaced by floods in Burkina Faso', was a more recent headline at World News, quoting the Associated Press (2009). According to the report, 'an estimated 48,000 people uprooted by severe flooding in Burkina Faso are sheltering in temporary accommodation such as schools, churches and public buildings while another 40,000 are living with host families.' 'A UN Disaster Assessment and Coordination (UNDAC) team that went to Burkina Faso in the wake of the recent flooding also found that facilities in many of the buildings in which people are taking shelter, especially sanitation, are under strain,' the report concluded.

In Fass Mbao, Senegal, the Associated Press (2009) reports on torrential rains that lashed Africa's western coast for three months, killing 159 people and flooding the homes and businesses of over 600,000 others. 'Thousands of West African families work to make flooded homes livable in torrential rains',was the headline. 'The only piece of furniture that survived the most recent flood in Fatou Dione's house is her bed. It's propped up on cinderblocks and hovers just above the water lapping at the walls of her bedroom. The water stands a foot deep throughout her house. She shakes off her wet feet each time she climbs into her bed. To keep it dry, she tries to place her feet on the same spot so that only one corner of her mattress becomes moist.' 'I lost my entire house. All of my furniture. All of my things. We swam for 45 minutes to get out of the flooded area," said 54-year-old Marieme Fall in Rosso, Mauritania.

Among the six countries where the September 2009 flooding is most severe — Senegal, Sierra Leone, Mauritania, Burkina Faso, Niger, and Ghana — the neighborhoods most affected are the poor ones. Typically these communities are the result of urban sprawl, built without municipal approval, using unsafe materials. 'In Ouagadougou, the hard-hit capital of Burkina Faso, many of the flooded homes were made of nothing more than clay.' Associated Press (2009) reports further recounting personal tales: 'As the rain continues to come down, families are waging individual battles with water. About 32 kilometers away from Fass Mbao, in the flooded suburb of Tivaouane, 37-year-old Mansour Ndiaye tries to scoop water into a bucket using a large sponge. The courtyard to his family's home is a pool. He had managed to dry out the hallway of his family's home by the time the afternoon rain started. 'I'm doing the best I can,' he said. His elderly neighbor, Assane Sock, had spent the day before carrying buckets out of his house. The water seeped back in overnight. He spends the afternoon looking for pieces of wood and stones to try to elevate his furniture and his Singer sewing machine. He's a tailor, he explained. And he can't sew if his clients' clothes are trailing in the water. 'I live like a fish,' he said. 'I eat in the water. I sleep in the water. And now I work in the water.'//END

Dasgupta et al. (2009) examined the potential impact of storm surge on coastal countries, estimating the toll of such changes on economic performance, urban areas, agriculture and wetlands. The estimates show that about 19.5% of the combined coastal territory of 84 countries is vulnerable to inundation. A 10% future intensification increases the potential inundation zone to 25.7%, taking into account sea level rise. This translates to an inundation threat for an additional 52 million people; representing 29,164 km^2 of agricultural area; 14,991 km^2 of urban area; 9% of coastal GDP and 29.9% of wetlands. The impacts are not uniformly distributed across the regions and countries of the developing world, and a GDP loss of US$ 1.8 billion is projected for sub-Saharan Africa, with low-income countries such as Djibouti, Mozambique and Togo susceptible to very significant damage. The study further identifies the top ten major urban centers worldwide that are located in storm-surge zones, with most of these in poor countries, and the risks particularly severe in poor neighborhoods and slums, where infrastructure is often nonexistent or poorly designed and ill-maintained. These findings are corroborated by the anecdotal evidence in Box 1.

Intrinsic defense and accommodation by exposed groups requires either limited or full protection. Such protection strategies involve defensive measures and other activities to protect areas against inundation, tidal flooding, effects of waves on infrastructure, shore erosion, salinity intrusion and the loss of natural resources. The measures include an array of structural solutions, which can be applied alone or in combination, depending on the specific conditions of the site. Existing arrangements for managing climate and other risks offer some protection at a cost (Yohe and Schlessinger 1998). While entitlements and assets of individuals and households could maintain minimum level of consumption in the face of changing trends, cycles and shocks with limited risk management and productive functions (Davies 1989; Moser 1998); these costs are however at best partially successful at shielding households from adverse impacts given the inherent vulnerabilities (Goklany 2008). The fluctuations in consumption and 'decumulation' of human and physical assets that result from shocks have adverse consequences for household well-being and for economic growth that often persist after the original shock has subsided (Dercon 2004). Adequate public infrastructure could reinforce households coping strategy. Fanos et al. (1995) identify diverse public protection works along the Nile Delta coast to include drains, jetties and dikes. In addition, mechanisms must be developed to ensure feedback of learning from local to national policy levels. Zeidler (1997) and Yohe and Schlesinger (1998) provide insight on the value and cost of protection of property at stake, for instance, Zeidler (1997) shows that limited or full protection in coastal zones could cushion against property losses worth US$ 30 billion. El Raey et al. (1998) indicate that beach areas could be severely affected, up to US$ 2126 million for a 0.5 m sea level rise.

3 Methodology

3.1 Selection and implementation of protection options

In this study we estimate protection costs[3] by assuming the goal of individuals, households and the community is to minimize the overall human welfare loss from extreme climatic events. In other words, coastal residents seek to minimize protection cost and the residual

[3] As a benchmark, the cost of protection is described as a function of the characteristics of the house, its location, and the value associated with each characteristic. We estimate the protection costs by looking at the options of people who are willing to defend their homes and courtyard in anticipation of extreme climate events.

damage cost. Operationally, this objective is addressed by conducting a survey of homeowners to obtain information that identify the methods for protecting against flood/storm damages, and costs (expenditures) of reinforcing homes. Three steps are applied, viz. (i) properly defining the study area, (ii) listing and estimating possible damages to homes from key flood/storm events, and (iii) listing and evaluating tangible costs of household management measures against storm/floods.

The selection of the option for protection is analyzed within the framework of a multinomial logit model (McFadden 1981; Chow 1983). We assume that each household makes decisions for protection mindful of need to minimize cost. We examine choices of individual protection measures as well as combinations of protection measures, i.e. households might combine two different protection measures as a choice. The full set of choices is mutually exclusive: the household head picks one choice from a full set. The probability that a measure is taken up depends on how less costly it is likely to be relative to other options. We assume that each household i's cost in choosing protection set j (j=1,2,….J) is

$$C_{ij} = V\left(K_j, S_j\right) + \varepsilon\left(K_j, S_j\right) \tag{1}$$

Where K is a vector of exogenous characteristics of the house and S is a vector of characteristics of the household head i. For example, K could include windstorms, flash floods and access variables and S could include the age of the household head, gender and household size. The cost function is composed of two components: the observable component V and an error term, ε. The household will choose the measure that leaves them with the least cost combination. Defining $Z_{ji} = \left(K_j, S_j\right)$ the household head will choose measure j over all other measures w if:

$$C^*\left(Z_{ji}\right) < C^*(Z_{wi})\ for\ \forall w \neq j \tag{2}$$

Or if:

$$\varepsilon(Z_{wi}) - \varepsilon\left(Z_{ji}\right) < V\left(Z_{ji}\right) - V(Z_{wi})\ for \ldots w \neq j \tag{3}$$

In other words, household i's problem is

$$\arg\min[C^*(Z_{1i}), C^*(Z_{2i}), \ldots., C^*(C_{Ji})] \tag{4}$$

The probability P_{ji} of the j_{th} protection measure being chosen is then

$$P_{ji} = \Pr\left[\varepsilon(Z_{wi}) - \varepsilon\left(Z_{ji}\right) < V_j - V_w\right]\forall w \neq j, where\ V_j = V\left(Z_{ji}\right) \tag{5}$$

Assuming ε is independently distributed and $V_w = Z_{wi}\gamma_w + \alpha_w$, then

$$P_{ji} = \frac{e^{Z_{ji}\gamma_j}}{\sum_{w=1}^{J} e^{Z_{wi}\gamma_w}} \tag{6}$$

Equation (6) gives the probability that household i will choose protection measure j among J options. The parameters are estimated by Maximum Likelihood Method using iterative non-linear optimization techniques that ensure the estimates are consistent and asymptotically normal under standard regularity conditions (Greene 2003).

3.2 Data

Primary data are essentially used for this study drawn from the coastal zone of Cameroon which cuts across three regions, the South, Southwest and Littoral regions with cities and towns bordering the Atlantic Ocean. However, for sake of expediency, this study is limited to the coastal region of Fako Division in the Southwest region. The coastal region in Fako Division opens from Tiko to the Oil Refinery/exploration city of Limbe (formerly Victoria) and stretches west through tourist resort towns along the coast to the fishing port town of Idenau on the Rio del Rey Basin (see Fig. 1). This region cuts across two important administrative districts: the *Limbe subdivision* and *Idenau subdivision* and comprise of about 200.000 inhabitants. These two subdivisions are studied. While the Atlantic equatorial rainforest dominates the region, the study area extends to communities on the fringes of the active volcanic Mount Cameroon (4,095 m.a.s.l) on the coast.

Cluster sampling technique is employed. About 2000 homes in the coastal towns are 'simple-randomly' sampled, and a subset of 200 homes that were exposed to the 1999, 2001 and 2005 floods sampled for study. Another sub-sample of 200 homes in human

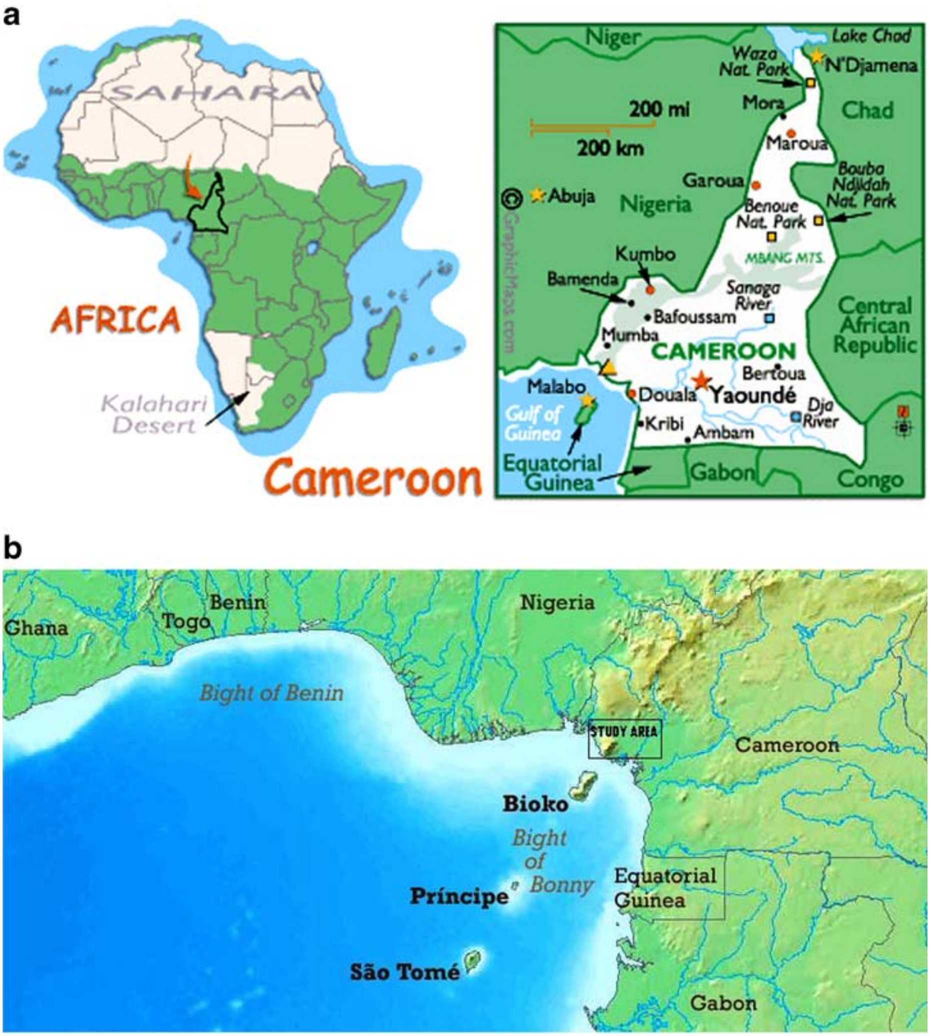

Fig. 1 **a** Map of Cameroon and Geographical Location. **b** Cameroon's Southwestern Coast and Relief

settlements 30 km away from the coast that were not impacted by the floods were also drawn for study, to assess the value of the environmental amenity with respect to the absence of floods, storms and climate related impacts on properties in the non-coastal areas in Cameroon. Hence, our sample size consists of 400 homes. Additional information is obtained from unobtrusive observation, rapid rural appraisal and discussion with community heads. Homes are studied on the renovations and modifications made to the withstand storm surges and floods, the current prices charged and the economic value attached to the property.[4] Equation 6 is then assessed using both household socio-economic and demographic characteristics variables that are expected to influence selected methods for home protection. The dependent variable was the proportion of household using a particular method measured from zero up to 100%. The independent variables were of household-specific socio-economic and demographic characteristics that included education, ownership and assistance measured as dichotomous variable. Meanwhile, household size, longevity in neighbourhood and income are measured as continuous variables. Complete definition of the variables is given in Table 3.

4 Results and discussion

4.1 Climate, vulnerability and cost of protection

While the macro policy environment is described by limited government ownership of adaptation effort to climate related risks and limited financing available for climate change adaptation, local government and surrounding communities remain responsible for household protection. The communities in the southwestern coastal region cope with natural disasters and mitigate their effects in many ways. Recurrent natural hazards of flash floods and inundation are threats to residents at Idenau, as well as coastal storm surges at Bota and rainstorms at Debundscha. As shown in Table 1, the upland areas such as Mukundange suffer from flash floods following landfall of tropical storms associated with heavy rainfall. With fertile volcanic soils to the east and a coast to the west, the communities are predominantly employed in fishing and agriculture. The livelihoods based on agriculture, fishing and aquaculture are particularly vulnerable to the attendant tropical storms, storm surges and flash floods. Besides inundation, more frequent flooding, saline water intrusion, and tornadoes, agriculture and natural ecosystems are seriously affected through alteration of growing periods, crop calendars and crop distribution, increase in pest and virus activity and potential migration of some plant and animal species to higher altitudes towards Mount Cameroon.

Two tropical storms, with wind speeds greater than 55 mph, formed in the study region in the last five years. The extent of destruction was reported to be serious. The devastating storms, floods and mudslides that hit Limbe municipality and surrounding communities were severe, resulting in loss of life and property. Houses were flooded and less resilient

[4] The data are drawn from responses to a survey instrument featuring many questions concerning homeownership and neighbourhood satisfaction. The survey begins with questions concerning the respondent's current residence, neighbourhood, climatic conditions and likelihood of moving. Housing profiles are also studied in relation to neighbourhood configuration, neighbourhood housing density, surrounding land uses, road and transport amenity, rating of neighbourhood safety (four categories ranging from somewhat unsafe to very safe), rents, purchase price of house and home reinforcements against coastal erosion, floods and storm surges. In addition, the survey elicits information of the age, design and size of the property, and the demographic variables of house occupants including household income and budget constraint.

Table 1 Typology of environment related natural hazards in the Southwest Coast

Municipality	Principal Hazards
Limbe	Mud slides, high tides and storm surges, salt water intrusion
Bota	High tides, coastal storm surges
Isokolo	Coastal storm surges, rain storms
Mokundange	Rain storms, flash floods, saline water intrusion
Debunscha	Rain storms, flash floods, mud slides
Batoke	Flash floods, coastal storm surges
Idenau	Flash floods, landslides, lava flow from eruption

(Author's summary, 2009)

property collapsed and class rooms were damaged. The agricultural sector was affected with flooded croplands and damaged field crops. As shown in Table 2, the fishery sector observed losses in boats, canoes and flooded fish ponds. The damaged property included cars, motorbikes and household appliances. Additional damages include direct effect on community infrastructure (roads, water and electricity supply lines, communication systems, schools, hospitals, churches) and the environment (environmental pollution and degradation), and indirect losses through loss of gainful employment and disruption of economic activities.

The nature and resilience of private property has largely defined the extent of the damage incurred by households. On average, the houses are 16.4 years old with about 4.5 bedrooms. About 34% of homeowners think their house is of good quality, 75% report cemented floor and 85% of houses are roofed with corrugated iron sheets. Forty-five percent of the homes are classified to be in proximity to flood plains with 26% on average having borne the brunt of very severe storms. About 55% report that their homes have once been flooded due to flash floods, and this has occurred about 3 times in the last five years. Fifty-four percent of the homes have been hit at least once by strong winds, on an average of 2 times in the last five years. Meanwhile, 29% of houses have once been hit by storm surge or heavy waves from the sea nearby. About 68% of residents think their house is exposed to floods and windstorm destruction.

After the flood or windstorm, residents respond to protect their home against future attacks by relocating (22%), migrating (6%), rebuilding (23%), reinforcing the strength of the house (68%), building protective walls (18%) and planting trees (4%).[5] In reinforcing homes after a flood or windstorm, protection measures adopted include elevation, barriers, dry floodproofing, wet floodproofing, roof protection, basement protection berth and planting of trees.

About 18% report that they do have a disaster plan. The disaster plan development includes gathering information about hazards, meeting with family members to create a plan, and attending community meetings to prepare a plan. To gather information about hazards, about 9% contact the local weather service office, 4% the emergency management

[5] Reinforcement of homestead includes modifying windows, doors and house furniture. Construction of protective walls involves building brick walls around homesteads more as a windbreak rather than burglary proof. Tree planting is related to the planting of diverse species of coconut, eucalyptus and fruit trees to protect roofs. In disaster plans, some homeowners do have prescribed procedure which is communicated to other household members on activities to take in the event of a storm. Relocation defines changing homes and moving into more secure property. Migration is characterized by moving out completely from the sea front and potential storm paths to other parts of town perceived to be more secure.

Table 2 Vulnerability and natural disasters in the Southwestern Coast of Cameroon

Natural disaster	Major impacts	Estimated loss (US$)
Floods in Limbe Municipality (2001)	- 210 houses flooded	576,000
	- 15 houses collapsed	
	- 39 class rooms damaged	
	- 200 ha of cropland flooded	
	- 45 ha of oil palm damaged	
	- 3 ha of fish ponds flooded	
	- 25 tons of fish and shrimps destroyed	
	- 8 cars destroyed	
	- flooded Limbe Botanical and Zoological Gardens with destruction of rare plant and animal species	
	- 23 persons died and 50 injured	
	- 1,500 persons homeless	
Wind storms along the coast Southwestern coast (2000, 2003 2007)	- 18 houses collapsed	452,000
	- 11 schools damaged	
	- 3 hospital centres flooded	
	- 40 ha of maize field crops damaged	
	- 73 ha of farmland flooded	
	- 16 ha of fish ponds flooded	
	- 15 boats damaged	
	- 11 cars destroyed	
	- flooding of Mile 6 beach and recreation sites	
	- Limbe Wildlife Centre damaged	
Lava flow through Bakingili (1999)	- 60 ha of oil palm field damaged	238,000
	- 14 km of road damaged	
	- 83 ha of arable farmland damaged	
	- 50 houses destroyed	
Mudslides in Limbe and Isokolo (1998, 2001, 2003)	- 34 houses damaged	175,000
	- 2 ha of banana fields damaged	
	- loss of life and household appliances	

Author's summary (2009)

office, 10% use the Red-Cross chapter, 43% rely on the Community Head or Quarter Head for information.

About 26% of residents assert that they have once been assisted by government to protect their house against disasters. Such assistance includes financial (cash) and in-kind materials. Non-governmental organizations provided assistance to 36% of residents, in the form of cash and in-kind materials such as roofing sheets, 50-kg bags of cement, wood, medicines, drinking water, clothes and beddings. No homeowner attested paying to Insurance Firms.

On average, the coastal residents report spending 145,500 FCFA (US$ 346)[6] in the last five years in preparation against floods. Parts of homes and living compound are reinforced

[6] The exchange rate to the US dollar is estimated at 420 FCFA for 1 US$, as on 6 November 2008.

costing on average 83,000 FCFA (US$ 198). Despite these efforts, the fence, walls of house, sea walls, trees and house furniture are prone to destruction by floods or windstorms. Following extreme climatic events, residents report destruction on roof, windows, doors and house furniture, spending on average 243,000 FCFA (US$ 579) in repairing per flood incident. For those who owned their dwelling, on average they expressed Willingness-to-Accept about 10,300,000 FCFA (US$ 24,500) as minimum payments if a request is made to sell their house. The tenants indicated their Willingness-to-Pay 6,800,000 FCFA (US$ 16,000) if an offer is made for them to buy their current dwelling.

4.2 Selection and implementation of protection options

On examining the factors that are most influential in determining the selection of protection measures, as expected and shown in Table 3 below, the factors of income, education and age have significant positive impacts on a household's probability of selecting diverse measures. Unemployment significantly reduces the selection of all forms of protection. Ownership of property and longevity in the locality discourage relocation and migration, contrary to youthfulness and income that increase the option of migration. Absence of gainful unemployment and possibly lower incomes lower the possibility of households having a disaster plan. Larger households have a lower probability of reinforcing homesteads and constructing protective walls, whilst being female significantly lowers the probability of either planting tree as a protective measure or rebuilding. Financial and material assistance by government and non governmental organizations significantly enhance the possibility of rebuilding and selecting a broad array of protection measures.

The importance of gender, age and education indicate that the choice of protection measure is the result of a complex set of interactions between comparable options and the homeowner's socio-economic and demographic characteristics. That being an educated middle-aged male increase the chances of selecting resilient protection methods provides important illumination on the socioeconomic and cultural constraints faced by many homeowners. Gender and education not only insure access to better incomes through gainful employment but also provide access to credits as well, required to bear the cost of either reinforcing homesteads or relocating. Hence, the different behaviour of homeowners regarding the uptake of protection, whether it is the construction of protective walls, tree planting, disaster planning, relocation or reinforcement of homestead, may be as much a function of different opportunities and constraints as of inherent differences in characteristics and perceptions of the worth of the method, and as such the perceived attributes of protection types could condition the behaviour of homeowners.

While it is important that in developing reliable adaptation strategy, the current protection activities and policy of coastal protection should be quantified, it must be borne that disaster prevention inherently starts at the household and community level, and for effectiveness of these decisions, there is need for both financial and technical support underpinned by government to have a real large scale impact. This is more so true since the decision-making process is driven by various, often conflicting, criteria, but related to households' pool of tangible and intangible factors, be it social, cultural and natural environment situation, in addition to their economic status.

Disaster warning and preparedness must therefore become a key aspect in Cameroon's response to climate related threats. Governmental and non-governmental agencies could contribute to reduce the vulnerability of urban and rural communities to climate related

Table 3 Multinomial logistic maximum likelihood estimation for protection

	Reinforcement of homestead[a]		Construction of Protective walls		Tree Planting		Disaster plan		Rebuilding		Relocation		Migration	
	Coef	*t-value*	*Coef*	*t-value*	*Coef*	*t-value*	*Coef*	*t-value*	*Coef*	*t-value*	*Coef*	*t-value*	*Coef*	*t-value*
Gender	0.001	1.891*	0.001	1.688*	−0.007	−1.211	0.016	2.897**	−0.029	−1.908*	−0.004	−1.886*	−0.052	−2.693**
Age	0.017	1.946*	0.006	1.792*	0.008	1.663*	0.024	1.360	0.018	1.660*	0.001	1.197	0.177	1.056
Age-2	0.052	2.233**	0.081	2.078**	0.100	2.108**	0.173	1.991*	0.135	2.813**	−0.016	−1.873*	0.081	1.798*
Unemployed	−0.001	−2.478**	−0.007	−1.999*	−0.009	−1.671*	−0.004	2.006**	−0.008	−1.716*	−0.013	−1.567	0.009	2.960**
Marital status	0.006	2.610***	0.001	1.289	0.004	1.998*	0.019	1.872*	0.016	1.730*	−0.002	−1.960*	−0.007	−1.891*
Education	0.071	2.581**	0.069	1.341	0.018	2.617**	0.007	1.620*	0.004	1.226	0.007	2.123**	0.007	1.967*
Assistance	0.152	3.123***	0.138	1.807*	0.077	1.692*	0.019	1.933*	0.017	1.821*	−0.005	−1.698*	−0.006	−2.087**
Household size	−0.081	1.987*	−0.006	−1.888*	0.014	1.796*	0.002	2.109**	0.001	1.073	−0.041	−2.088**	−0.007	−1.346
Ownership	0.010	2.612**	0.005	2.278**	0.111	2.473**	0.002	2.230**	0.053	2.179**	−0.107	−3.451***	−0.029	−3.006***
Longevity in neighborhood	0.005	1.934*	0.037	1.379	0.200	3.179**	0.008	2.649**	0.029	1.897*	−0.008	−2.176**	−0.004	−1.996*
Income	0.262	3.786***	0.109	2.878**	0.001	1.969*	0.034	2.368**	0.007	3.246***	0.122	2.457**	0.137	2.107**
Constant	24.318	3.456***	0.791	2.893**	2.683	1.980*	6.445	2.256**	12.208	1.965*	−9.001	3.763***	3.980	2.632**

[a] See footnote 5 for a definition of the protection options.

The independent variables are measured as gender (female = 1, male 0), age (years), unemployment (unemployed = 1, otherwise 0), marital status (marriage = 1, otherwise 0), education (above primary=1, otherwise 0), assistance (received financial assistance = 1, otherwise 0), household size (number of persons), ownership (owned = 1, rented or otherwise 0), longevity in neighborhood (years of living in location) and income (amount earned per month in local currency FCFA). Base category protection: Information availability on weather forecast and early warning. *** $p<0.01$, ** $p<0.05$, * $p<0.1$

Diagnostic test results:

Number of obs=400

LR chi2 (76)=2,901.7 Prob > chi2=0.000

Pseudo R2=0.432 Log likelihood=−3223.0125

McFadden's R2=0.441 McFadden's Adj R2=0.418

hazards, including whirlwinds, floods and tropical storms. Improving early warning for disasters, gathering and reporting damage data, and promoting collaboration between meteorological data services and the national media should be encouraged in order to make information more readily and more widely available to households. Facilitating protection and possible adaptation is about making society more robust and more flexible—and even if there were no climate change, societies have to be robust and flexible to withstand other environmental changes, many of which are more rapid than global warming. Governmental effort is thus important since the availability and communication information to homeowners could be key in determining decisions that they make. The use therefore of meteorological service, media and location visits to inspect and ascertain the rationality of protection methods could complement the role of available resource endowments[7] among homeowners in taking up particular protection measure. What stands out from the observations in Table 3 is that reinforcing the coping strategies of households will require not only strengthening their capacity in different areas but also increasing their opportunities, perceived or real. Sustaining these household-based decisions cannot occur without political will at the highest level. Climate policy will therefore have to take into consideration the full impact of climatic extremes and its human consequences, especially in key issues such as vulnerability and sustainable development. Preparedness for extreme events needs to take into account both new response strategies and a re-evaluation of previous development strategies in order to determine their validity and reliability in the face of increasing vulnerability. The bonus of such climate policy will be its holistic approach that empowers homeowners and coastal dwellers by focusing on improving their asset base. With improved access to and control over different types of assets, communities are better able to employ resilient coping strategies.

4.3 Institutional and policy environment

The Ministry of Environment and Protection of Nature defines the country's institutional framework and policy environment in relation to climate. It is the national focal agency for climate and climate change related activities. In recognition of the rising threats posed by human-induced climate change, the country ratified the United Framework Convention on Climate Change (UNFCCC) in 1994 and acceded to the Kyoto Protocol in 2002. However, the Government is yet to pursue specific programmes on vulnerability and adaptation assessments. The absence of an institutional response system for natural disasters such as storms and floods not only reflects the country's vulnerability to these events but highlights the relative newness of the threats and urgency to incorporate the changing environment into national policy plans.[8] Recent preparations of a policy framework for implementing adaptation measures are being undertaken as indicated in the national communication on climate change to the UNFCCC. While institutional arrangements for disaster management, climate risk and development remain a weakness, urban planning and municipal works include coastal defences, dyke

[7] Assets include natural capital (forests, water, land, fish, energy resources, and minerals); social capital (relationships of trust and reciprocity, groups, networks, customary law); human capital (skills, knowledge, beliefs, attitudes, labor ability, and good health); physical capital (basic infrastructure); and financial capital (monetary resources).

[8] The Disaster Management System in Cameroon derived from Law No. 86-16 of 6 December 1986 to reorganize civil protection; and Law No. 98-15 of 14 July 1998 relating to establishments classified as dangerous (MINAT/UNDP 2003), emphasis ex-post disaster measures and its 'top-down' hierarchical structure puts more emphasis on disaster response than prevention and mitigation.

management and mangrove restoration projects. In the study area, physical protection from storm surge and rising sea water levels is provided by the Limbe Urban Council's system of levees. Local government and surrounding communities remain responsible for sea dyke protection. Coastal mangrove forest remains an important and highly effective form of coastal protection from storm surges. Proposed establishment of a national Climate Change Observatory has raised expectation for improved capacity for monitoring and collation of satellite data.

5 Conclusion

Current climate variation and climate change is a very real threat to continued socio-economic development, with erratic and variable rainfall, intense extreme weather events having significant impacts across sectors, regions, and income groups. The well-being of coastal residents could be advanced in the face of climatic irregularities, particularly on vulnerable populations, by reducing their current vulnerabilities to climate-sensitive problems. In this light, since income, education and gender are shown to be significant factors determining household's probability of selecting protection measures to accommodate climatic constraints, it is prudent that future policy measures reinforces the socioeconomic capacity of coastal residents and homeowners. Risk spreading through income diversification and disaster preparedness via early warning systems could strengthen livelihood resilience. This could further be enhanced through communal and public actions for protection such as providing storm-surge protection, erecting sea walls, constructing dykes and relocating vulnerable human settlements. While climatic threats are now being acknowledged in policy making quarters, but information and awareness remains at a low level in the absence of a climate change observatory. Cameroon does not yet have national or local climate strategy and climate change adaptation policy, and national and local capacity building is urgently needed to ensure that policy responses are adequate and effective.

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References

Associated Press (2009) Thousands of West African families work to make flooded homes livable in torrential rains. http://cgi.wn.com/?action=display&article=90422006&template=worldnews/paidnews.txt&index=recent Accessed on 13 September 2009

Cameroon Tribune (2009) Douala: de nombreux blessés suite aux inondations. Yaoundé www.cameroon-tribune.cm Accessed on 13 September 2009

Chow G (1983) Econometrics. McGraw-Hill, New York

Dasgupta S, Laplante B, Murray S, Wheeler D (2009) Sea-level rise and storm surges: a comparative analysis of impacts in developing countries. *Policy Research Working Paper*, No: WPS 4901, World Bank, Washington DC

Davies S (1989) Are coping strategies a cop out? IDS Bulletin 28(4):60–72

Dercon S (2004) Growth and shocks: evidence from rural Ethiopia. J Dev Econ 74(2):309–329

Donnelly JP, Woodruff JD (2007) Intense hurricane activity over the past 5, 000 years controlled by El Niño and the West African monsoon. Nature 447:465–468

El Raey M, Frihy O, Nasr SM, Dewidar Kh (1998) Vulnerability assessment of sea level rise over Port-Said Governorate, Egypt. Environ Monit Assess 56:113–128
El Raey M, Dewidar Kh, El Hattab M (1999) Adaptation to the impacts of sea level rise in Egypt. Clim Res 12:117–128
Ellis F (1998) Household strategies and rural livelihood diversification. J Dev Stud 35(1):1–38
Emanuel KA (2005) Increasing destructiveness of tropical cyclones over the past 30 years. Nature 436:686–688
Fanos AM, Khafagy AA, Dean RG (1995) Protective works on the Nile Delta. J Coast Res 11:516–528
Goklany IM (2008) What to do about climate change policy analysis, No. 609 Cato Institute, Washington DC
Greene WH (2003) Econometric Analysis, 5th edn. Prentice Hall, New Jersey
Heltberg R, Bennett PS, Jorgensen SL (2008) Addressing human vulnerability to climate change: toward a 'No Regrets' approach. Paper presented at the Workshop on Social Aspects of Climate Change, held March 5-6, 2008 at World Bank headquarters in Washington DC
IPCC (2007) Climate change 2007: scientific basis. Fourth assessment report of the intergovernmental panel on climate change. Cambridge University Press, Cambridge
Jallow P, Bubu P, Toure S, Malang MK, Barrow A, Achy M (1999) Coastal zone of The Gambia and the Abidjan region in Côte d'Ivoire: sea level rise vulnerability, response strategies, and adaptation options. Clim Res 12:129–136
Keim BD, Robbins KD (2006) Occurrence dates of North Atlantic tropical storms and hurricanes: 2005 in perspective. Geophys Res Lett 33:L21706
Kurukulasuriya P, Mendelsohn R, Hassan R, Benhin J, Deressa T, Diop M, Eid HM, Fosu KY, Gbetibouo G, Jain S, Mahamadou A, Mano R, Kabubo-Mariara J, El-Marsafawy S, Molua E, Ouda S, Ouedraogo M, Sène I, Maddison D, Seo SN, Dinar A (2006) Will African agriculture survive climate change? World Bank Econ Rev 20:367–88
Mann ME, Emanuel KA, Holland GJ, Webster PJ (2007) Atlantic tropical cyclones revisited. Eos 88 (36):349–350
McFadden DL (1981) Econometric models of probabilistic choice. In: McFadden DL (ed) Structural Analysis of Discrete Data and Econometric Applications. MIT, Cambridge
Mimura N (1999) Vulnerability of island countries in the South Pacific to sea level rise and climate change. Clim Res 12:137–143
MINAT/UNDP (2003) Rapport sur l'Etat de la Protection Civile au Cameroun en 2002 . Yaounde: MINAT/DPC, 2003
Molua EL (2002) Climate variability, vulnerability and effectiveness of farm-level adaptation options: the challenges and implications for food security in rural Cameroon. J Environ Dev Econ 7(3):529–545
Molua EL (2006) Climate Trends in Cameroon: Implications for Agricultural Management. Clim Res 30:255–262
Molua EL (2008) Turning up the heat on African agriculture: economic impact of climate change on agriculture in Cameroon. Afr J Agric Resour Econ 2(1):45–64
Moser C (1998) The asset vulnerability framework: reassessing urban poverty reduction strategies. World Dev 26(1):1–19
Neba A (1999) Modern geography of the Republic of Cameroon, 3rd edn. Neba, Bamenda
Resio DT, Westerink JJ (2008) Modeling the physics of storm surges. Phys Today 61(9):33–38
SAPA (2007) 50 homeless after storms. South African Press Association, Johannesburg
Sen A (1981) Poverty and famines: an essay on entitlement and deprivation. Clarendon, Oxford
UNEP/GEF (2000) UNEP/GEF Country Case Studies on Climate Change Impacts and Adaptation Assessments (Estonia, Pakistan, Antigua & Barbuda, Cameroon). In: O´Brien,K., (Ed.), Developing Strategies for Climate Change: The UNEP Country Studies on Climate Change Impacts and Adaptations Assessment. Published by CICERO (Center for International Climate and Environmental Research, Oslo), Report No. 2000:2. (ISSN: 0804-4562), pp. 49-70. http://www.cicero.uio.no/media/314.pdf
Webster PJ, Holland GJ, Curry JA, Chang HR (2005) Changes in tropical cyclone number, duration, and intensity in a warming environment. Science 309:1844–1846
Yohe GW, Schlesinger ME (1998) Sea-level change: the expected economic cost of protection or abandonment in the United States. Clim Change 38(4):447–472
Zeidler RB (1997) Climate change vulnerability and response strategies for the Coastal Zone of Poland. Clim Change 36(1-2):151–173