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CLIMATE AND LOCATION VULNERABILITY IN SOUTHWESTERN CAMEROON: ASSESSING THE OPTIONS AND COST OF PROTECTION TO PROPERTY IN COASTAL AREAS

Ernest L. Molua

Department of Economics and Management, University of Buea, Cameroon

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LIST OF ACRONYMS

CDC	Cameroon Development Corporation
FCFA	Francs de la Communauté Français d’Afrique
GEF	Global Environmental Facility
HRA	High Risk Area
IPCC	Intergovernmental Panel for Climate Change
LUC	Limbe Urban Council
RZ	Risk Zone
SONARA	National Oil Refinery of Cameroon
UNEP	United Nations Environmental Programme

EXECUTIVE SUMMARY

Climate extremes impact on the Atlantic coast of Cameroon through increased intensity of storms, floods and land subsidence which may have significant implications for human settlement and urbanisation. Cameroon is threatened because of factors related to vulnerability of society and sensitivity of the environment. These include restricted population mobility, inadequate health facilities, low incomes and high population growth rates. Protection and adaptation may mitigate the adverse consequences.

This research reviews and assesses the options and costs of protection by homeowners in the coastal zone. The study contends that current climate variation, weather events such as storms and floods may impact on cost of protection along the Atlantic coastal region in the Southwest region of Cameroon. The coastal zone is studied because of the observed deleterious effect of recent extreme climatic events. While we use this region as the laboratory for analysis, the lessons learnt may inform and guide policy measures for other coastal regions in the country and African continent with significant human settlement, coastal assets and property.

From a research sample of 400 households; the house types and protection measures taken to offset adverse effects on property are identified. We assume the cost of a homeowner protecting property is a function of the attributes that characterize the home and incidents of climate events such as floods and storms. We then estimate a ‘cost function’ that relates household-level protection costs to their characteristics. The choice or measure of protection is analyzed within the framework of a multinomial logit model in which we assume that each household makes decisions for protection mindful of need to minimize cost. Examining the determinants of the cost of current protection stands good stead to better inform policy to promote future adaptation to climatic stress. With an average monthly income of 120.000 FCFA (US$ 285), the coastal residents report spending on average 145,500 FCFA (US$ 346) in the last five years in preparation against floods. Parts of homes and living compound are reinforced costing on average 83,000 FCFA (US$ 198). The maximum likelihood cost coefficients of the flood and storm variables have positive signs and are statistically significant, implying that the location of homes within floodplain reinforces the cost of protection no matter the structural characteristics of the property. The elasticity of protection cost with respect to changes in proximity and elevation are – 0.039 and – 0.044, respectively, indicating that the marginal impacts for protection costs are negative away from the coast and at higher ground. The elasticity of protection cost with respect to income is positive, indicating that increasing income improves the chances for protection, provides resilience and possibly reduces risks of damage through better reinforcements and repairs. The multinomial logit function reveals income, education, age and gender are significant factors determining household’s probability on the selection of protection measures. The study concludes that the ability of homeowners to extensively respond will have to be reinforced by communal and public works projects in the region.

1. Introduction

Coastal inhabitants in the world are already suffering from consequences of extreme climate events as indicated in retreating shorelines, threatening sand dunes and coastal lagoons (see Bardach, 1989; Warrick et al, 1993). Most of Africa's largest cities, characterized by teeming populations, industries, dense transportation and communication networks as well as extensive tourist resorts, are along coasts, e.g. Douala, Lagos and Cape town. Most of these cities are low-lying. Cameroon has significant proportion of its population living along the coast in the city and towns of Douala, Limbe, Tiko and Kribi. Sea-level rise, coastal erosion, saltwater intrusion, and flooding will have significant impacts on these communities and economies (see Ibe and Awosika, 1991; El Raey *et al*., 1999; Jallow *et al*., 1999; Jallow *et al*., 1996; Dennis *et al*., 1995). Extreme climate would not only affect the coastline and the structures (e.g. roads, bridges and buildings) along it, but also the hydrology, soils and natural or cultivated vegetation over an appreciable distance inland thus reinforcing vulnerabilities (Adger 1999; Dasgupta et al. 2007).

The stresses incurred on coastal areas may be reinforced by global warming and climate change. Global warming evidence established in IPCC (2007) indicate that global temperature increased and precipitation patterns changed over the 20th century and that the mean annual global surface temperature will increase by 1-3.5^{o}C by the end of the 21st century with global mean sea level will rise by 15-95 cm. These increases are expected to affect storms, with sea surface temperatures playing a huge role in storm intensity. Nowhere would these consequences be more severe than in coastal zones being biologically important areas and densely populated.

Projected rise in sea level, for instance may lead to loss of farmland by inundation and to increasing salinity of ground water in coastal areas. Such a rise could pose a threat to agriculture in low-lying coastal areas, as well as to settlements and human health. 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).

With 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 from the Gulf of Guinea, 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 5000 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^{o}C to 3.33^{o}C with a mid-value of 2.31^{o}C for the coastal zone. Temperature increases are projected in northern Cameroon from 2.13^{o}C to 4.53^{o}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).

According to the 2007 Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC, 2007), "increases in the amount of precipitation are very likely in high-latitudes, while decreases are likely in most subtropical land regions," and "it is very likely that hot extremes, heat waves, and heavy precipitation events will continue to become more frequent." The IPCC posits further that, "it is likely that future tropical cyclones (typhoons and hurricanes) will become more intense, with larger peak wind speeds and more heavy precipitation associated with ongoing increases of tropical sea surface temperatures." 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. As growth and development continue, the damages caused by severe weather will increase regardless of global warming. 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.

The foregoing problem set raises some broad questions and illustrates the path of future environmental economics research in the region, pertaining to the response to changing climatic conditions: (i) What factors explain the vulnerability of the coastal region? (ii) How do homeowners in the coastal region protect their property against climatic extremes? (iii) What collective action(s) are needed, for example, storm-surge protection, erection of sea-walls, and relocation of vulnerable human settlement to mitigate the impact of climate change on coastal areas? (vi) What are the costs of these protections at the individual and collective levels (government and other agencies)? (v) What socioeconomic factors influence the cost and extent of protection?

This research thus assesses the factors that influence private protection in the face of unstable and changing climate. The specific objectives are to: (i) identify the choices for protection by homeowners in the coastal region to changing climatic conditions; (ii) estimate the costs of protection, and (iii) investigate the relationship between protection costs, environmental and socioeconomic characteristics of homeowners. Based on the research objectives, the research sets out to statistically test the *null hypothesis* that: “climatic factors do not significantly affect protection costs in the study location.” The rationale is that current protective efforts constitute the building blocks for long-term adaptation, and therefore it is empirically prudent to deconstruct their microeconomic influences. The rest of the paper is organised as follows. Section two reviews the literature on climatic extremes and puts into context the cost to vulnerable communities. The analytical framework is highlighted and discussed in section three. Section four previews the nature and sources of data. The empirical observations and estimates are presented in section five. Section six concludes the paper with some policy recommendations.

2. Literature Review

What people do in case of climate extremes has been the conjecture of some studies (Smit and Wandel, 2006). Climate has been shown to influence the residential choices of people (Maddison and Bigano, 2002). While an increase in the average global temperature is likely to lead to changes in precipitation and atmospheric moisture because of associated changes in atmospheric circulation and increases in evaporation and water vapour, tropical storms and hurricanes are likely to become more intense, produce stronger peak winds, and produce increased rainfall over some areas due to warming sea surface temperatures - which can energize these storms. Saunders and Lea (2008) quantify the contribution of sea surface temperature and wind patterns to Atlantic hurricane activity between 1965 and 2005 and find that hurricane frequency and activity increase 40 percent with a 0.5 °C rise in sea surface temperature. Consensus on how future climate change is likely to affect the frequency of tropical storms and floods is also indicated in Trenberth and Shea (2006) that the unusual warmth in sea surface temperatures during the record 2005 Atlantic hurricane season was due to global warming.

Hoyos et al (2006) show from the relationship between hurricane intensity and sea surface temperature from 35 years of tropical storm and hurricane data from all six hurricane regions of the world, that sea surface temperature is the only factor that explain the global increase in the number of Category 4 and 5 hurricanes over the years, while other factors such as humidity, wind shear, and zonal stretching deformation contribute to short-term (but not long-term) and regional (but not global) patterns of hurricane intensity. Similarly, Michaels et al (2006) from 24 years of data finds that warmer waters had hurricanes with greater maximum wind speeds and conclude that rising sea surface temperature will act to increase the percentage of major hurricanes. Meanwhile Klotzbach (2006) restricting to a 20-year period, divided into two 10-year blocks: 1986-1995 and 1996-2005; compared hurricane activity between blocks and reveal that the total number of Category 4 and 5 hurricanes increased 10% between time periods. These studies suggest a temperature tipping point for hurricane development consistent with global warming and climate change.

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 Ninos 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. In this light, Keim and Robbins (2006) show that 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. According Mann et al (2007), even with uncertainties in early Atlantic hurricane records, there is a connection between sea surface warming and Atlantic hurricane activity.

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 along River Nile. A combination of experience based and scientific methods were employed to reveal the overall vulnerability of and possible impacts on the coastal zone sectors. The studies identified the common impacts on and vulnerability of these areas. Inundation and flooding are the common threats to these 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. Other threats include beach erosion, saltwater intrusion, and impacts on the infrastructure and coastal society. Efforts are ongoing in some countries and cities to protect against climatic changes and sea-level rise. For some island countries, the frequency and extent of floods and storms have influenced the cost of protection and associated risks of damage to property in most coastal cities.

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.

The array of structural solutions employed for intrinsic defence and accommodation by exposed coastal groups requiring either limited or full protection against inundation, tidal flooding, effects of waves on infrastructure, shore erosion, salinity intrusion and the loss of natural resources, come at a cost (Yohe and Schlesinger, 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). Ziedler (1997) and Yohe and Schlesinger (1998) provide insight on the value and cost of protection of property at stake, for instance, Ziegler (1997) shows that limited or full protection in coastal zones could cushion against property losses worth US$ 30 billion.

Costs of protection may impact on the values of properties. A substantial amount of literature examines the extent to which exposure to environmental hazards are capitalized in the value of surrounding properties (Farber, 1998; Dale et. al 1999; Jackson, 2001; Boyle and Kiel, 2001). This literature generally supports the hypothesis that exposure to hazards adversely influences surrounding property values. This indicates the possibility of adoption of measures to protect not only human lives, but also to avoid a decline in value of property.

According to UNEP (1998), extreme climatic events have negative impacts on tourism, freshwater supply and quality, aquaculture, agriculture, human settlements, financial services and human health. Storm surges, flooding, inundation, erosion and intrusion of sea water are likely to have a harmful impact leading to costly investments in protective measures. Such impacts affect productivity, disrupt the lives of frontline populations and seriously compromise economic well-being. This would influence residential location, levels of protection and property values. While literature on lifecycle provides empirical evidence that people adjust their housing consumption in order to fit changing household needs with their progression through the cycle of life, e.g. changes in household size, age of household members, and marriage status (Clark and Onaka, 1983; Kendig, 1984), in Cameroon as in most developing states, factors such as income, employment and perceived climate risk are important in determining the residential location choices. It is empirically established that households prefer less climate variation and climate risk on their property and livelihood (Englin 1996; Harrison et al., 2001; Maddison and Bigano, 2002; Rehdanz, 2002; Rehdanz and Maddison, 2003).

Factors that shape private and public response, be it policy, governance or levels of income, are in good stead to enhance the resilience (ability to resist or recover from damage) and adaptive capacity of exposed communities. This is captured in Figure 1 which shows a cyclical framework for protection and adaptive capacity as microcosm for future adaptation. The schema essentially surmises that vulnerability or susceptibility to damage, protection, adaptive effort and resilience are inter-temporal dynamic processes that reinforce each other within communities, on the premise that households aim to maximize positive effects and to minimize adverse impacts, thereby reducing vulnerability. Protection is considered here as actions taken in response to expected change in the climate or other change in the environment. Protection may be reactive or proactive, and may occur at any level (local, provincial, national or international) or at a combination of these levels. The adaptive capacity or the ability of households to protect against climate stress could be facilitated by technological options, economic resources and their distribution, human and social capital, and governance (Yohe and Tol, 2002).

Coastal households, for instance, do perceive climate risk as not only inherent to their survival but also to their day-to-day wellbeing, and thus take the responsibility for managing risks even for expected extreme weather events and natural disasters. Individuals and households still adopt a variety of measures, structural and non-structural to safeguard life and property, supplementary to external support from municipal authorities and national governments. An array of ex-ante protection options e.g. physical reinforcements that reduce property exposure and ex-post management strategies e.g. rebuilding or relocation, provide a menu of choices employed to reduce effects from natural hazards. As highlighted in Figure 1, the interaction of private initiative and public protection from municipal authorities controls covariate risks and enhance the capacity of households to withstand frequent repetitive risky events could exhaust household options. Protection experiences allow households to learn how to rebuild both assets and livelihoods at shorter intervals, which may stand them on good stead in the long-term. Whilst these protective options are therefore immediate containment for the direct and indirect effects of extreme weather events, they provide a path through repetitive activities and a learning experience that allows households to select from an array of options better to provide long-term resilience and adaptation.

Formal public structural and non-structural intervention in the form of cash and material transfers, climate early-warning systems coupled with market-based instruments (e.g. access to finance) promote resilience and directly feed the adaptive capacity of households and communities; where adaptive capacity relates to the ability of households to respond to climate change facilitated by technological options, economic resources and their distribution, human and social capital, and governance (Yohe and Tol, 2002). The choice for possible adaptation is therefore contingent on the experiences from ex-ante and ex-post protection options.

Based on this brief review, an inspiring question that comes to mind is: are homeowners motivated to incur the cost required for protection despite the perceived risks and anticipated losses? Identifying these magnitudes is important for theoretical reasons as well as for the design of policies aimed at prompting adaptation to future climate change, particularly on coastal fringes. This is the rationale for this current project on protection effort and costs in Cameroon, and the potential contribution to the existing body of literature while relying on Cameroon as the laboratory from which we generate findings for wider applications.

3. Analytical Framework

In this study we estimate protection costs 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 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) and benefits from the protection measures employed. Three steps are thus 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.

3.1 Assessing Socioeconomic Factors Influencing Protection: A Cost Model Approach

Assuming the total damage function from an extreme climatic event is the sum of a set of individual functions for the households living in the location/neighbourhood, then the total damage function is given as $D = f(\psi)$ and the total protection costs function $C = f(H)$, where ψ is the level of damage and H is the amount of damage controlled by the defensive expenditures of households and $\hat{\psi}$ is the uncontrolled effects. H accounts for effects from flood (F) and storm incidents (T). With global warming expected to contribute to the frequency of extreme climatic events (IPCC, 2007), in graphical term this implies that the total and marginal cost functions for damage incurred have the shapes shown in Figure 2. However, the total and marginal protection cost function of households in terms of incidents experienced (e.g. storms making landfall or house inundation by floods) will be in the form shown in Figure 3.

In-depth analysis of the protection cost or expenditures (C) made to reduce the adverse climatic effects (H) provides an important avenue for public policy. Assuming the cost (*Ci*) of a household *i* protecting property is a function of the bundle of attributes that characterize the home and incidents of climate events (floods, storms, etc.)., the cost of any household protecting property, *Ci* can be described as a function of structural (X_i), locational characteristics (Z_i), income (Y_i) as well as flood (F_i) and storm incidents (T_i):

$$C_i = f_i(X_i, Z_i, Y_i, F_i, T_i).$$

If these factors are non-linearly related, then their interaction could be expressed as:

$$C = \alpha_0 X_i^{\alpha_i} Z_i^{\beta_i} K_i^{\nu_i} A_i^{\gamma_i} Y_i^{\vartheta_i} e^{\eta_i F + \varphi_i T} \qquad (1)$$

The basic cost function can be described as a double-log equation as follows:

$$\ln C_i = \alpha_0 + \sum_i^n \alpha_i \ln X_i + \sum_i^m \beta_i \ln Z_i + \nu_i \ln K_i + \gamma \ln A_i + \vartheta_i \ln Y_i + \eta_i F_i + \varphi_i T_i + \varepsilon \qquad (2)$$

Hence the cost of protection of homeowner C_i is determined by *Xi*, an indicator of the *j*th attribute of the house and *Zi* the *k*th environmental attribute of the house, where n and m are the reported number of characteristics for house structures and the neighbouring environment, respectively. K_i is the proximity to the coast measured in meters, Y_i is income, A_i is altitude above sea level in meters, F_i is a set of dummy variables to account for occurrence and exposure to floods, S_i is dummy variable to account for exposure to storms and ε is a random error term. The cost of protection C_i includes cost of reinforcing homes against climate hazards. Treated in a static cost-minimization framework, the basic premise of the method is that the cost incurred in protection is related to the services the effort provides and the socioeconomic and environmental characteristics of the homestead.

Decoupling the house (Xi) and environmental (Zi) characteristics to include surface size, age of the house, house design, floor type, etc., the following cost function is thus estimated:

$$\begin{aligned} \ln c_i &= \alpha_0 + \alpha_1 \ln Surface_i + \alpha_2 \ln Age_i + \alpha_3 \ln Age_i^2 + \alpha_4 HQual_i + \alpha_5 Floor_i + \alpha_6 Roof_i + \\ &\ldots\ldots\ldots\ldots + \alpha_7 \ln Baths_i + \alpha_8 \ln Bedrooms_i + \alpha_9 Walls + \beta_1 NQual_i + \nu_1 \ln DSEA + \vartheta_1 \ln Y \qquad (3) \\ &\ldots\ldots\ldots\ldots + \gamma \ln ALT_i + \eta Flood_i + \phi Storm_i + \varepsilon_i \end{aligned}$$

In eq. (3) Cost (c_i) relates to total costs incurred in protection in the last five years, Surface defines the area of the house in square metres, Age is the year the house was built subtracted from 2007, HQual is the housing quality measured as a dummy (1 if good quality, i.e. superior design, 0 otherwise), Floor (1 if cemented, 0 otherwise), Roof (1 if corrugated iron sheet, 0 otherwise), Bath (number of bathrooms), Bedrooms (number of bedrooms), Walls (1 if brick, 0 otherwise), NQual is neighbourhood quality (1 if good quality, i.e. good situational planning, 0 otherwise), Coast (1 if coastal resident, 0 otherwise), ALT is height above sea level in metres, Flood is dummy for house within floodplain (1 if floodplain, 0 otherwise), Storm is a dummy for windstorm brunt (1 if damaged before by storm, 0 otherwise), and DSEA is Distance from the sea in metres. *A priori* it is expected, as shown in Figure 4, that cost will decay as distance from the coast increases.

3.2 Maximum Likelihood Choice for Protection

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

$$C_{ij} = V(K_j, S_j) + \varepsilon(K_j, S_j) \tag{4}$$

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 $Z_{ji} = (K_j, S_j)$ the household head will choose measure *j* over all other measures *w* if:

$$C^*(Z_{ji}) < C^*(Z_{wi})\ for \forall w \neq j \tag{5}$$

Or if:

$$\varepsilon(Z_{wi}) - \varepsilon(Z_{ji}) < V(Z_{ji}) - V(Z_{wi})\ for ... w \neq j \tag{6}$$

In other words, household i's problem is

$$\arg\min[C^*(Z_{1i}), C^*(Z_{2i}), ..., C^*(C_{Ji})] \tag{7}$$

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

$$P_{ji} = \Pr[\varepsilon(Z_{wi}) - \varepsilon(Z_{ji}) < V_j - V_w] \forall w \neq j, where V_j = V(Z_{ji}) \quad (8)$$

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

$$P_{ji} = \frac{e^{Z_{ji}\gamma_j}}{\sum_{w=1}^{J} e^{Z_{wi}\gamma_w}} \quad (9)$$

Eq. (9) 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). Equation 9 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. The definition of the variables is given as note in Table 10.

4. Data

4.1 Study area

Primary data is essentially used for this study drawn from the coastal region of Cameroon which cuts across three provinces, the South, Southwest and Littoral province 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 province. 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 Figure 5). 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.

These two subdivisions are socially and political important locales on the fringes of the Atlantic Ocean. Fishery is the leading sector in the economy of the region in terms of its contribution to household income and employment. Fishery is supplemented with livestock and crop agriculture, providing food security for both the rural and urban populations. The region's endowment of marine resources, mangroves and rich onshore volcanic alluvial soils ensures a diversified economy. However, rapidly expanding population, urbanization and invasion by larger foreign-owned fishing trawlers cause occasional imbalances between supply and demand for fish and other marine products such as prawns. The mean annual rainfall of 2500mm and 38^{o}C midday summer temperatures provide good potential not only for fishery and agricultural productivity, but also for wildlife and year-round ecotourism experience.

4.2 Sample

About 2000 homes in the coastal towns that were exposed to the 1999, 2001 and 2005 floods were randomly selected. From this a sub sample was then drawn for study. In determining the size of the sub-sample, the Cochran (1963) and FAO (1990) equation are employed in which $n = z^2 pq / e^2$ where $q = 1 - p$ to yield a representative sample where n is the sample size, Z^2 is the abscissa of the normal curve that cuts off an area at the tails (1 - equals the desired confidence level, e.g., 95%), e is the desired level of precision, p is the estimated proportion of households adopting coastal protection, and q is 1-p. The value for Z is found in statistical tables. In the current study we desire a 95% confidence level and ±5% precision (sampling error) and assume p= 0.5 (maximum variability). The resulting sample size is thus:

$$n = (1.96^2)(0.5)(0.5)/0.05^2 = 383...houses.$$

The sample size was then augmented to 400, with each half accounting for houses in and out of the coast. That is 200 homes in human settlements 300 m.a.s.l and 30 km away from the coast were comparatively studied against 200 houses in closest proximity to the coast. The two groups are studied on the cost of protection with respect to the presence of floods, storms and climate related impacts. Homes are studied on the renovations and modifications made to withstand storm surges and floods, the current prices charged and the economic value attached to the property. The expenditures are thus the sums of the preparatory costs prior to and the repair (maintenance) cost after each identified storm or flood event, as was posed in the survey instrument. Unobtrusive observation and discussion with community heads are further employed to ascertain the state and effects on community infrastructure in the study area. In addition, secondary data on the vulnerability of public infrastructure is obtained from the Southwest Regional Delegation of the Ministries of Lands, Town Planning, Housing and Urban Affairs. This complements the primary field survey.

4.3 Survey Design

The survey which took place in January 2008, began with questions concerning the respondent's current residence, neighbourhood, climatic conditions and likelihood of moving. The survey elicits information of the age, design and size of the property, demographic variables of house occupants including household income and home reinforcements against floods and storms. The questionnaire is pre-tested to 40 households and the instrument updated with relation to the housing profiles i.e. neighbourhood configuration, neighbourhood housing density, surrounding land uses, rents, and purchase price of house.

5. Survey Observations and Analytical Estimates

5.1 Climatic Activities

The landing of a tropical storm presents a major physical threat to the well-being of the inhabitants of the 360 km coastline of Cameroon, with most damage occurring as a result of the associated surge, heavy rainfall and wind. Two tropical storms, with wind speeds greater than or equal to 55 mph, formed in the study region in the last five years. This would seem that Cameroon is not a high-risk tropical storm-prone area. However, if the extent of destruction is considered, the tropical storms are serious indeed. If climate change, however, causes any increase in storm activity, the situation is likely to further worsen. In Cameroon's West Coast, storm surge heights in excess of 3 m are not uncommon. Surge water that hits the coastline from Limbe to Idenau travels inland. On the basis of the penetration distance of surge water and the depth of inundation, the West Coast area can be delineated a Risk Zone (RZ) and a High Risk Area (HRA). Considering past surge heights, penetration distance and topography, the RZ with risk to damage of property from inundation is estimated to extend 15 km from the coast. Obviously, any increase in surge heights due to climate change will lead to an increase in the extent of the RZ. The HRA within the RZ where there is a possibility of loss of lives due to substantial inundation by storm surges is estimated to extend 5 km from the coast, with a population density of about 150 per square km.

5.2 Socioeconomic Profile and Vulnerability of Coastal Residents

The vulnerability of a community to climate is a function of its exposure and susceptibility to environmental change, and its inherent or protective capacity in the face of such episodic events.

Adger and Kelly (2000) describe vulnerability as the capacity of individuals and social groups to respond to, that is, to cope with, recover from or adapt to, any external stress placed on their livelihoods and well-being. While the macro policy environment is described by limited government ownership of adaptation effort to climate related risks and limited financing available for public works, 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 identified by community leaders as 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 observed to be predominantly employed in fishing and agriculture. The livelihoods based on agriculture, fishing and aquaculture are reported by community leaders to be 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.

Given the characteristics reported in Table 2, the properties may be at risk of damage. On average, the houses are 16.4 years old with about 4.5 bedrooms. About 34% think their house is of good quality, 75% report cemented floor and 85% of houses are roofed with corrugated iron sheets. These houses are on average 3.1km from the sea and 8.6m above sea-level. 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.

5.2.1 Economic Profile of Homeowners

About 43% of persons studied personally owned their homes, 39% live in rented property and 18% report living in ‘extended’ family owned homes. As summarised in Table 3, the residents engage in multiple activities. Seventeen percent are formally unemployed, 42% are businesspersons, 32% are State workers, 10% are retired, 15% are farmers and 32% are fishers. About 63% of homeowners are male, with an average age of 55 years. It is observed that 25% of homeowners have only primary education, 33% have secondary level education, 23% are university educated and 19% have never been to school. Of these 36% are single. This social status is expected to reinforce the resilience of residents to climatic shocks, as the diversity of income sources and access to resources, as well as the social status of individuals or households within communities define the nature and extent of their vulnerability (Adger and Kelly, 1999). The average number of persons living per house is 5. For those who are tenants, they pay on average 42.000 FCFA (US$ 97) per month for a three-bedroom apartment. The average monthly income of the residents is 120.000 FCFA (US$ 285).

5.2.2 House Location and Structure

A significant proportion of the residents have been living in this locality for 43 years, reporting that they were attracted by the closeness to the sea, closeness to the forest, economic opportunity such as farming, fishing, trading and a beautiful environment. Of these, 25% report that their home is near the seashore; on average 2.8 km. About 4% report that their home is located in the government residential area (GRA), 6% in the business district and 17% in the Municipal Council allocated area. The structure of homes is paramount to withstand environmental stress and strain. About 52% report having the walls of the house constructed with cement block/mortar, 40% use wood and 8% report living in mud-brick homes. These houses are bungalow (60%), villa (18%) or apartment blocks (22%), with 5 living rooms on average. About 48% have toilet and bathing facility within the house. When enquired on the flooring, 80% report the floor of the house is cemented. For 88% of the homes, the roof is made of corrugated iron sheet and 8% use thatch. The types of lighting facility include electricity (75%) and kerosene lamp (25%). However, 68% of homes do have access to motorable roads, taking about 42 minutes on average to drive from home to jobsites and 25 minutes to the business centres. About 28% of these houses have view to the sea. The residents report having lived for 13 years on average in their current dwelling.

5.2.3 Private Housing and Environmental Effects

About 55% of residents report that their homes have been flooded due to flash floods, and this has occurred on average 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. This has occurred on average 2.2 times in the last five years. About 68% of residents think their house is exposed to floods and windstorm destruction.

5.2.4 Vulnerability of Public Infrastructure

A broad category of public assets are observed to border the Atlantic Ocean in the study area, with a distance of 0.5 – 1.8 km from the seas. This includes, a 230 km modern tarred road running along the

West coast, 12 primary schools, 8 nursery schools, 4 secondary schools, 5 health centres, 4 banks, 1 botanic garden with rare species, 1 wildlife sanctuary, the headquarters of the second largest non-governmental employer in Cameroon - the Cameroon Development Corporation (CDC), 9000 hectares of export crop (Oil Palm) and Cameroon's lone National Oil Refinery (SONARA) that contributes about 15% to the national GDP which is about US$ 30 billion (EIU, 2007). In light of the importance of the coastal assets, the City Councils of Limbe I, Limbe II and Idenau have invested millions of dollars in developing and upgrading its storm-water, sewage and waste treatment systems, all of which could be damaged to varying degrees by extreme climatic events. Given public investment information, the infrastructure at risk in Limbe and Idenau municipality is valued at US$ 6 million (LUC, 2001). Our extrapolation shows that flooding would affect approximately 125,000 m^2 of right-of-way (valued at US$ 4.5 million) and sidewalks to the value of $ 0.3 million, excluding the value of the land on which they are located. Unobtrusive observation shows that 25% of the infrastructure of the National Oil Refinery (SONARA) facility could be at risk, incurring an approximate asset value replacement cost of US$ 2 billion (GOC, 1977). Some "indirect costs and/or damages" due to lost wages and health care costs caused by property owners taking time from their work for clean-up would occasion a cost directly related to the surge incident, as would businesses being closed for repairs. The employment revenue created in the efforts to repair, service and rebuild commercial establishments may not offset the costs incurred by individuals and households.

5.3 Types of Protection

5.3.1Private homeowners

Whilst none of the homeowners attested to purchasing hazards insurance, effort to minimize loss of property and life hinges primarily on other non structural measures shown in Table 4. According to the residents, if they expect a flood or windstorm, preparations they usually make include: elevating their homes (18%), reinforcing the homes (42%), elevating the furnace, water heater, and electric panel that are susceptible to flooding (28%), install "check valves" in sewer traps to prevent flood water from backing up into the drains of the home (8%), constructing barriers such as levees, beams, floodwalls to stop floodwater from entering the building (28%), and sealing of walls in basements with waterproofing compounds to avoid seepage (12%). Most of the residents, during a flood or windstorm, report listening to the radio or television for information (6%), wait for instructions to move (6%), evacuate (42%), secure the home (56%), move essential items to an upper floor (20%), turn off utilities at the main switches or valves (8%), and disconnect electrical appliances (34%). After the flood or windstorm, about 64% listen for news reports, 28% avoid floodwaters, 35% avoid moving water, 11% stay away from downed power lines, and report them to the power company, 28% return home only when authorities indicate it is safe, 63% stay out of buildings surrounded by floodwaters, 36% use extreme caution when entering buildings, 48% service damaged septic tanks, cesspools, pits, and leaching systems as soon as possible and 41% clean and disinfect everything that got wet.

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. 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%). 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.

A range of non-physical intangible responses are employed by households. 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 office, 10% use the Red-Cross chapter, 43% rely on the Community Head or Quarter Head for information. On meeting the family to discuss the information gathered, the house occupants usually agree to pick a spot to meet outside the home. About 12% pick a place away from the neighbourhood, 5% choose a far away district as the “family check-in contact” for everyone to call if the family gets separated and 18% discuss what to do if advised to evacuate. In the implementation of the disaster plan, 14% install safety features in the house, such as smoke detectors and fire extinguishers, 11% inspect the home for potential hazards such as items that can move, fall, break, or catch fire, and correct them, 3% have their family learn basic safety measures, such as CPR and first aid; how to use a fire extinguisher; and how and when to turn off water, gas, and electricity in the home, 8% teach children how and when to call the local Emergency Medical Services number. About 39% assert they keep enough supplies in the home to meet needs for at least three days, 28% assemble a disaster supply kit with items that may be needed in case of an evacuation, 8% store disaster supply kits in sturdy, easy-to-carry containers, such as backpacks, 38% keep important family documents in a waterproof container and 5% keep a smaller disaster supplies kit in the trunk of the car.

5.3.2 Public and Governmental Effort on Protection

About 26% of residents assert that they have once been assisted by government to protect their house against disasters. Various protective *structural* measures have been employed by the local or national government in the last 5 years in the coastal community. These including building of reservoirs, building of levees and walls, constructing drainage and diversion channels, modifying bridges, altering water channels, pumping out water, and land treatment. Protective *non-structural* measures taken in the last 5 years include: flood or storm warning and preparedness, temporary evacuation, permanent evacuation, relocation, land regulations including floodway delineation, flood plain zoning, building codes and regulation, flood proofing, area renewal policies, and conversion to open space. Ongoing public works project that aim at reinforcing the resilience of public property includes: (i) c*onstruction of embankments* to obstruct the penetration of surge water; and even if the surge overtops them, the water energy will be greatly reduced; and (ii) *management of mangrove forests*, from denudation via implementation of afforestation program all along the coastal belt. The afforestation also helps stabilize land, create more accretion leading to more land, and also raise the level of topography that reduces inundation. This is coupled with watershed management programs of the government aimed at rehabilitating watershed areas. Both concerned government and private entities also attempt undertake strict implementation of existing forestry rules and regulations. After a flood or windstorm, about 19% of residents reported receiving assistance from government. 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.

5.4 Cost of Protection

5.4. 1. Expenditures incurred in Individual and Family Homes

As shown in Table 5, the agriculture and fishery sectors are affected, with flooded croplands and damaged field crops. 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.

Expenditures are therefore incurred by both family homesteads and the local government. In preparation against floods or windstorms, roofs, windows, doors and furniture are reinforced. On average, the coastal residents report spending 145,500 FCFA (which translates to US$ 346, for an exchange rate of 420 FCFA for 1 US$, as on 6 November 2008) in the last five years in preparation against floods. Parts of homes and living compound are reinforced costing on average 83,000 FCFA (US$ 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. As summarised in Tables 6 the *ex post* costs for repair exceed *ex ante* costs for protection whether in self-owned or rented property. For those residing in rented property, some rental agreements allowed for limited infrastructural investments (detachable or non-detachable) in the houses which if permanent and approved by the property owner, the costs are later deducted from the monthly bills of the tenants and the cost thus borne by the landlord. However, in cases where tenants never made any such investments and the property owner undertook reinforcements and/or renovations on the behest of the tenant, the identified development is also estimated and accounted for in the survey.

In Table 7 a test is performed to ascertain whether the variances in the costs of protection from different options are significantly different. The F-test is statistically significant at 5% indicating that the protection choices have different variances, and that the options have different levels of cost diversity as protection measures. This would imply that the protection choice is contingent on the perceived costs and possibly the value of the homes. The average value of the homes is 14,300,000 FCFA (US$ 34.000). For those who owned their dwelling, on average they expressed Willingness-to-Accept about 10,300,000 FCFA (US$ 24,500) as minimum payments and 17,250,000 FCFA (US$ 40,952) as maximum 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.

5.4.2 Econometric Relationship between Protection Costs and Environment

The underlying cost coefficients are as shown in Table 8. Virtually all of the important variables are statistically significant. The coefficient for exposure to floods is statistically significant and has a positive sign in both equations at the 5% level. The magnitudes of the impacts on cost of protection are small, with the elasticity (percent change in protection cost for a 10-percent increase in flood incident) is 0.19 for homes close to the coast and 0.08 for homes away from the coast. The estimated effect for the flood variable implies that the location within the floodplain increases the cost of protection, but this effect is small. The coefficient of the storm variable (Storm) is similarly statistically significant and has a positive sign on both groups of residents. This positive result indicates that storm incidence increases the cost of protection. The cost of protection to storms and floods has a negative correlation with the proximity to the coast as measured by the distance from the sea (DSEA) in both models. The coefficient for distance suggests that a 10% increase in distance from the sea decreases the cost of protection by approximately 5.5% and 3.2%, respectively, and this is statistically different from zero at the 1% significance level.

As expected, income is positively related to capability to protect. Household heads with higher incomes have better ability to meet cost of protection, as a 10% increase in the income levels significantly increases protection cost by 7.71% and 3.94%, respectively. It could therefore be possible that either higher income residents tend to construct houses of superior quality or they use expensive materials and designs which are implicit in their protection costs. In contrast, it could also be that low-income households would typically allocate smaller defensive expenditures because most of their income is spent on the basic necessities of life. The policy implication is that the susceptibility of residents is not only accounted for by the physical challenges of storms and floods and the environmental threats to surrounding ecosystems on which their livelihood depend, but could be reinforced by socioeconomic conditions and institutional context in which significant proportion of residents find themselves. This is all the more important since income comes from diverse sources. A significant proportion of households report engaging in income pooling among household members (68%) receive external financial assistance from governmental and non-governmental agencies and rely on remittances, both from within (61%) and outside the country (44%) as insurance for coping with diverse risks including climate risks. While this exogenous injection of incomes to augment household-heads' earned-income tends to alleviate a possible endogeneity problem in the current study, further research which disaggregates and tests for the shocks of endogenous income dynamics will be required.

Most of the coefficients of structural and neighbourhood variables are statistically significant, with all having the expected signs and have significant associations with the value of protection. The variables measuring age is positive and significant, indicating that increasing age increases the cost of protection. However when 'age square' is tested as a variable, it turns out negative indicating that older houses incur less in protection. One would expect that the much older the house the more prone it is to destruction and the higher the costs it incurs in protecting against weather extremes. However, the results obtained highlight the possibility of much older homes having already been reinforced in the past and this contributes to reduce their current cost of protection.

The findings indicate that houses of superior quality and design and those located in good quality better planned neighbourhoods with hardened cemented floor and tensile corrugated iron-sheet roofs spend less in rebuilding after floods and storms, and significantly spend much less in preparing for impending weather extremes. However, the bigger the house in terms of surface area, more bathrooms and bedrooms the increasing costs incurred in preparing and rebuilding following weather calamities, and the protection costs are reinforced in circumstances in which more than 55% of the homes are having walls made of wood and other easily destructible materials. This susceptibility is reduced if the homes are built further away from the coast and out of flood plains. The costs of protection are further reduced by increasing distance from the sea and in higher ground. Thus, proximity to the coast and in flood plains significantly increases the cost of protection.

To ascertain deeper meaning on the climate coefficients, we estimate the marginal cost of protection found by differentiating (eq. 3) with respect to ALT_i, $DSEA_i$ or Y_i while other attributes are held constant. Table 9 displays the results of using the regression from Table 8 to estimate the marginal effects of proximity to the coast, elevation of homes and income. The estimates assume coastal residents with monthly average income of 120.000 FCFA living 15 km from the sea and 30 m.a.s.l and non-coastal residents with mean monthly income of 80.000 FCFA at 30 km from the sea and above 300 m.a.s.l.. The elasticity of protection cost with respect to changes in proximity and elevation are – 0.039 and – 0.044, respectively, indicating that the marginal impacts for protection costs are negative away from the coast and at higher ground. The elasticity of protection cost with respect to income is positive, indicating that increasing income improves the chances of protection, provides resilience and possibly reduces risks of damage through better reinforcements and repairs. For both groups of residents, protection cost is elastic with respect to income. For coastal residents, a 1% increase in income would lead to a 0.647% increase in protection expenditures, though a similar change in elevation and distance from the seashore would lead to only 0.04% declines in protection costs. For non coastal residents, a 1% increase in income leads to 0.048% increase in expenditures for protection, 0.002% and 0.009% declines in cost of protection due to elevation and distance from the seashore, respectively. Protection cost is thus inelastic (-0.002) with respect to elevation above ground for non-coastal residents. That the marginal impacts though small are yet statistically significant, indicates that occurrences of floods and storms weigh on the cost of protection, confirming that additional incidences are likely to have increasing stress effects on households. This will be consequential unless measures are taken to ease the constrain on protection choices, through structural design such as elevation, location out of flood plains away from the sea, better income or credit transfer and perhaps with complementary public structural and non structural measures..

5.4.3 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 11, 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 employment 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 trees 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 ensure 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 strategies, the current 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 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 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 among homeowners in taking up particular protection measure. What stands out from the observations in Table 10 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.

6. Conclusion and Policy Implications

Cameroon's coastal zone is characterized by a rich diversity of economic systems and a great number of socioeconomic activities. The population along the Atlantic coast has been growing double the national rate of population growth (Ngwa, 1999). With about 30 percent of the national population living in the coastal zone, the findings of this study highlight that these coastal residents may be liable to effects of climate induced risks (seawater inundation, river floods and floods due to precipitation, storm surges, accelerated wave activity, land subsidence, erosion and mud slides).

Three lessons can therefore be drawn from these results. A first lesson is that incidences of floods and storms appear to have significant positive impact on the cost of protection, even after correcting for proximity to the coast. The second lesson is that income levels of consumers enhance their ability to protect themselves. The third lesson is that education, employment status and previous experiences approximated by longevity suggest that homeowners are more discerning in selecting the strategies and choices for protection. This has important policy implications for both housing and environmental policy.

Housing represents substantial investment, more especially in coastal cities and towns with huge populations and increasing development which may be vulnerable to storm surges, with potentials for loss of life and property. Protecting these investments in the face of potential damage from storm surge, heavy rain and high wind is a daunting effort that depends strongly on what sort of protective measures employed. That superior quality and better designed houses suffer less protection costs is plausible because owners of superior quality and design houses may have already suffered flood and storm disaster protection costs or may have had to spend a bit more than usual to make their homes resilient in instances of floods and storms. However, more interesting is the difference between the costs associated with pre-empting the impacts of floods and storms and the costs associated with recovering from the effects of floods and storms. Since the latter costs are less then it is rational to emphasise properly designed protection rather than deal with the after effects of floods and storms. The inference is that the cost effective way to deal with anticipated increases in floods and storms is enhancing protection which entails lower costs and that feeds adaptation and resilience.

The findings also have triple implications for coastal management. First, there is need to avoid development in areas that are vulnerable to inundation. Second, municipal authorities need to ensure that critical natural systems continue to function. Third, effort must be put to protect human lives, essential properties and economic activities against the ravages of the seas. The exorbitant costs for public works require that non structural resilient natural protective features, such as beaches, sand dunes and mangroves are enhanced, which also maintains biological diversity, aesthetic values and recreation. While income, education, age and gender are significant factors determining household's probability selecting protection measures, the ability of coastal residents and homeowners to extensively respond will be reinforced by communal. Such public actions for protection will include providing storm-surge protection, erecting sea walls, constructing dykes and relocating vulnerable human settlements. In this vein, further research is therefore required to examine in-depth the nature and role of public works and public protection in catering for the wellbeing of these coastal residents.

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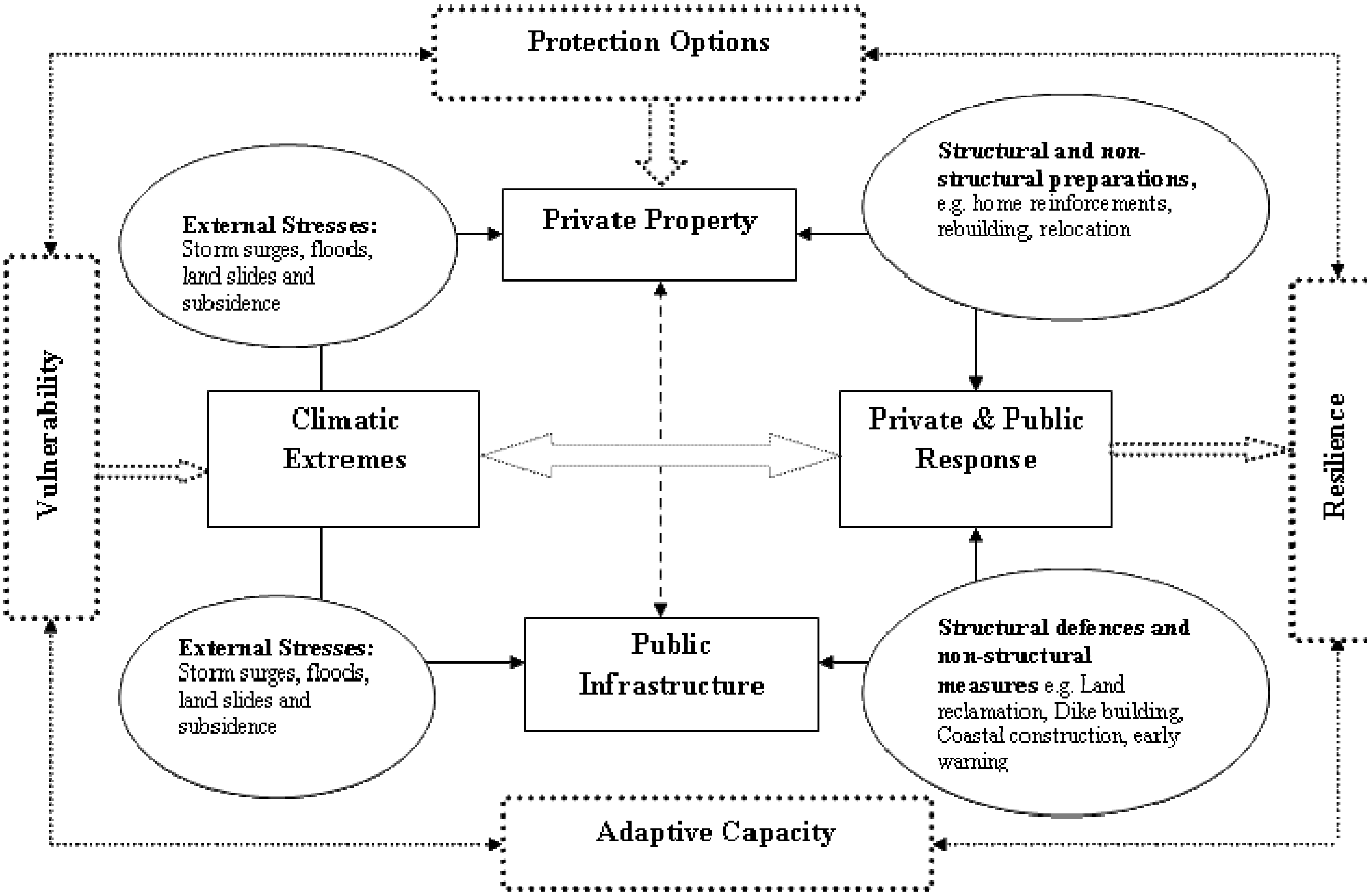

Figure 1: Cyclic Interaction of Private and Public Protection to climatic Stress

(Author’s conceptualization)

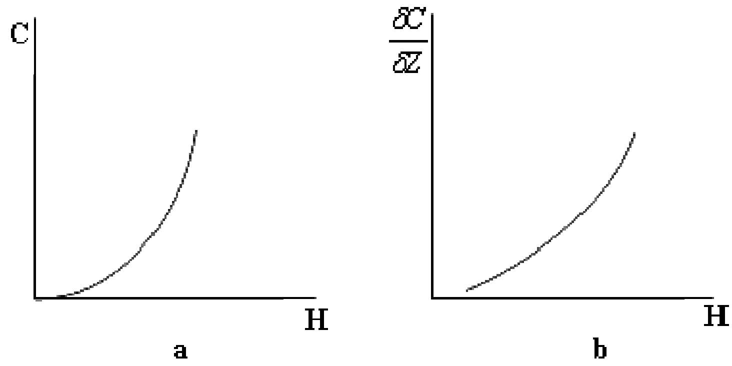

Figure 2: Total Damage cost (a) and Marginal Cost (b) of Climatic Event

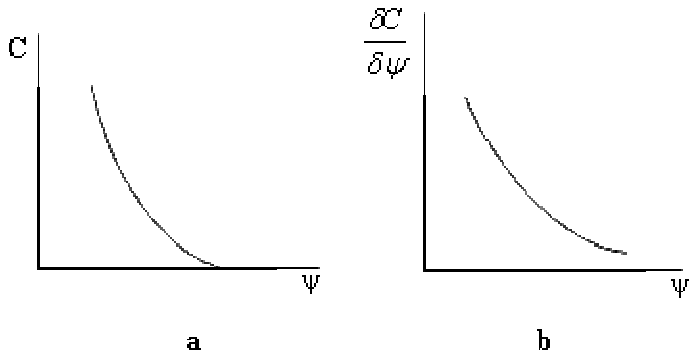

Figure 3: Total Protection cost (a) and Marginal Protection Cost (b) of Climatic Event

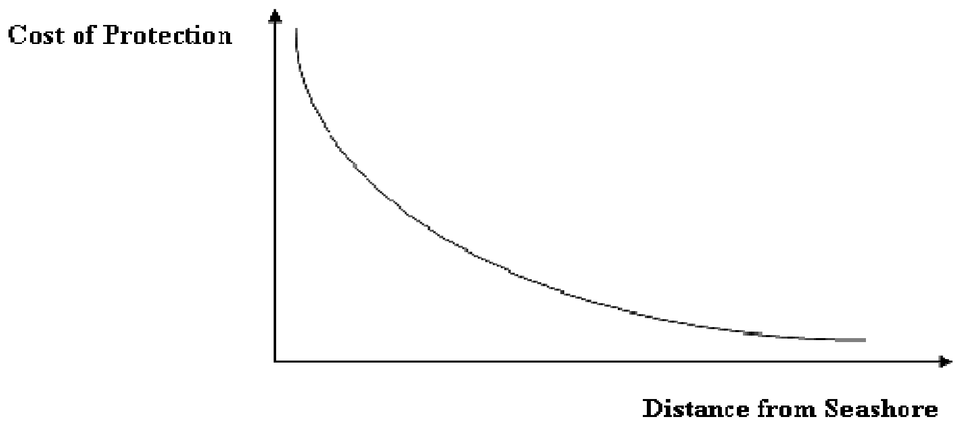

Figure 4: Increase in protection cost due to proximity to the Coast

Figure 5: Cameroon’s Southwestern Coast and Relief

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

‘50 homeless after storms!’ is the screaming banner headline at News24, 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. ‘North West Department of Local Government and Housing Spokesperson Lesida Kgwele said families who were affected were mostly from rural areas.’ According to the 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

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

(Source: Author's summary, 2008)

Table 2: Summary statistics: House and Neighbourhood Characteristics

Variable	Mean	Std. Dev.	Minimum	Maximum
Cost (FCFA)	165,000.2	41,916.5	45,300.7	622,255.3
Surface (m^2)	52.53	11.27	17.55	175.51
Age of property (years)	16.4	4.06	3.53	60.74
HQual (dummy)	0.34	0.06	0.00	1.00
Cemented Floor (dummy)	0.75	0.02	0.00	1.00
Iron Roof (dummy)	0.85	0.02	0.00	1.00
Bath (number)	1.63	0.04	0.00	1.00
Bedrooms (number)	4.53	1.28	1.25	8.6
Brick Walls (dummy)	0.66	0.03	0.00	1.00
NQuality (dummy)	0.57	0.03	0.00	1.00
DSEA (km)	3.14	2.04	0.5	45.5
ALT (m)	8.63	0.50	0.3	6.1
Flood (dummy)	0.45	0.05	0.00	1.00
Storm (dummy)	0.26	0.07	0.00	1.00
Income (FCFA)	120,000	54,000	35,000	650,000
Note: Number of observations equal 400				

Source: Author's computation from Survey data, 2008

Table 3: Bio-economic Profile of Residents

Employment (%)	
Businesspersons	42
State workers	32
Retired	10
Farmers	15
Fishers	32
Unemployed	17
Gender* & marital status *(%)	
Male	63
Single	36
Education (%)	
Primary	25
Secondary	33
University	23
Never been to school	19
Tenancy (%)	
Personal property	43
Rented property	39
Living in shared facility	18
House structure (%)	
Cement block/mortar	52
Wood	40
Mud brick	8
House Types (%)	
Bungalow	60
Villa	18
Apartment blocks	22

(Source: Author's computations using Field Survey, 2008)

Table 4: Protection by Private homeowners

Protection methods*	**Proportion of Homes (%)**
Construction of barriers e.g. levees, beams, floodwalls	28
Elevating homes	18
Reinforcing the homes	42
Elevating home appliance	28
Installing "check valves" in sewer traps	8
Sealing walls with waterproofing	12
Listen to radio and television	6
Evacuate	42
Move essential items	20
Turn off utilities	8
Disconnect electrical appliances	34
Wait for instructions	6
***Note**: Residents employ more than one measure	

(Source: Author's computations using Field Survey, 2008)

Table 5: 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 - 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	576,000
Wind storms along the coast Southwestern coast (2000, 2003 2007)	- 18 houses collapsed - 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	452,000
Lava flow through Bakingili (1999)	- 60 ha of oil palm field damaged - 14 km of road damaged - 83 ha of arable farmland damaged - 50 houses destroyed	238,000
Mudslides in Limbe and Isokolo (1998, 2001, 2003)	- 34 houses damaged - 2 ha of banana fields damaged - loss of life and household appliances	175,000
Note: Information is compiled from (i) focus group discussion with community head heads, and (ii) reports from the Regional Delegation of the Ministries of Lands, Town Planning, Housing and Urban Affairs.		

Author's summary (2008)

Table 6: *Ex ante* average Costs (Reinforcement) and

Ex post average Costs (Repair) of Homes and Courtyard

Property	***Ex ante* Cost**		***Ex post* Cost**	
		Flood	**Windstorm**	
Part of House				
Roof	7,300	22,900	13,500	52,000
Windows	18,000	12,500	23,000	38,000
Doors	10,300	28,500	15,200	28,500
Garage door	4,700	11,600	5,400	11,600
House furniture	10,600	40,700	34,900	40,700
Sub-total (A)	*50,900*	*116,200*	*92,000*	*167,800*
Part of compound				
Fence	28,200	39,300	41,000	72,000
Wall of House	17,400	75,700	29,300	127,000
Sea wall	45,700	56,300	75,800	84,000
Trees	3,300	8,900	4,900	19,500
Sub-total (B)	*94,600*	*180,200*	*151,000*	*302,500*
TOTAL	**145,500**	**296,400**	**243,000**	**470,300**

Source: Author's computation from Survey data, 2008

Table 7: Average cost for Different Protection Measure

Protection Option	**Cost (FCFA/house)**
Reinforcement of homestead	450,870
Construction of Protective walls	265,200
Tree Planting	36,900
Disaster planning	25,800
Rebuilding	320,650
Relocation	278,000
Migration	139,400
F-value	12.532*

Note: *Significant at 5%

(Source: Author's computations using Field Survey, 2008)

Table 8: Estimates for Climate Protection Cost Function

	Coastal Residents		Non-coastal Residents	
Variables	Coefficient	t-statistic	Coefficient	t-statistic
ln Income	0.771	2.723***	0.394	1.653*
ln Surface	0.035	2.314**	0.021	1.684*
ln Age	0.018	2.506**	0.011	1.718*
ln Age.Sq	- 0.014	- 3.130***	- 0.008	- 2.221**
ln Bath	0.016	1.798 **	0.012	1.061
ln Bedrooms	0.017	1.287	0.009	1.418
ln DSEA	- 0.055	- 2.589***	- 0.032	- 1.475*
ln ALT	- 0.284	- 1.978**	- 0.159	- 1.690*
House Quality (dummy)	- 0.013	- 1.985**	- 0.008	- 2.137**
Floor (dummy)	- 0.022	- 1.482	- 0.016	- 1.233
Roof (dummy)	- 0.049	- 1.788*	- 0.031	- 1.596
Walls (dummy)	0.018	1.969 *	0.012	1.326
Neighourhood Quality dummy)	- 0.029	- 2.643***	- 0.023	- 1.816**
Exposure to Flood (dummy)	0.022	2.863 ***	0.019	1.891 *
Exposure to Storm (dummy)	0.019	2.658***	0.008	1.926*
Constant	12.89	8.026***	10.06	5.327***
Pseudo R^2	48.79		39.16	
Model chi2	15.56		16.98	
Log likelihood	637.481		642.058	
N	200		200	
Notes: The t-values denoted * are significant at 10%, ** significant at 5%, and *** significant at 1%. Non-coastal residents are homes located at least 30 km away from the coast, and 300 m.a.s.l.				

Source: Author's computation from Survey data, 2008

Table 9: Marginal Impacts on Cost of Protection (FCFA/House)

Variable	Coastal Residents	Non Coastal Residents
Distance from Sea (DSEA)	-0.039 (- 2.04)**	-0.009 (- 1.69)*
Elevation (ALT)	-0.044 (- 2.31)**	-0.002 (- 1.87)*
Income (Y)	0.647 (3.18)***	0.048 (2.20)**

The values in parenthesis are t- statistics.
* Significant at 10% level, ** significant at 5% level and *** significant at 1% level
(Source: Author's computations using Field Survey, 2008)

Table 10: Multinomial Logistic Maximum Likelihood Estimation for Protection

	Reinforcement of homestead		**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	2.613***	0.001	1.289	0.004	1.998**	0.019	1.872*	0.016	1.730*	-0.002	-1.969**	-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**

Notes: ♠See footnote 13 for a definition of the protection options.
The 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) =2901.7 Prob > chi2 = 0.000
Pseudo R2 = 0.432 Log likelihood = -3223.0125
McFadden's R2 = 0.441 McFadden's Adj R2 = 0.418

Source: Author's computation from Survey data, 2008