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ClimAfrica

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1. Introduction

1.1 Short summary

The study uses innovative statistical tools to identify and characterize vulnerable households in West and East Africa. For rural areas in West Africa, we find that being vulnerable is associated with having a young head of household, no education, being agricultural self-employed, within agro-pastoral millet or cereal root crops mixed farming systems, bad economic circumstances and little or no remittances from outside the households. Ethnic discrimination does not seem to figure as a distinguishing feature. For rural areas in East Africa, low education and a relatively old head of household characterize vulnerable and very vulnerable populations. In addition, the very vulnerable are also the poorest households Limited involvement of the very vulnerable in religious or community groups, and the relatively short time they have lived in their current resident could point to fact that these households are internally displaced persons or refugees, although data on this is not available in the surveys used. Combining these characterizations with most likely effects of climate change (necessarily preliminary!), we draw conclusions on the populations that are most at risk.

1.2 Rationale for this deliverable

The importance of the report lies in the insights gained by combining data from different sources to obtain a rich picture of populations at risk, including locality, economic characteristics and social integration in the community. The issue the report addresssing is the identification and

characterization of the populations that are most likely to be unable to cope with climate change without additional preventive or coping mechanisms. It fits within the global frame of the project because it (1) provide insights into areas where policy interventions may be most needed, and (2) paves the way for further analysis done in this project that is aimed at modelling the transmission of local climate shocks to other areas, through social network dependencies, migration and price transmission.Therefore, it contributes to the project objectives 2 (assess climate impacts in key sectors of SSA livelihood and economy, especially water resources and agriculture.) and 3 (Evaluate the vulnerability of ecosystems and civil population to inter-annual variations and longer trends (10 years) in climate)

1.3 Problems encountered and envisaged solutions

No specific problems other than data paucity for Sudan and South Sudan and outdated databases for Côte d'Ivoire and Togo. Statistical techniques for estimation of missing data and geo-referencing of surveys have been applied. Update of the document could be considered if more and more recent data become available.

2 Full description

See the attached documents: the report itself "A spatially explicit assessment of specific vulnerabilities of the food system due to climate change and characterization of vulnerable groups, Technical report for Climafrica Project, SOW-VU, February 2013", and the executive summary for wider distribution, "A spatially explicit assessment of specific vulnerabilities of the food system due to climate change and characterization of vulnerable groups Executive summary of technical report for Climafrica Project
SOW-VU, February 2013"

3 References

References are included in both documents

A spatially explicit assessment of specific vulnerabilities of the food system due to climate change and characterization of vulnerable groups

Executive summary of technical report for Climafrica Project
SOW-VU, February 2013

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1. Introduction

Future climate change conditions will potentially have a strong impact on the African continent, particularly on vulnerable groups that lack the means for coping mechanisms and do not avail of supportive social networks that can mitigate harmful effects. Identification, location and characterization of these vulnerable groups is, therefore, urgently needed so as to timely inform decision makers about possible interventions that can curb the negative effects of climate change. Yet, profiling vulnerable groups is not an easy task as many economic and location specific characteristics influence the strength of people's ability to act in response to a changing climate. This study aims to identify, locate and characterize groups that are vulnerable for climate change conditions in two country clusters; one in West Africa (Benin, Burkina Faso, Côte d'Ivoire, Ghana, and Togo) and one in East Africa (Sudan, South Sudan and Uganda). Data used for the study include the Demographic and Health Surveys (DHS) , the Multi Indicator Cluster Survey (MICS) and the Afrobarometer surveys for the socio-economic variables and grid level data on agro-ecological and climatic conditions.

This executive summary focuses on the method used and the results obtained. A detailed description of the study area, the assumptions made and steps taken to arrive at the results and the data used, are included in the background report (SOW-VU, 2013).

2. Methodology

In defining vulnerability, we follow WFP (2009) and IFPRI (2012) and combine indicators for food security with health indicators that signal vulnerability in a physical sense. IFPRI's Global Hunger Index uses three indicators to measure hunger: the number of adults being undernourished, the number of children that have low weight for age, and child mortality. Other classifications of food security use the variety of the diet as an indicator, combined with anthropometric data on children. However, in the DHS data there is no information available on child mortality, nor on dietary composition. Given these data limitations, we use data on the nutritional status of women (BMI) and children (weight for age) as indicators for food security. These data are combined with data on morbidity among adults and children, specifically the occurrence of malaria, cough, and diarrhea. Combinations of indicators lead to a classification of households as being very vulnerable, vulnerable, nearly vulnerable and not vulnerable. The Afrobarometer surveys do not include data on the BMI of adults nor weights for children. Here, we use the reported times the household went without food in the year prior to the date the survey was conducted as vulnerability indicator.

The next step is to characterize the nearly vulnerable, vulnerable and very vulnerable populations in terms of socio-economic aspects. If the vulnerability situation is seen as an outcome, then socio-economic characteristics as well as biophysical aspects of locations can be considered as explanatory variables. Common explanatory variables named in the literature are the age and gender of the head of household, number of dependent household members, wealth index, education of adult household members, type of occupation, current working situation, and distance to markets. Furthermore, characteristics of the locality are included, indicating the suitability for crop growing and vulnerability of the area to climate change (current production in cereal equivalents per capita, Length of Growing Period (LGP), dominant land use, soil suitability, land degradation index, and an indicator map for irrigated agriculture). A Digital

Elevation Map (DEM) and a slope map account for the vulnerability of an area for floods and run-off. Finally, we include the extent to which households are able to cope with adverse shocks as an additional characteristic. Coping mechanisms may include deliveries of food aid, the existence of household members sending remittances to the household, and integration in the community. On the negative side, discrimination on the basis of ethnic background or religion may increase the vulnerability of specific groups.

The combination of (geo-referenced) surveys and grid-level data enhances our insights into the complex interaction of factors leading to a specific vulnerability classification as observable outcome. Joint analysis of these two types of data provides insights into the profiles of vulnerable groups, and through this identifies possible focal areas for interventions aimed at mitigating the consequences of climate change. The method we use in this report is referred to as "polling", and before we present the results, we briefly introduce and motivate this methodology.

In opinion polls, individuals are asked about their preferred candidate or party as well as about their personal situation, their motives and opinions. On the basis of this information, analysts can report on how given voters' characteristics such as age, sex, education and occupation, are distributed among candidates, and discuss changes in these distributions relative to earlier polls. Reporting will be on each characteristic separately or for two or three jointly.

More in-depth studies also indicate how characteristics *jointly* affect preference for a particular candidate or party, using statistical methods such as cluster analysis, factor analysis and logit and probit regression, and support-vector classification so as to identify major determinants. Countless findings were obtained in this way. Yet, it would seem that, between the partial, descriptive approach and the multivariate, regression-type approaches, the option of a descriptive analysis is being skipped that jointly looks at a large number of answers, aiming at comprehensiveness and understanding of the underlying mechanisms that lead to vulnerability as an outcome. This motivates the use of a methodology that is able to analyze different types of data in an integrated way. The GRCP (Gridding, Regression, Classification and Polling) software (Keyzer and Pande, 2010) developed at SOW-VU offers a platform to perform such integrated analysis.

First, the GRCP software allows the projection of data from a map to a geo-referenced survey. It assigns the numerical value of a specific map variable at a location to all the survey observations as an additional attribute. For our analysis, this option is used to complement the DHS survey information with the agro-ecological, geo-physical and climate data available as maps.

Secondly, The GRCP software allows the projection of data from a geo-referenced survey on a map. Two cases must be distinguished here: projection of available data at survey points and interpolation of results to points for which the data is missing. For categorical data on a specific variable at a survey point, the software determines the class that occurs most frequently at that point, computes its probability, and projects this as the grid value. Interpolation of data to account for missing data (either because the survey has missing data, or because there are no survey observations at this location), is done using nearest neighbor interpolation of the probability weighted mass, or by using kernel functions to define distances between points in a more comprehensive way.

Thirdly, the DHS surveys and the Afrobarometer surveys are explicitly geo-referenced. However, the MICS survey used for Sudan and North Sudan only include a district reference. Here, we have determined the conditional frequencies of variables in the survey that are also available as grid-level data, notably urban/rural indicators, livestock and land possession, and irrigation indicators, and then applied zoning to geo-reference the survey observations.

The analysis we perform uses two different types of surveys: DHS/MICS and Afrobarometer surveys. The two types of surveys are complementary to each other, but also share some common variables that make it possible to combine the two, by appending estimation results from one to the other. In our study, the two surveys both are geo-referenced, and both have data on the age of the head of household, and the educational attainment. Estimation results for an administrative unit, i.e. the most probable associations of variables in the Afrobarometer survey within such a unit are used to complement the DHS/MICS survey observations. In this way, the two types of surveys are combined and analyzed jointly – obviously, appending the raw data by location is not an option, since the two surveys represent different samples. In fact, the application of estimated relations to append the set of characteristics of individuals is also used in the large field of poverty mapping. Here, estimations based on surveys are applied to a census, to extrapolate the findings to areas and populations that were not included in the survey (e.g. see Bedi et al., 2007 for an overview of theory and applications of poverty mapping).

One additional step could be to identify causal relations, for example by considering matching pairs of individuals that differ only in a single aspect, identifying the contribution of this difference to, say, nutritional status, and concluding that the "treatment" with this specific characteristic improves nutritional status. In this report, we do not take this step. There are two different types of reasons for this.

First, although it is possible within the given data to identify the contribution of a single characteristic to the outcome, the interpretation of such an outcome is far from straightforward. First, identification of a treatment effect presupposes a *theory* of treatment based on theoretical insights in the determinants of vulnerability, and no such clear theory exists, although there are many studies that mention possible factors contributing to vulnerability. Secondly, and related to this, is that there are many variables, say, religion or ethnic background, for which concluding that there is a treatment effect only begs the question of why this is the case, and whether or not this particular variable is in itself determined by other characteristics.

Secondly, although vulnerability is described in this report as an outcome, it is the outcome of an extremely complex interaction of different factors. Identification of a treatment effect of one or a few selected variables would deny this fact. Specifically, the interactions of households with other households and the dynamics of coping mechanisms cannot be adequately captured in such an approach. This is the reason why this exploratory study that classifies and profiles vulnerable households will be complemented by the formulation of an applied model where the effects of climate disasters, and in particular the spread of the effects throughout a society is simulated.

Hence, the current study does not claim to identify causal relations, but identifies associations of vulnerability with location – providing the link to probable locations of climate disasters, and socio-economic characteristics – to gain insight in the type of adaptation or coping strategies that may fit these profiles. We supplement the computation of marginal probability distributions for selected characteristics relevant for vulnerability with an approach that treats these characteristics as a joint empirical frequency distribution. Conditional frequency distributions can be derived from this joint distribution by partitioning the answers by say, S respondents indexed s into a vector y of K_y dependent variables and a vector x of K_x independent variables, taking the frequencies of y conditional on x. Secondly, as the conditional frequencies are naturally interpreted as probability estimates, we also compute the most probable characteristics associated to each x-value, which can be interpreted as winner of the election, as well as the runner up and so on. We report on the top-2 profiles including the frequencies of occurrence and

on the top-N profiles that jointly describe half of the population under study, as an additional test on stability of the findings.

3. Results : West Africa

The analysis reveals that there are differences in the vulnerability between rural and urban locations, as is illustrated in Table 1, where percentages refer to the share of the reference population, with rural populations being more vulnerable than urban ones, in line with common perceptions. The percentages in parentheses refer to results based on the Afrobarometer survey. For the region as a whole and for each country separately, the percentage of very vulnerable populations in the DHS-based estimates is rather modest (below 0.5%), but vulnerable populations comprise a substantial part of the total population, varying between 13% in Ghana to 27% in Burkina Faso. Although the individual classes of very vulnerable and vulnerable differ substantially between the two surveys, taken jointly, the percentages are similar and the same holds for the classes of nearly vulnerable and vulnerable grouped together. Hence, the Afrobarometer data and the DHS based estimates seem to confirm the general picture of vulnerability.

Table 1 Vulnerability of households in West Africa study area

		Very vulnerable	Vulnerable	Nearly vulnerable	Not vulnerable
Total urban/rural	West Africa	0.1% (8.6%)	18.4% (15.3%)	25.6% (28.7%)	55.9% (47.4%)
	Benin	0.2% (6.8%)	31.8% (16.1%)	27.2% (45.2%)	40.8% (31.9%)
	Ghana	0.1% (9.5%)	13.3% (10.8%)	20.6% (19.7%)	66.0% (60.0%)
	Côte D'Ivoire	0.0%	19.2%	24.4%	56.4%
	Togo	0.1%	15.2%	33.3%	51.4%
	Burkina Faso	0.4% (7.4%)	26.7% (23.5%)	32.3% (40.7%)	40.6% (28.4%)
Urban	West Africa	0.0% (11.0%)	9.6% (16.0%)	20.9% (25.4%)	69.5% (47.6%)
	Benin	0.0% (6.8%)	46.5% (10.5%)	23.3% (45.2%)	30.2% (37.5%)

	Ghana	0.0% (14.4%)	2.2% (13.7%)	12.5% (11.6%)	85.3% (60.3%)
	Côte D'Ivoire	0.0%	12.0%	20.3%	67.7%
	Togo	0.0%	12.2%	33.2%	54.6%
	Burkina Faso	0.0% (5.2%)	8.2% (22.1%)	29.6% (49.2%)	62.2% (23.5%)
Rural	West Africa	0.2% (6.1%)	27.2% (14.7%)	30.3% (32.0%)	42.3% (47.2%)
	Benin	0.4% (6.8%)	24.9% (18.4%)	29.0% (45.2%)	45.7% (29.6%)
	Ghana	0.2% (3.7%)	22.4% (7.4%)	27.3% (29.3%)	50.1% (59.7%)
	Côte D'Ivoire	0.0%	31.4%	31.3%	37.3%
	Togo	0.1%	19.7%	33.5%	46.7%
	Burkina Faso	0.6% (9.8%)	34.1% (25.0%)	33.4% (31.7%)	31.9% (33.5%)

Note: results are population-weighted averages

A spatial representation is given in Figure 1 that present the distribution of vulnerable and very vulnerable populations in numbers of persons per km2.

Spatial representation of the vulnerable

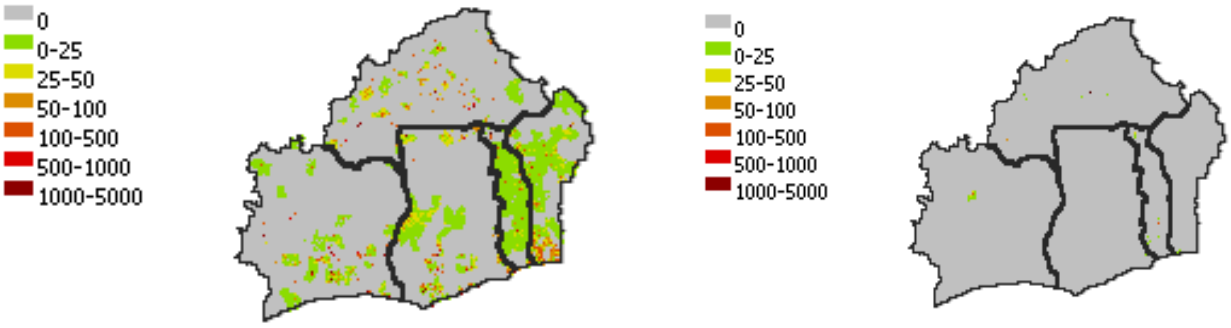

Figure 1 Vulnerable and very vulnerable populations in persons per km2

and very vulnerable populations based on the Afrobarometer data (Figure 2) reveals that the most important difference is the higher level of spread of the vulnerable population under the DHS estimates; especially in Benin and Togo, where Afrobarometer estimates only identify vulnerable populations in the southern urbanized areas. These differences probably can be explained by the different definitions used in the two types of surveys as well as differences in coverage of the surveys and reference years.

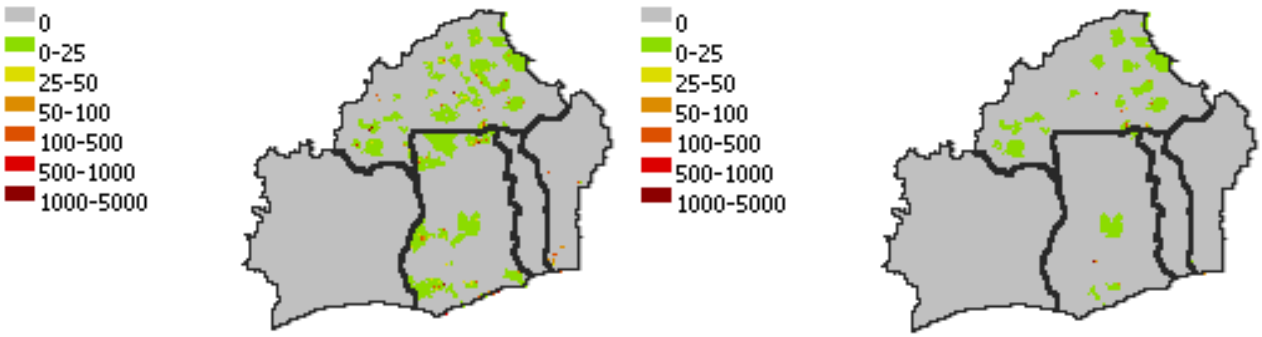

Figure 2 Vulnerable and very vulnerable populations in persons/km2 (Afrobarometer)

Rural West Africa

For rural West Africa, univariate analysis (Figure 3) reveals that the very vulnerable, on average, are more likely to remain in the same residence, to have more adult children away from home, to receive no payments for work, have no education and are agricultural self-employed. Very vulnerable households are much more likely to be employed as household and domestic servants, and have an older head of household. They are more likely to have sons and daughters outside the households than any other class; implying that in times of need, they can call upon relatives outside their own location for assistance, which is one important transmission channel for (climate induced) hardship to spread over a larger area.

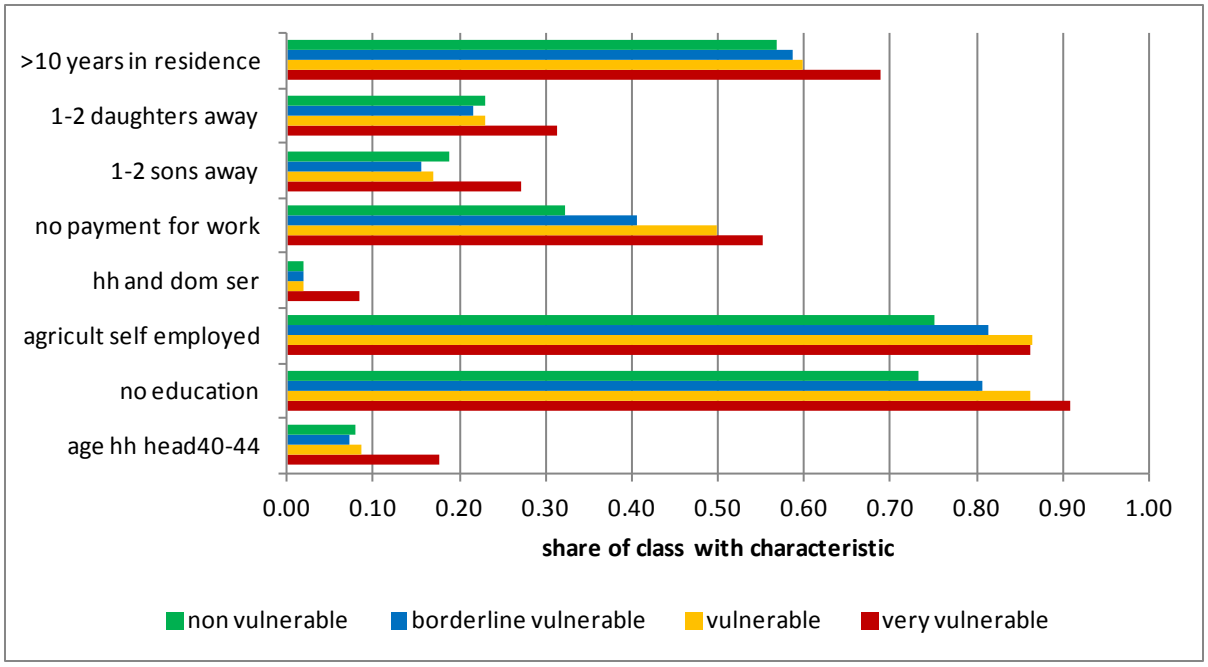

Figure 3 Socio-economic characteristics, rural areas

Very vulnerable households are more likely to be agro-pastoralists or working in mixed cereal-root crop systems. The areas where they live are very likely to be 50-75% grass and woodlands. Furthermore, the very vulnerable live in areas with slopes between 5-8% with 20-40% of the area being characterized by constraints. Climatically, most very vulnerable households are located in dry sub-humid areas: while almost 65% of the very vulnerable live in these areas, the share of vulnerable households is 46%, that of the nearly vulnerable almost 40% and of the non-vulnerable households only 31% are located in these areas. for the Afrobarometer data, self-reported perceptions on the economic situation are related to the vulnerability status: the more vulnerable the household is, the more likely it reports the economic situation as being very bad.

Special attention should be given here to the role of religion; whereas Islam is the religion of 48% of the very vulnerable households and 45% of the vulnerable ones, only 29% of nearly vulnerable households are Islamic and Islam is totally absent among the non-vulnerable ones. Non-vulnerable households are predominantly (50%) Protestant Presbyterian or Methodist (only 6% of very vulnerable have this religion) while nearly vulnerable are predominantly Roman Catholic (43% against 27% of very vulnerable households and non for vulnerable ones). It is difficult to interpret these outcomes, as they may point to discrimination of groups based on religion, but may also be an outcomes of the geographical spreading of the vulnerable population, with historical determinants of religious beliefs.

The Afrobarometer survey (Figure 4) provides some support for ethnic discrimination: at least the perception of being treated unfair because of ethnic background is related to vulnerability status. In line with the DHS results on the number of sons and daughters away from home, remittances received by very vulnerable households are important. Very vulnerable households report more often than any other class in rural areas, including the non-vulnerable ones, to receive remittances at least once a year. As such this stresses the fact that local (climate) disasters may spread over a larger area through the use of social networks as coping mechanisms.

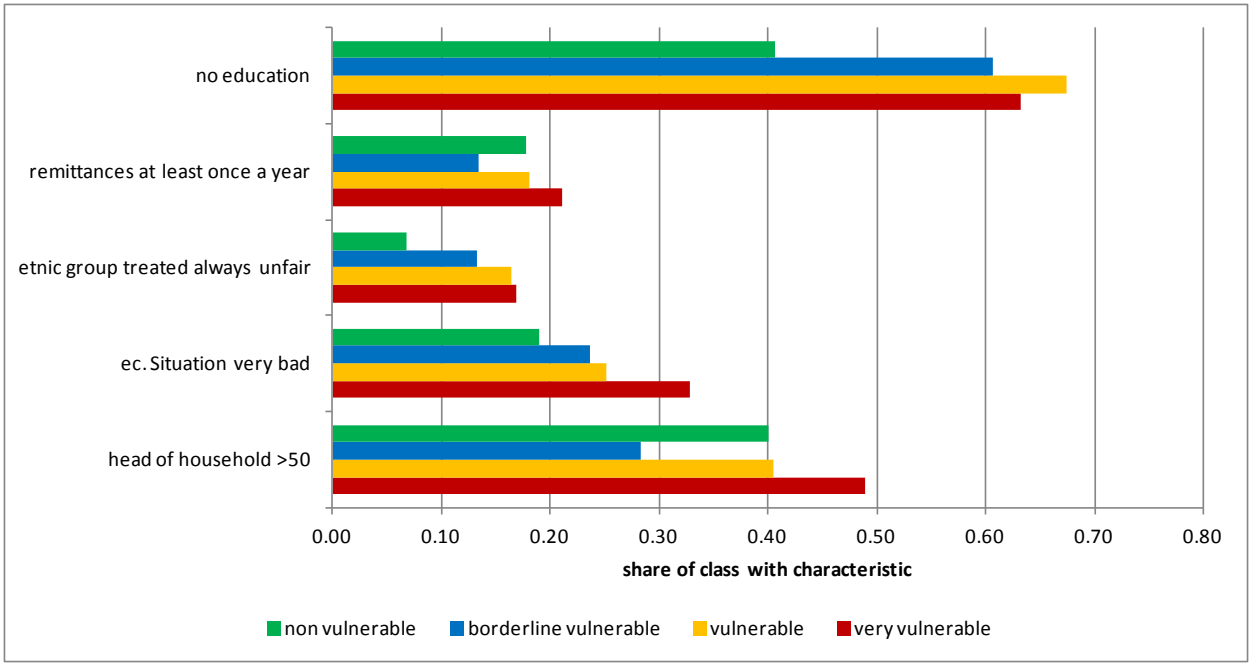

Figure 4 Socio economic characteristics rural population, Afrobarometer

The polling analysis that considers the characteristics jointly reveals that the profile of the very vulnerable includes the following characteristics: no education, agricultural self-employed, no payment for work, an older head of household, and involved in the cereal-root crops farming system.

For the vulnerable population, there are two profiles that are almost equally likely when age of the head of household, education, occupation, payment for work, and farming system are included, 7.3%, 7.1% of the total number of vulnerable households, respectively.The profiles of the vulnerable rural households and the very vulnerable are very similar for these characteristics. From an analysis of most common characteristics in profiles covering 50% of the class, it follows that the main difference between the profiles of the very vulnerable and the vulnerable rural population is the age of the head of household, with older heads being more associated with very vulnerable households, and the association with the agro-pastoral millet farming system, which is more pronounced among the vulnerable population.

For Benin, Ghana and Burkina Faso, estimates from the Afrobarometer survey have been appended to the DHS survey and yield the following insights for the vulnerable households in these countries (the limited number of observations for very vulnerable households does not allow for an analysis of profiles). From the analysis, we infer that being vulnerable is associated with having a young head of household, no education, being agricultural self-employed, within agro-pastoral millet or cereal root crops mixed farming systems, bad economic circumstances and little or no remittances from outside the households. Ethnic discrimination does not seem to figure as a distinguishing feature.

Urban West Africa

The most common profile of very vulnerable groups in the urban areas of West Africa is characterized by a low wealth index, a high share of uneducated persons, not being paid for services provided, and a higher probability to have lived longer in the present place of residence (Figure 5). Combined with the higher share of the vulnerable that reports to be agriculturally

self-employed, this may point to the fact that the urban vulnerable live in the outskirts of the cities without many opportunities to move to more profitable occupations: less vulnerable households are more engaged in sales and the non-vulnerable ones also in services.

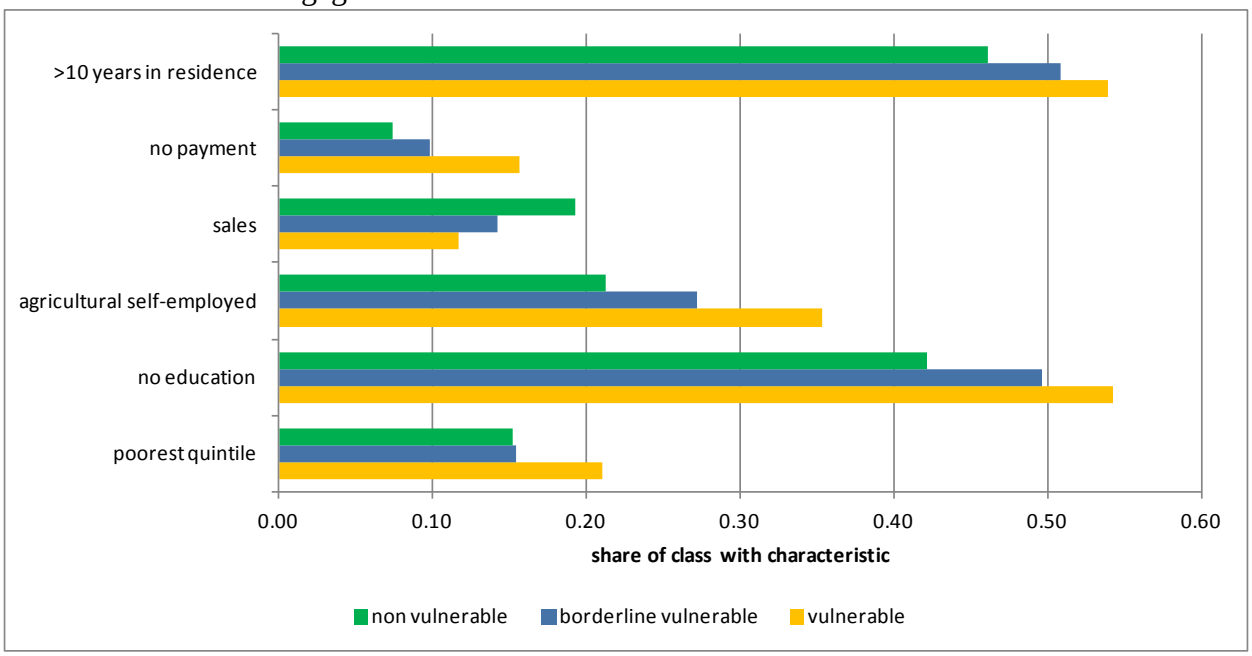

Figure 5 Socio economic characteristics, urban population

Again, we pay special attention to the role of religion; similar to rural areas, vulnerable populations are much more likely to report Islam as their religion (65% of vulnerable households report to be Islamic, against 44% of nearly vulnerable and non-vulnerable households). As for rural areas, this result may point to discrimination of groups based on religion, but any interpretation must be done with care.

Analysis of the Afrobarometer data (Figure 6) reveals that more vulnerable populations are relatively less educated and have an older head of household. Self-reported perceptions on the economic situation are related to the vulnerability status, similar to the relation between wealth quintiles and vulnerability in the DHS. The Afrobarometer survey also provide some support for ethnic discrimination: at least the perception of being treated unfair because of ethnic background is related to vulnerability status.

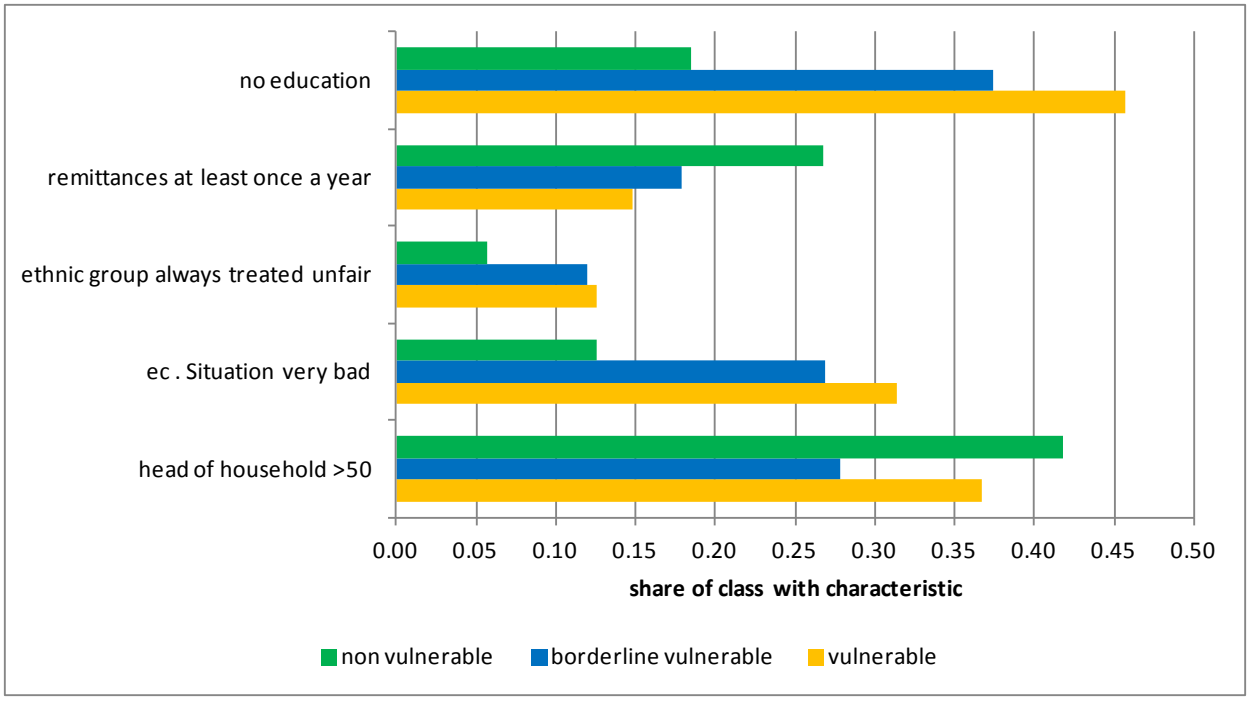

Figure 6 Socio economic characteristics urban population Afrobarometer data

The findings from the univariate analysis are confirmed in a polling analysis combining characteristics into profiles. The two most common profiles (characterizing 6.2% and 2.7% of the class as a whole) confirm all but the association with the wealth index and the non-payment for work. However, in the wider analysis of the top-36 profiles that jointly characterize 50% of the urban vulnerable population in West Africa, the relation with the lowest wealth indices is again restored.

For Benin, Ghana and Burkina Faso, we may include the estimates from the Afrobarometer surveys. From this we infer that being vulnerable is associated with having no education, receiving cash payments for work, having lived in the current residence for a long time, and receiving no remittances (or only limited remittances) from outside the household.

West Africa: effects of climate change

A preliminary analysis of the likely effects of climate change on these populations reveals that for West Africa, especially the vulnerable and very vulnerable populations in Burkina Faso and the northern areas in Benin, Ghana and Togo may experience climate shocks, in the case of declining rainfall. For Burkina Faso, effects on yields range from 10% in the South to 100% in the north, and given that the very vulnerable and vulnerable are agricultural self-employed, yield decreases translate almost one-to-one to increases in vulnerability. For northern Ghana, yield decreases of 10% may result from climate change, impacting on the vulnerable population there, and the same holds for northern Benin, where also very vulnerable populations are in the zones where yield decreases of 10% are to be expected, and Togo, where vulnerable population may experience yield decreases up to 25%. In the case of increasing rainfall, however, these areas will benefit most.

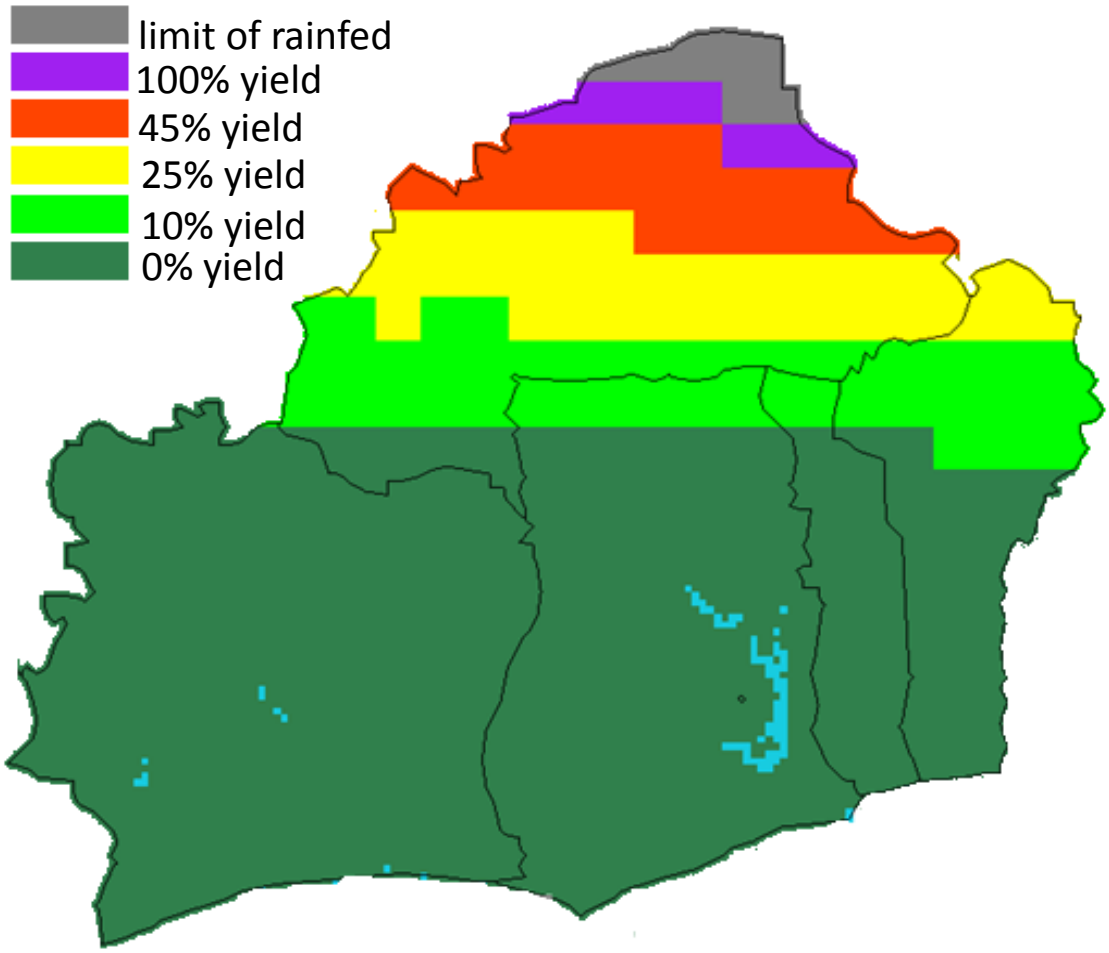

Figure 7 West Africa: vulnerability of food production system, shortening season of 1 LGP class

4. Results: East Africa

Table 2 summarizes the results at country and regional level. The difference between rural and urban vulnerability is clearly recognizable for the region as a whole and for the individual countries, with the share of very vulnerable rural households being much higher than for urban households, and the reverse holds for the share of non-vulnerable populations. The results based on the Afrobarometer data are in parentheses. It is clear that the Afrobarometer data provide a much more positive image than the DHS based estimates, particularly in the classification of very vulnerable and vulnerable populations vis-à-vis nearly vulnerability. This lower estimate of vulnerability is probably largely caused by the absence of observations in the Karamoja region of Uganda, where the percentage of vulnerable households is very large.

Table 2 Vulnerability of households in East Africa study area

		Very vulnerable	Vulnerable	Nearly vulnerable	Not vulnerable
Total urban/rural	East Africa	2.1%	37.2%	35.4%	25.2%
	Sudan	2.5%	37.1%	39.2%	21.2%
	Uganda	0.5% (3.2%)	37.6% (6.3%)	20.0% (46.3%)	41.9% (44.2%)
Urban	East Africa	0.4%	38.5%	30.3%	30.8%
	Sudan	0.7%	38.1%	39.7%	21.5%
	Uganda	0.0% (1.9%)	39.2% (3.9%)	13.8% (47.2%)	47.0% (46.9%)
Rural	East Africa	2.8%	36.7%	37.4%	23.1%
	Sudan	3.1%	36.8%	39.1%	21.0%
	Uganda	1.0% (4.7%)	36.1% (9.4%)	25.5% (45.3%)	37.4% (40.6%)

Note: results are population-weighted averages

Figure 8 projects the very vulnerable, and the vulnerable population in persons per km2 based on the DHS survey, whereas Figure 9 depict the location of vulnerable and very vulnerable persons per km2 for the Afrobarometer data.

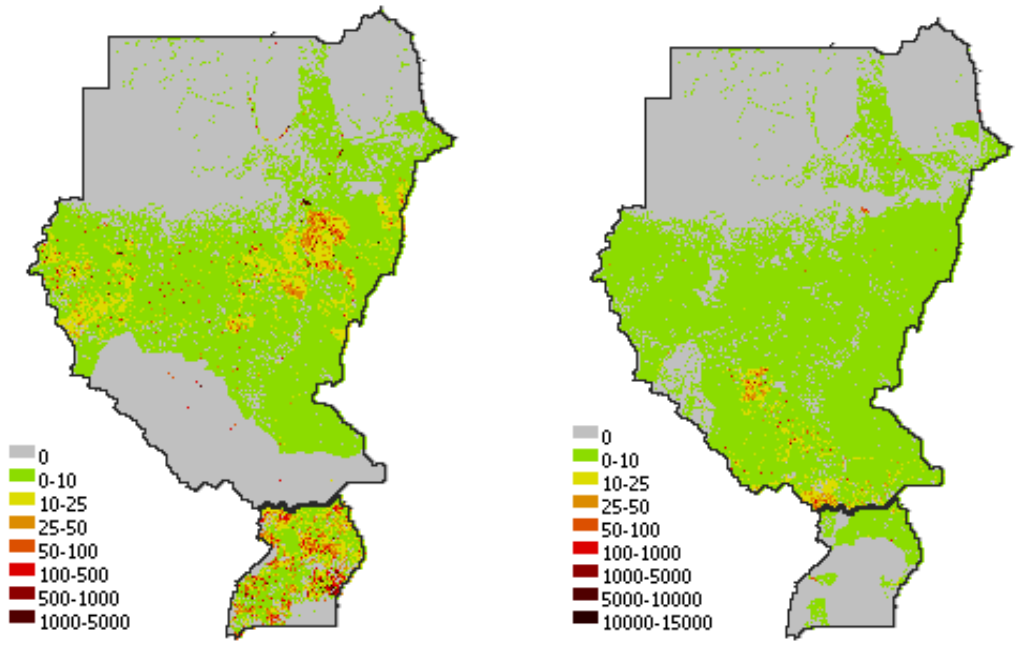

Figure 8 Vulnerable and very vulnerable populations in persons/km2

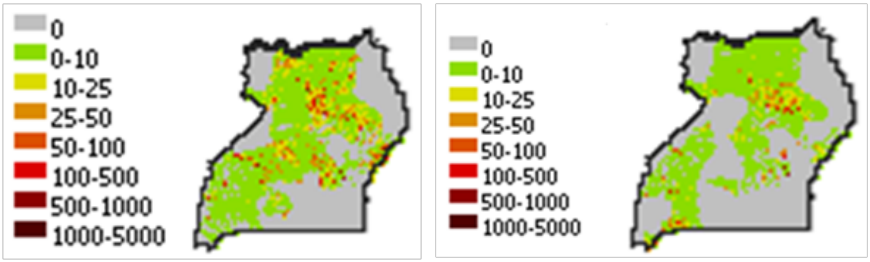

Figure 9 Vulnerable and very vulnerable populations in persons/km2 (Afrobarometer)

For the regions that are included in both surveys, the location and magnitude of the vulnerable population is very similar, while for the very vulnerable share, more areas are included in the Afrobarometer estimates than in the DHS based ones, consistent with the higher share of very vulnerable households in the Afrobarometer data. Overall, we conclude that the differences between the two surveys can be explained largely by the absence of observations in the Afrobarometer survey in a vulnerable area (the Karamoja region).

Rural East Africa

For rural areas in East Africa we find that the most vulnerable group is also the poorest one, the least educated and with the least sure employment (Figure 10). Furthermore, a very high share of the very vulnerable households is agricultural self-employed. On average, the very vulnerable are less rooted in their current residence, which may point to the fact that part of this population consists of internally displaced persons or refugees. However, there is no data in the survey available to corroborate this hypothesis.

The very vulnerable are much more likely than other groups to be located in sub-humid arid areas, in areas covered for more than 75% with grass and woodland, and to be in the maize-mixed farming system, which are dominant farming systems in South East Sudan and Northen Uganda.

For Uganda, Afrobarometer data is available and confirms the findings from the DHS surveys: Low education and a relatively old head of household characterize vulnerable and very vulnerable populations. In addition, the self-reported economic status is associated with vulnerability similar to the associated with wealth quintiles in the DHS (Figure 11). The limited involvement of the very vulnerable in religious or community groups could again point to fact that these households are internally displaced persons or refugees, although data on this is not available in the Afrobarometer survey.

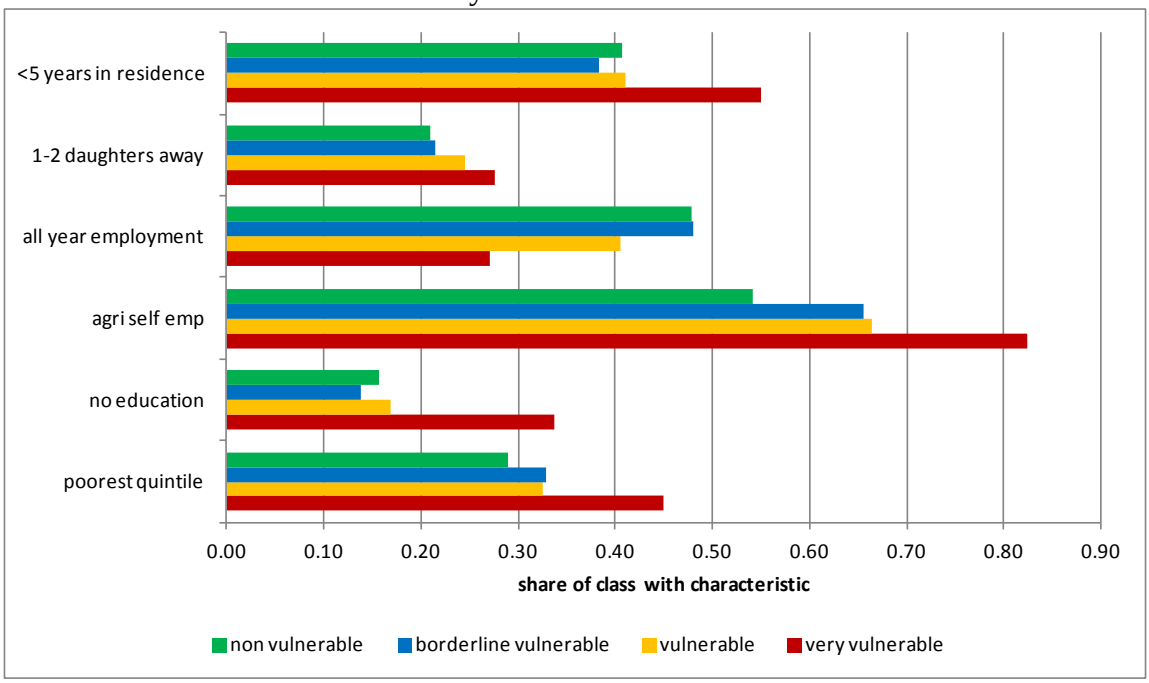

Figure 10 Socio economic characteristics, rural population

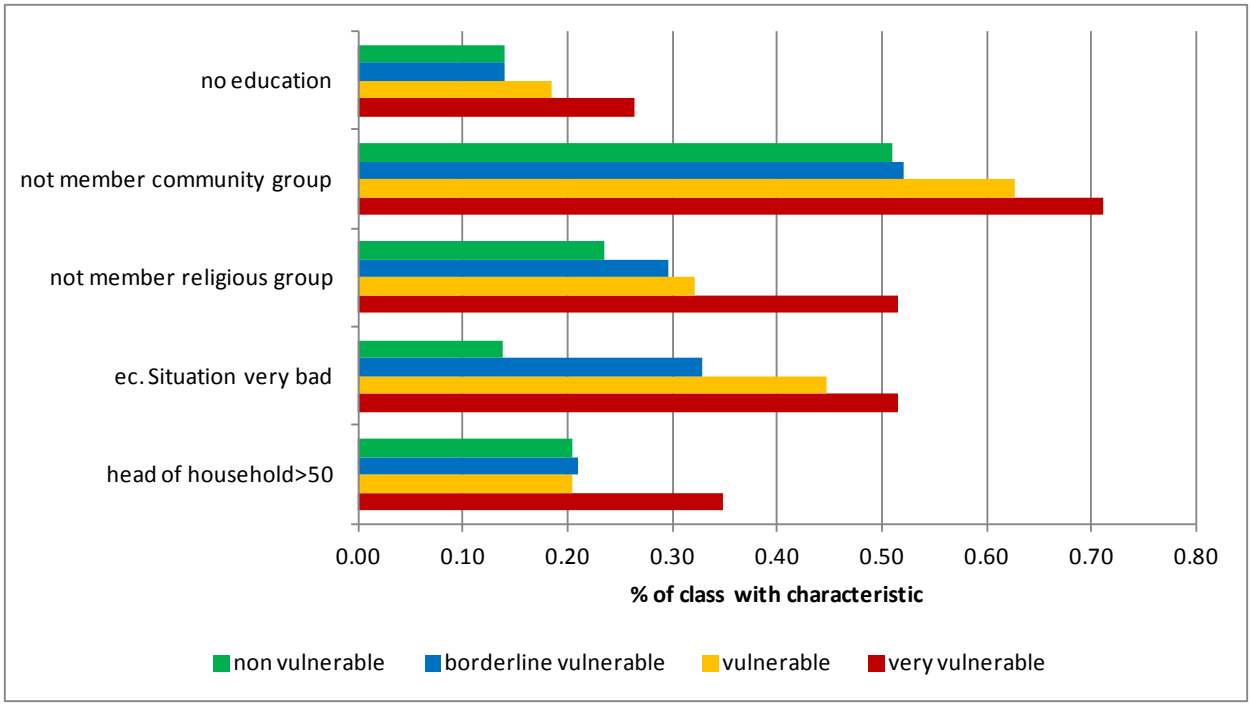

Figure 11 Socio economic characteristics, rural population, Afrobarometer

The results from the univariate analysis are partly confirmed in the polling analysis that includes the characteristics jointly. The two most frequently occurring profiles for this group represent 9.9% and 4.5% of the population. The poorest wealth quintile is represented in the profile of the runner-up, but not in the winning one; education levels are low, the very vulnerable are agricultural self employed or is professional technical management; employment is less secure in the top-2 than the univariate analysis suggests, and results on the number of daughters from home and the time lived in the current residence are not conclusive. Dry sub-humid areas are included in the top-2 profiles, but the land use in both cases differs from than identified in the analysis above. The very vulnerable are either involved in maize-mixed farming, or are pastoralists, which is in line with expectations, but did not directly follow from the analysis above. The wide analysis of the top-9 profiles that jointly describe 50% of the rural very vulnerable population reveals that the very vulnerable are in the poorest wealth quintile, have no or incomplete primary education, are agricultural self-employed or (often) unemployed, and if employed, the employment is seasonal or occasional. They have at least 1 or more daughters away from home, and predominantly have lived in the current residence less than 5 years. They reside in arid sub-humid areas, which are either grasslands or largely cultivated, and are either engaged in maize-mixed farming or pastoralists. As before, we note that many of these characteristics could point to the fact that at least part of the very vulnerable population are internally displaced persons or refugees.

For the vulnerable population, education, occupation, LGP, duration of work, LGP, land use, and farming system are included, based on the univariate analysis (see annex A for the presentation of the complete results for the univariate analysis). It follows that they are lowly educated, agricultural self-employed, and are located in maize mixed farming. An analysis of the frequency with which characteristics occur in the top-27 profiles for vulnerable households (50% of class) reveals that the picture of the top-2 is largely confirmed, although the association with LGP and land use is less clear.

For Uganda, we combine DHS data with Afrobarometer estimates. For the very vulnerable households, too few observations are available to draw any conclusions. The vulnerable rural households are characterized by low education, occasional employment, a fairly bad economic situation, low involvement in the community, but a fairly high involvement in religious groups. This implies that the network of the rural vulnerable appears to be mainly associated with a common religious background.

Urban East Africa

For urban areas of East Africa, univariate analysis of the vulnerable population suggests that these households have a very young head of household. The vulnerable are less likely to have sons outside the household, which partly is related to the age of the head of households. A very high share of the vulnerable households reports "sales" as the major occupation. Although the vulnerable report to be employed more often than nearly vulnerable households, they receive no payment for the work done in a much higher share of the cases. The combination of very young heads of households with the employment characteristics leads us to conclude that the vulnerable urban population has very little power in the labor market, and can be easily abused, which is to some extent corroborated by the fact that, on average, the vulnerable are less rooted in their current residence than less vulnerable classes (Figure 12).

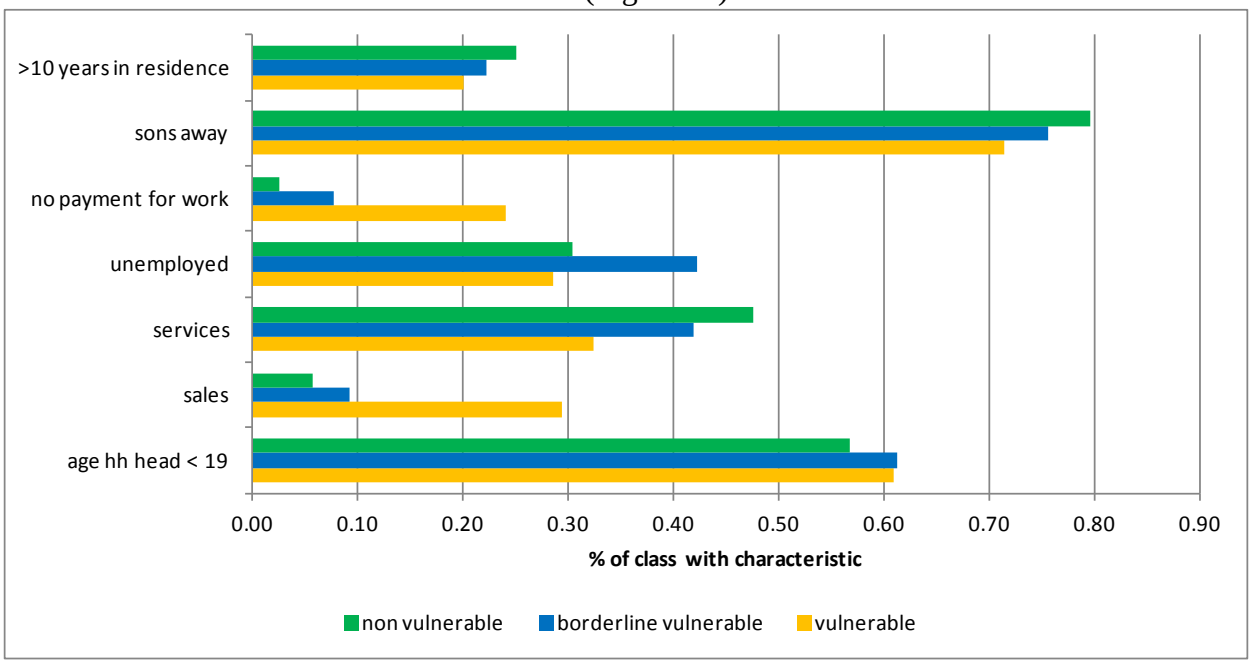

Figure 12 Socio economic characteristics, urban population

Analysis of the Afrobarometer data for Uganda reveals that vulnerable households are characterized by a young head of household, low levels of education, a bad economic situation and almost no remittances, which highlights the fact that the vulnerable population cannot rely on an external network to cope with shocks (Figure 13).

Combining the different characteristics into profiles using the polling approach reveals that in the top-2 profiles (characterizing 8.3% of the population each), all results from the univariate analysis are confirmed, except for the result on the age of the head of household, and the same result follows from the wider analysis of the top-9 profiles that jointly cover 50% of the households in the relevant group. Hence, we conclude that occupation in sales, receiving no

payments for work, having no or few sons away from home, and being relatively new in the residence are factor that characterize the vulnerable households in urban areas. We note that we do not report on the results of the joint analysis of DHS and Afrobarometer data since for the very vulnerable population, too few observations were available.

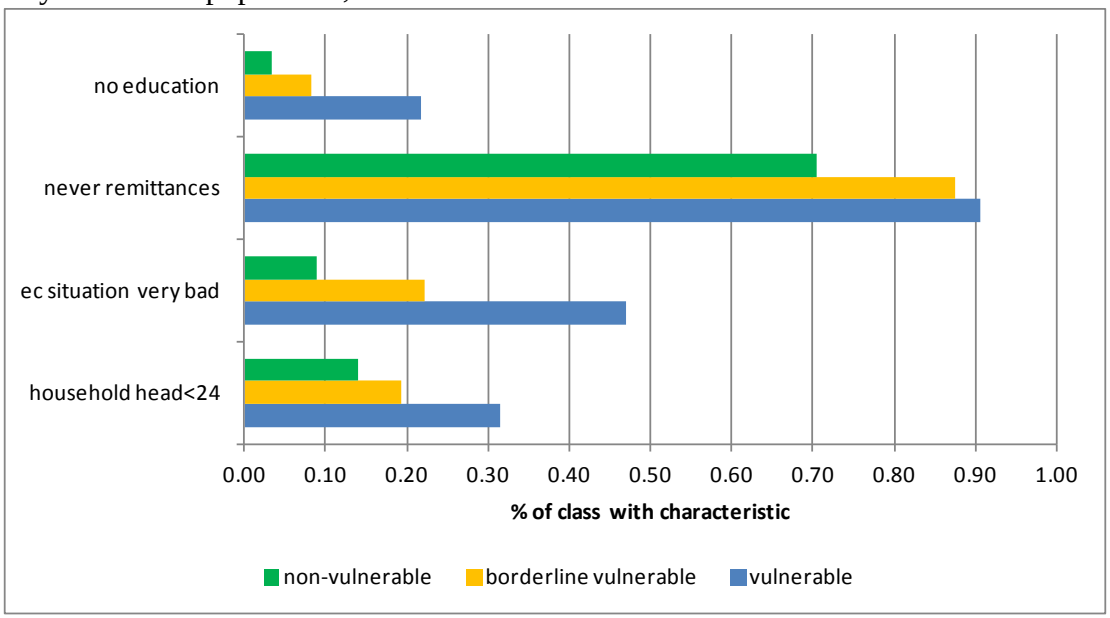

Figure 13 Socio-economic characteristics, urban population, Afrobarometer

East Africa: effects of climate change

For Uganda, the Karamojo region, already home of many vulnerable and very vulnerable households, is the area where the largest negative effects of climate change may occur, with yield decreases of 10%-25% in case of declining rainfall, and vulnerable populations being largely agricultural self-employed. For South Sudan, the South East part is likely to experience the same magnitude of yield decreases with similar effects on the very vulnerable population located there. For Sudan, the northern areas are already unsuited for crop cultivation, and hence, climate change must be understood as bringing more hardship to the pastoralists residing here, but quantification is not possible in this preliminary analysis. For the middle part, yield decrease may range between 10% to 100%, impacting on the very vulnerable and vulnerable populations located there. Also here, in the case of increasing rainfall these areas will benefit most.

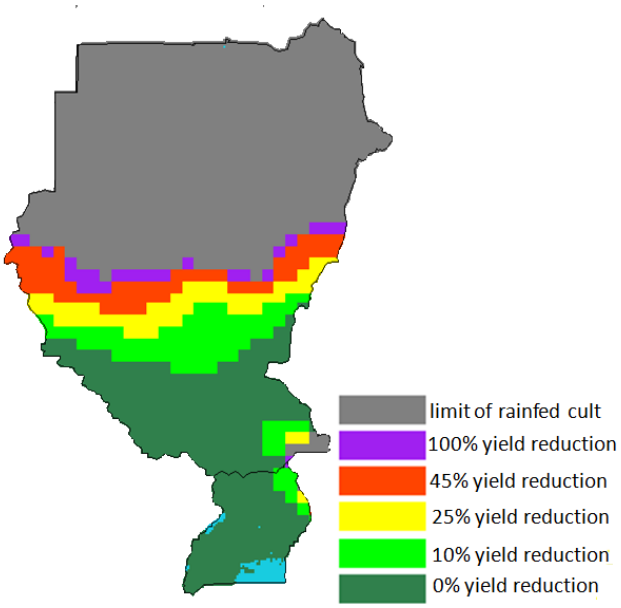

Figure 14 East Africa: vulnerability of food production system, shortening season of 1 LGP class

5. Concluding remarks and further work

For both regions, we stress that our analysis is necessarily preliminary, as results on the effects of climate change in yields will follow from other Work Packages in the Climafrica project in the coming months. Yet, the results point to the fact that many already vulnerable populations are at risk and they highlight the need to identify possible coping mechanisms, including relying on relatives or a larger circle of people to cushion shocks.

Indeed, this report also provides the background for our further analysis of the indirect effects of climate disasters. The inclusion of specific variables indicating the rooting in the local community, the number of household members who are outside the households and hence may be able to assist the household in times of need and the possibility to rely on remittances to cope with shocks already presents one step in the direction of modeling the spatial and social networks connecting the vulnerable and very vulnerable populations to others.

As we have indicated in the methodology section, the identification of treatment effects is not an appropriate method to follow here, given the complex interaction of many different forces and circumstances that leads to a household classifying as being vulnerable. Therefore, the next step is to combine the insights gained from this analysis with other information to calibrate a theoretical model that represents the dependencies of people on each other and their resilience against shocks, to be able to simulate the effects of local climate disasters on the vulnerable populations in that location, but also on populations elsewhere, vulnerable or non-vulnerable.

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A spatially explicit assessment of specific vulnerabilities of the food system due to climate change and characterization of vulnerable groups

Technical report for Climafrica Project
SOW-VU, February 2013

Table of contents

7. Introduction

Future climate change conditions will potentially have a strong impact on the African continent, particularly on vulnerable groups that lack the means for coping mechanisms and do not avail of supportive social networks that can mitigate harmful effects. Identification, location and characterization of these vulnerable groups is, therefore, urgently needed so as to timely inform decision makers about possible interventions that can curb negative climate change effects. Yet, profiling vulnerable groups is not an easy task as many economic and location specific characteristics influence the strength of people's ability to act in response to changing climatic conditions. This study aims to identify, locate and characterize groups that are vulnerable for climate change conditions in two country clusters; one in West Africa (Benin, Burkina Faso, Côte d'Ivoire, Ghana, and Togo) and one in East Africa (Sudan, South Sudan and Uganda).

The study combines food security indicators (Body Mass Index of women and weight for age, weight for height of children) and health information (morbidity among adults and children caused by malaria, cough, and diarrhea) from geo-referenced surveys to categorize households as being severely vulnerable, vulnerable, nearly vulnerable and not vulnerable. These households will be characterized by their socio-economic and biophysical environment to explain the incidence of vulnerability. Socio-economic and biophysical variables are derived from geo-referenced surveys as well as from geographical information systems. The selection of socio-economic explanatory variables is based on factors that are frequently named in the literature. Biophysical aspects concentrate on the location's characteristics that are conducive for agricultural production or are directly related to specific climatic hazards, such as floods and droughts.

As our data are mostly integer-valued, we use conditional frequencies that can be interpreted as probability estimates for specific combinations of variable values. Computing most probable characteristics associated to vulnerability, we report on 'winners' and 'runners up', and on the top-N profiles that jointly describe half of the population under study, as an additional test on stability of the findings.

The report is organized as follows. Section 2 describes the study areas in West and East Africa. Section 3 presents and discusses the data sets that are used for this study. Section 4 discusses the methodology used, Section 5 identifies and section 6 characterizes the vulnerable populations in West and East Africa. Section 7 analyzes the impact of climatic shocks to these vulnerable households and section 8 concludes. Technical annexes report in detail on (A) methodologies and (B) the data used.

8. Description of study areas

West Africa

In West Africa, the following countries are included in the analysis: Benin, Burkina Faso, Côte d'Ivoire, Ghana, and Togo (Figure 1).

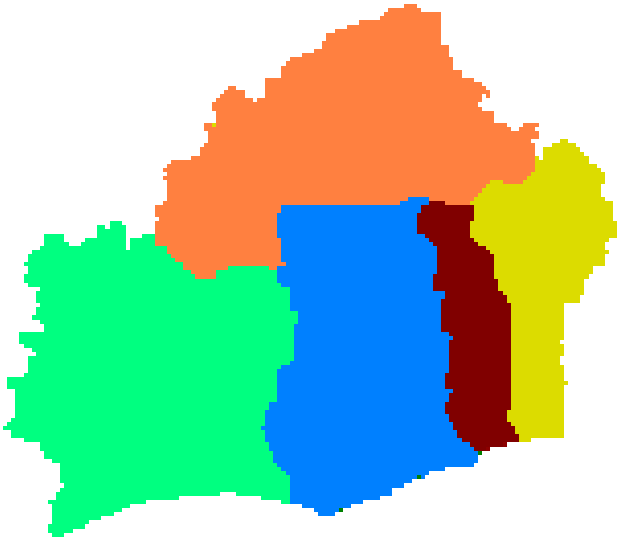


Figure 15 Selected countries in West Africa

The entire area consists of tropical lowland with altitudes mainly remaining well below 1000 m above mean sea level. The topography in this West African country group is quite level with slopes rarely exceeding 8 % (Figure 2 and Figure 3).

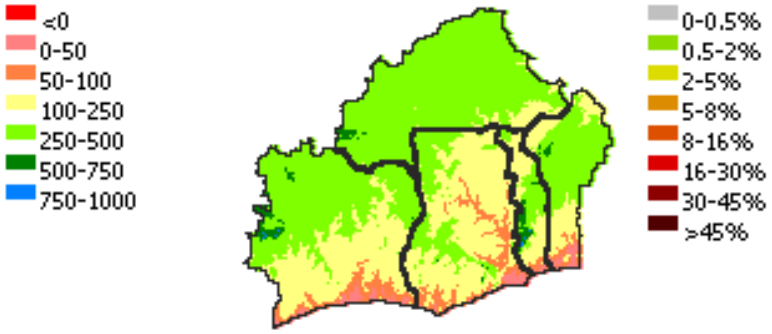


Figure 16 Altitude in meters above mean sea level

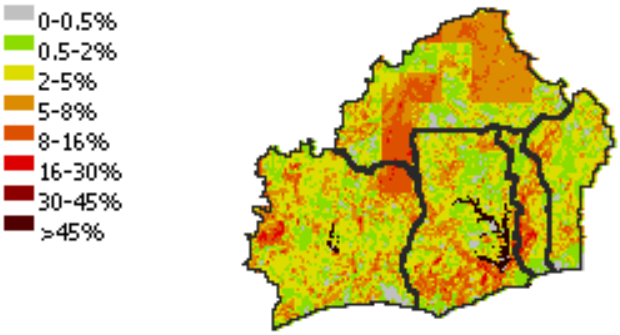


Figure 17 Slope in %

Few low run-off rivers flow through narrow valleys in North-South direction. The climate shows a North-South gradient from semi-arid in the North to humid in the South (For details see section 7). With respect to dominant soil types, sandy soils developed in Aeolian deposits prevail in Northern Burkina Faso, while the remainder of the study area is mainly underlain by Precambrian Basement Complex. In the coastal high rainfall belt the soils are leached (Acrisols, Ferralsols), but elsewhere base-saturated soils (Luvisols) are dominant. In the coastal belt of Benin and Togo, with lower rainfall, leached soils are lacking, but there is a rather narrow belt of good soils (Nitosols) developed in tertiary deposits. Natural vegetation types vary from North to

South from shrub- and wooded-grasslands, mosaics of wooded grasslands and open woodlands, woodlands (Isoberlinia) and finally tropical rainforest. Rainforest is rare in Togo and Benin though, and the woodlands extend up to the coast due to dryer conditions and less impoverished soils ('the Dahomey gap'). Rain fed agriculture is by far the most dominant mode of production and the common staple crops from North to South are the following: millet, sorghum, maize, yams, cassava and plantain. Rice is grown throughout the study area, in the North mainly as rain fed lowland rice and in the more humid South under rain fed upland conditions. In West Africa food staple crops are mainly grown for subsistence and hardly any fertilizers are used. Tomatoes and onions are cultivated in the North during the dry season (bas-fonds) and exported to richer Southern regions of Nigeria, Ghana and Benin. Cotton, as most important internationally exported fiber crop, is cultivated in Southern Burkina Faso, the Northern half of Côte d'Ivoire and Ghana, while extending to the coast in Togo and Benin. South of the cotton belt cocoa is the most important cash crop in Côte d'Ivoire, Ghana and Togo with Côte d'Ivoire as largest producer and exporter. Robusta coffee is also an important cash crop and its production area largely overlaps with that of cocoa (Figure 4 shows the distribution of farming systems).
The recent civil war in Côte d'Ivoire affected the cocoa cultivation negatively and deprived many farmers from their income. Assuming political stability at the longer term, climatic change could become the most important factor that might impact on the cultivation of commercial crops. Most of the livestock is concentrated in the Northern drier zone where trypanosomiasis is absent; as opposed to the Middle Belt that is a natural habitat of Tsetse fly (Figure 5). Cattle are transported to coastal urban areas for slaughter thus generating a cash income for the Northern dryer areas.

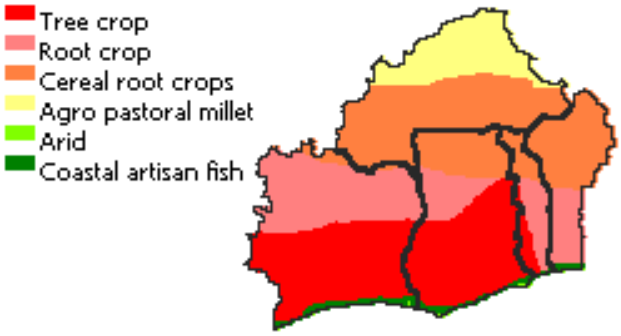


Figure 18 Farming systems

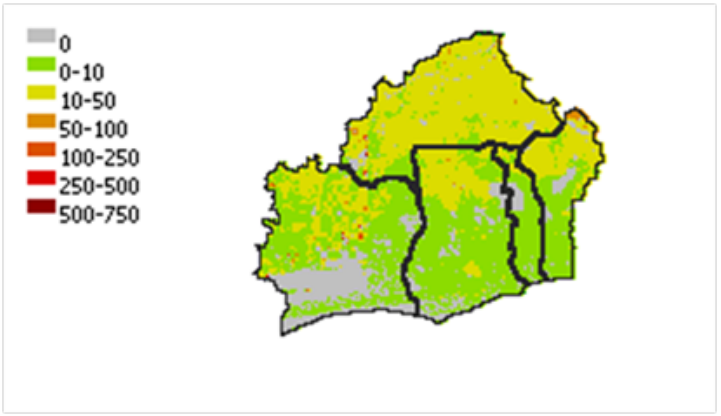


Figure 19 Tropical Livestock Unit density (TLU/km2)

Climate

Generally speaking rainfall is low in Northern Burkina Faso and increases towards the Atlantic Ocean with a important anomaly near the coast. Mean annual rainfall is very low in the desert margins of Northern Burkina Faso (300 mm) and gradually increases to about 1000 mm in Southern Burkina Faso and reaching a humid level at around 2000 mm in most of the coastal zones of Ivory Coast and Western Ghana. In eastern Ghana, Togo and Benin, the coastal zone is substantially dryer than further inland, with a low in Accra of 760 mm and increasing in eastward direction to 1325 mm at Cotonou. The Length of the Growing Period (LGP) varies according to the North-South rainfall gradient, from about 50 days and 150-180 days in northern and southern Burkina Faso, respectively, and then up to more than 300 days at the coast in the

east of both Ivory Coast and Ghana. In the eastern coastal zone of Ghana and the coastal areas of Togo and Benin, the LGP is in the order of 210-240 days. (FAO/IIASA, 2000).

FAO/IIASA (2000) is reasonably in accordance with FAO station analysis (1984) in Burkina Faso and also further south, deviations with FAO (1984) and the LGP map of Ghana (FAO, 2005) are mostly minor. However, at the coastal anomaly the differences between the sources used become quite large. This so-called Dahomey gap in Ghana, Togo and Benin, with lower rainfall levels and the absence of rainforest at the coast, is caused by upwelling of cold water from great depth in the Ocean at this part of the West African coast. For the central to eastern coastal strip of Ghana this results in a LGP of 150-180 days (FAO, 2005), while in FAO/IIASA (2000) the length is in the order of from 210 up to 240 days. These differences are also suspected to derive from the data generation method used by CRU (New et al., 1998). Similarly, South-East Ghana has a year-round LGP (FAO, 2005), while the maximum in FAO/IIASA (2000) is in de order of 320 days. The latter though is not of relevance for this study due to the length range involved.

The station data analysis (FAO,1984) suggests even greater differences that indeed are of great relevance. Accra appears to be the driest station at the coast with unimodal rainfall and an LGP of about 110 days. This focal point of dryness is surrounded by an area where rainfall is bimodal, with a long gap between both seasons (mostly about 60 days) and where the second season is too short to grow annual crops. The first (normal) LGP at Ada in the proximity of Accra is also about 110 days, but further away this first LGP becomes 120-150 days (including the following stations: Takoradi, Salt Pond, Lome and Cotonou). More inland and to the west, rainfall remains bimodal but with a shorter period in between (35-55 days), and with both seasons long enough to grow annual crops: Tabou, Sassandra, Abidjan (coastal stations in Ivory Coast), Axim (coastal Western Ghana) and Akuse (inland of Accra and Ada). The duration of the sum of both seasons is mainly 240-300 days with the exception of Tabou in West Ivory Coast at 330 days. Further inland there is still a tendency towards bimodality: there is a dryer period in the rainy season, but this is not severe enough for the cessation of the growing period. This so-called intermediate period is generally in the order of 20-50 days and the total season length is in the order of 240-300 days. The following stations belong to this group: Gagnoa, Bouake (Ivory Coast), Wenchi, Kumasi, Ho (Ghana), Atakpame (Togo), Bohicon (Benin). In Togo and Benin the values do not exceed 250 days. Exceptions to this general characterization are Gagnoa with an LGP of 330 days (again in Western Ivory Coast) and Kumasi where there are two intermediate periods totaling some 110 days. From this zone further northwards, rainfall is strictly unimodal and the LGP decreases gradually with increasing latitude from 300 days onwards in Ivory Coast and Ghana , and from 240 days onwards in Togo and Benin. The area with a strict bimodal LGP is presented in Figure 6 (Source FAO/IIASA, 2000).

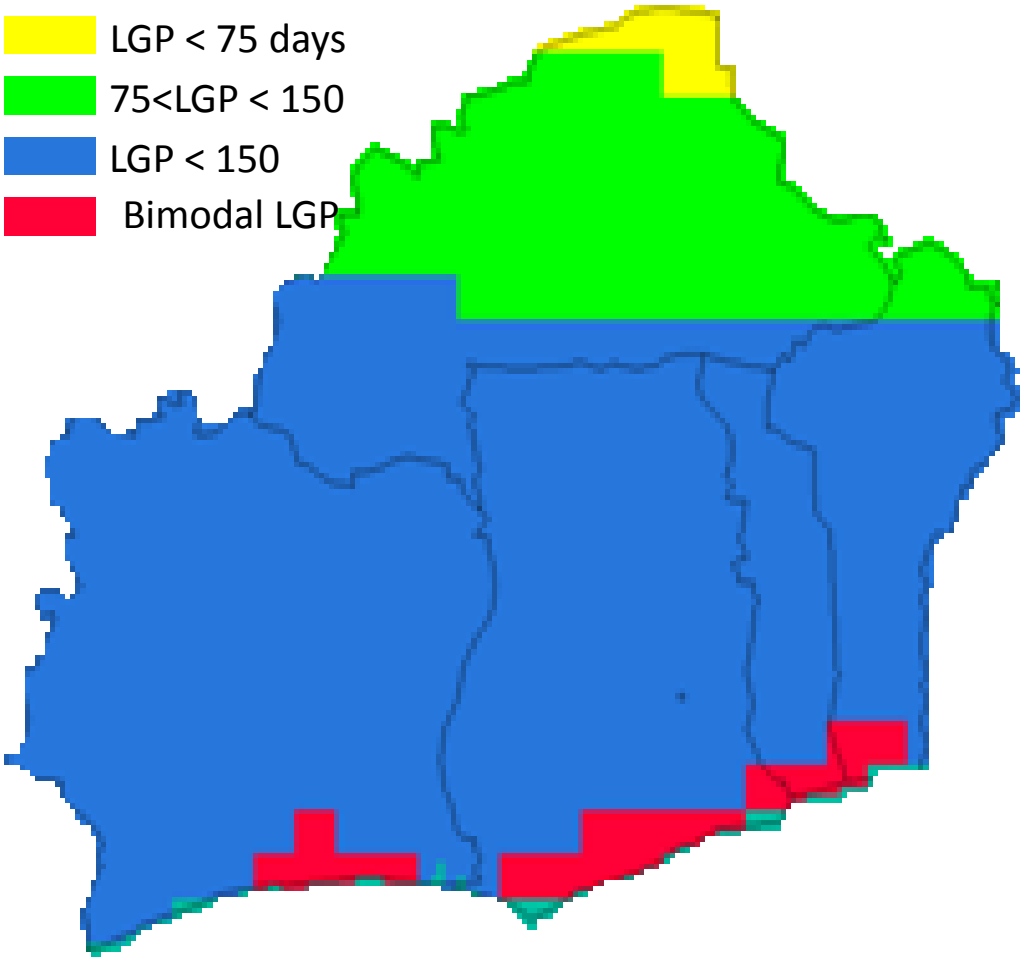


Figure 20 West Africa: areas with distinct bimodal LGP

In sum, what emanates is a consistent pattern from bimodal rainfall closest to the equator to a uni-modal rainfall at greater latitudes. At the Atlantic coast there is a large gap between two seasons, which northwards gradually decreases in length. Then the two seasons merge with still an intermediate dip, to subsequently become fully uni-modal. Clearly, the issue of bi-modality that plays an large role in the Southern parts of this region is an important characteristic for the assessment of the severity of climate change impacts. Lower rainfall in currently intermediate periods may cause the break-up of the main season into two separate shorter ones, possibly affecting the potentials for perennial crops, but also increasing the suitability for annual crops, and vice versa when rainfall will increase in currently dryer periods. Unfortunately, FAO/IIASA (2000) only maps the areas with outspoken bi-modality in the coastal zone and with respect to LGP length presents the summation over the two seasons (which partly explains the observed differences). Hence, we do not avail of the means to suitably address the impact of climate change in areas where rainfall is currently bi-modal or has a tendency towards bi-modality.

Population

For 2010, the total population of the countries in the selection has been estimated at 92 million people, 48% of whom live in rural areas. The population density equals 80 people per km^2 on

average, but varies markedly across the area, with low densities in the middle and northern parts, and population concentrations along the coast (Figure 7). There are 7 refugee camps in the area: Agame (Benin): 2800 people, Ouagadougou (Burkina Faso): 1100 people, Krisan, Accra, Bududuram (Ghana) with populations of 1000, 1040 and 11300 persons, respectively and Lomé and Tandjoare (Togo) with populations of 660 and 3660 persons, respectively. In addition, UNHCR officially recognizes 33400 refugees dispersed in rural areas of Ghana, Côte d'Ivoire and Togo and 8000 refugees living in urban centers in Benin and Côte d'Ivoire. (source: UNHCR, 2010)

Consumption

The estimated daily consumption equals 2129 kcal per capita for the area as a whole, with country averages being 2050 kcal per capita per day for Benin, 2195 for Ghana, 2192 for Côte d'Ivoire, 2097 for Togo and 2042 for Burkina Faso on average, and minor differences between rural and urban consumption (Figure 8). For the methodological background on the computation of consumption, see Van Wesenbeeck et al. (2009).

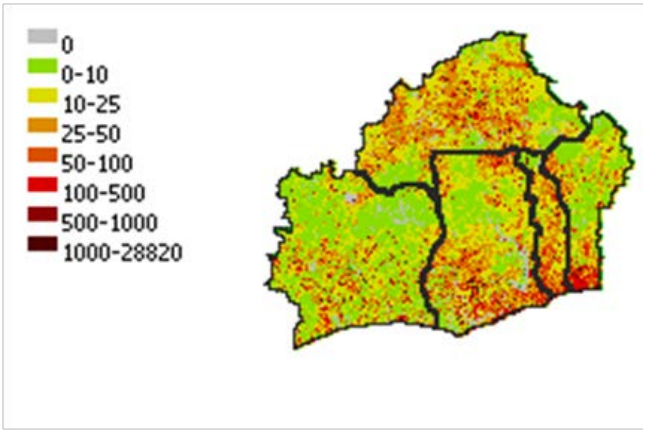


Figure 21 Population density (persons per km^2)

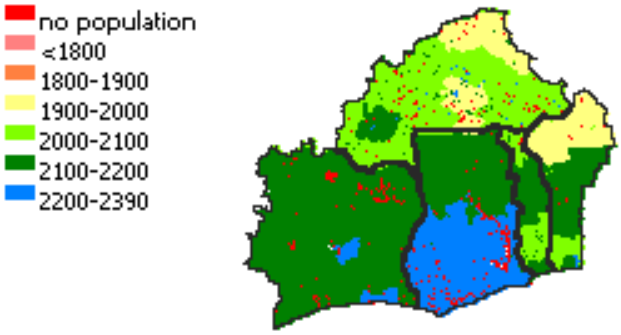


Figure 22 Per capita consumption (kcal/day)

Production

Figure 9 depicts the spatial distribution of production of food crops, per rural head of the population. The average production per rural capita in the region is 760 kg cereal equivalents, which is relatively high, with country averages being 681 kg for Benin, 880 kg for Ghana, 767 for Côte d'Ivoire, 1136 kg in Togo, and 570 in Burkina Faso. The maximum district average (2.0 mt cereal equivalents per rural capita) is reached in the district of Tiebissou, Côte d'Ivoire. (updated from Van Wesenbeeck and Merbis, 2012)

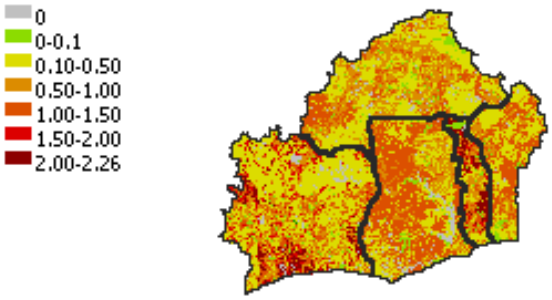


Figure 23 Production in mt cereal equivalents per rural head

Transport possibilities and costs

Primary roads mainly run north-south, complemented by east-west corridors (Figure 10) and are complemented by a relatively dense network of secondary roads. Because of this rather good infrastructure, total transport costs are relatively low: approximately US$ 0.20 per metric ton kilometer (mtkm, updated from Van Wesenbeeck and Merbis, 2012). (Figure 11).

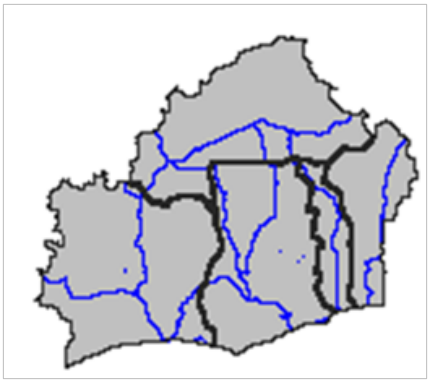


Figure 24 Primary roads

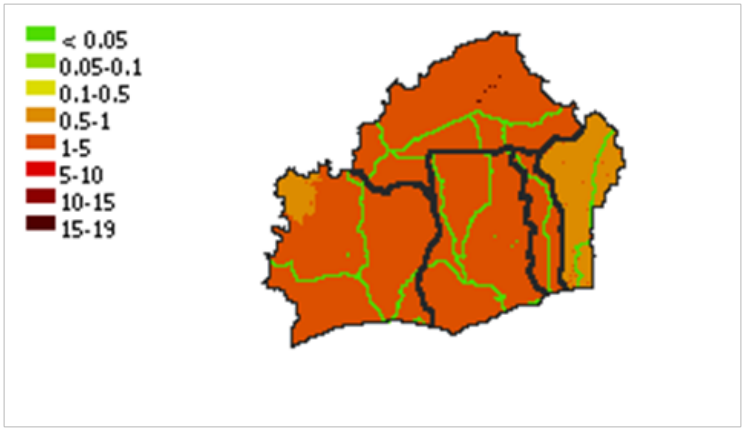


Figure 25 Transport costs in US$/mtkm

Food aid dependency

Average consumption per capita of food aid is only 41 kcal per day. In addition to the food aid provisions to the refugee camps, aid deliveries take place in response to emergencies or longer running programs (Figure 12). In Benin, school feeding programs are operational in various urban areas; a special program targeting AIDS and HIV-infected populations is active in the district of Abomey-Calavi, and emergency assistance is provided in the district of Zangnanado in response to the flooding that occurred. In Ghana, food aid is provided within the context of school feeding programs in the Upper East and Upper West regions and structural assistance to populations in the Northern, Upper East and Upper West regions, and the same combination of school feeding and general assistance programs explains the pattern of food aid deliveries to Côte d'Ivoire, with emphasis on the city of Abidjan for school feeding and on the northern regions for general support. In Togo, food aid assistance is provided in particular to the Togolese population in the Savanes region and to Ghanaian refugees, in the Maritime Region of southern Togo in response to the floods. In Burkina Faso, assistance is provided to flood victims in Ouagadougou (source: various publications by WFP).

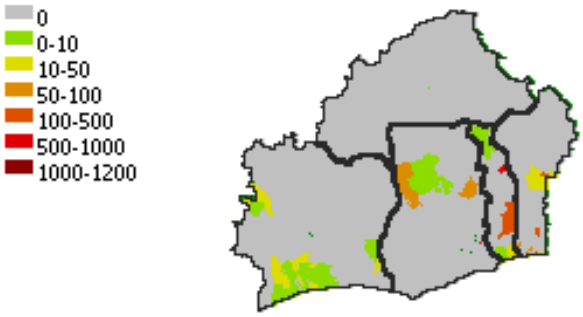


Figure 26 Food aid in kcal per capita per day

Eastern Africa

In Eastern Africa, the study area consists of Uganda, Sudan and South Sudan (Figure 13). Due to the complex nature of land resources and land use Uganda will be treated separately from Sudan and South Sudan. Sudan and South Sudan consist of tropical lowland mainly below 500m. In Sudan exceptions are a mountain range in Darfur (up to 2500 m) and the Eastern coastal zone (up to 1000m). In South Sudan the exceptions are located in a narrow rim along its Western and Southern boundary (mainly below 1000 m, but locally exceeding 2000 m). Land slopes in Sudan and South Sudan mostly do not exceed 8%, in Sudan obviously with exception of parts of Darfur and the coastal Rif slopes. In South Sudan greater slopes mainly occur towards its Southern border with Uganda (Figure 14 and Figure 15) The Blue and White Nile, with their confluence near Khartoum, are the main drainage system of the two countries, flowing in South-North direction.

Figure 27 East Africa study area

The climate in North Sudan is desertic and rainfall only gradually increases towards semi-arid in the south, further increasing to sub-humid in South-West South Sudan. The (hyper) arid zone of Sudan (say north of Khartoum) is characterized by desert soils such as Xerosols and Yermosols with substantial occurrences of shallow Lithosols as well. The desert soils are largely barren in the North, grading into desert vegetation without perennials and finally into a mosaic of desert grasslands and shrub lands further south. In Darfur there is some pastoralism and along the Nile irrigation is practiced (Figure 16) (for crops see below). Beyond

these two areas and a small coastal zone near Port Sudan, this area is practically devoid of population. In the semi-arid parts south of Khartoum from west to east three classes of soils dominate: shallow Lithosols, very sandy soils (Arenosols) and Vertisols, the latter having developed in Tertiary deposits. In the northern part of this zone there is first a west-east belt of Acacia wooded grassland and bush land, further south followed by woodlands, while the Vertisols mainly support edaphic grasslands. In the middle and west of this zone, land use changes with increasing rainfall towards the south: first predominantly pastoral land uses, further south followed by agro pastoral systems, based on millet and sorghum as grain staples and thereafter grading into mixed cereal-root crop systems (maize based). In South-East Sudan there are some large irrigation schemes on Vertisols (e.g. Gezira) with cotton, sesame, sugarcane and groundnuts as main crops and further a variety of fruits and vegetables. These are the most densely populated areas of Sudan (Figure 16)

The dominance of Vertisols continues in North and Eastern South Sudan up till the border with Uganda. Soils of the sub-humid South-Western parts, bordering D.R. of Congo, are a mosaic of dominantly shallow soils and leached Basement soils (Ferralsols). Just like in the south of Sudan, woodlands prevail on well drained soils, while the Vertisols mainly support edaphic grasslands. In the very south-west though, a narrow belt of rainforest occurs as well on deeper soils with the highest rainfall, while in the very south east, under dryer conditions deciduous bush land and thicket occurs. In South Sudan the main farming system is the mixed cereal-root crop production on both well drained upland soils and Vertisols. (Figure 17). It must be suspected though that the portion of root crops on Vertisols is very modest, because tuber expansion is hampered on these soils. In the wetter south-west a root crop system occurs, but population density here is very low for South Sudan, except close to the border with D.R. Congo, where better soils occur. In the eastern parts, on Vertisols, a maize-mixed system prevails, which in the driest parts of the extreme south-east (contiguous with Karamoja in Uganda) is replaced by pastoralism.

In contrast to Sudan and South Sudan, most of Uganda lies at elevations between 1000 and 1500 m, with the exception of part of the north west (Western Rift: 500-1000 m) and with isolated peaks at its border, such as Ruwenzori, the Muhabura highlands and Mount Elgon, rising to about 3500 m (Figure 14). Relief in Uganda, conform its differences in altitude, is more complex: the dominant slope class is 8-16%, but sizable tracts below 8 and above 16 percent occur as well (Figure 15). Climate in Uganda is again varied due its topography, presence of a large water body (Lake Victoria), but also because of the dual passage of the Inter-Tropical Convergence Zone (ITCZ). Because of the latter, northern Uganda (roughly North of Lake Kyoga) has an unimodal rainfall pattern, while the area west of Lake Victoria has a clear bi-modal rainfall consisting of two seasons separated by a dry period. The remainder of the country experiences in-between conditions, where there are two rainfall peaks, between which in June-August rainfall is unreliable. Overall the climate varies from semi-arid to humid (for details see following section).

Most of Uganda is underlain by Precambrian Basement Complex and leached Basement soils (Ferralsols) are by far the dominant soils and they occur throughout the country. In the northern half of Uganda these Ferralsols are not the dominant one though. In the entire area north of Lake Kyoga shallow soils (Leptosols, Petric Plinthosols) are widespread and so are sandy soils (Arenosols), poorly drained soils (Gleysols) and heavy cracking clay soils (Vertisols). In the North-Eastern part (Karamoja) Vertisols are the most dominant. The vegetation of the northern half of Uganda consists mainly of wooded grasslands interspersed with edaphic grasslands in the valleys. The dominant woody species vary with soil conditions: Butyrospermum, Combretum

(dry and moist variants) and Acacia /Commiphora (deciduous). On the western border, bordering D.R. Congo, there is a patch of rainforest (high rainfall) and in the central part a sizeable area of Terminalia woodland, both on deep permeable Ferralsols. The dryer Karamoja in the north-east is again an exception because of the large proportion of edaphic grasslands and absence of woodlands, but rather Acacia/Commiphora bush lands and thickets and also stunted bush lands (supposedly on Vertisols due to rooting problems). In most of northern Uganda the main agricultural activities are annual crop production and cattle raising, Karamoja again being the exception with mainly pastoral activities with few annual crops. The crops change from west to east with the decrease in rainfall: from cassava, maize and beans, some banana, finger millet and sorghum, with tobacco and coffee as cash crops, to a prevalence of millet and sorghum, with some maize, beans and sweet potatoes, and with cotton, sesame and tobacco as cash crops. Karamoja is the most important cattle area of Uganda and there is little crop production of sorghum, followed by maize and some beans and finger millet. (Figure 17, Figure 18)

South of Lake Kyoga at altitudes of 1000-1500 meters (Figure 14), Ferralsols, in combination with other leached soils, are practically dominant everywhere, but with different soils occurring in association: shallow soils and poorly drained soils, with more local occurrences of fertile soils: Volcanic soils, Nitisols and Luvisols. The one exception to this is the so-called Central Wooded Savannah, where shallow soils dominate in association with poorly drained soils. The potential natural vegetation in this medium altitude zone consists of semi-evergreen Guineo-Congolian rainforest with Combretum wooded grasslands on unfavorable soils such as in the earlier mentioned Central Wooded Savannah. In the central south-west, under substantially dryer conditions, there occurs a large area with evergreen and semi-evergreen bush land and thicket on both sides (western mountains and Lake Victoria) flanked by rainforest. In the entire zone, a large part of Uganda, banana is the most important staple. The cropping systems are mostly diverse and further include maize, beans, sweet potatoes and locally groundnuts as well, with cassava being also important under higher rainfall. Depending on location, cash crops include cotton, tobacco and Robusta coffee. In a restricted area, in the so-called cattle corridor, cattle are important. It includes the earlier mentioned Central Wooded Savannah and the contiguous dryer central south-west with more open natural vegetation. (Figure 17 and Figure 18)

Other exceptions to the dominance of Ferralsols occur all close to the national border at higher altitudes: the slopes of Mount Elgon where fertile soils (Nitisols) dominate; the south-western highlands and western high altitude extending north up to Lake Albert, where volcanic soils (Andosols) and non-leached soils (Luvisols) predominate. On the mountains in the south-western tip of the country, on Ruwensori and Mount Elgon Afromontane forests occur, in the latter two locations changing in combinations of Hagenia forest, Afro-montane bamboo, Ericaceous vegetation and Afro-alpine vegetation. The farming systems in these higher altitude locations are quite similar to the medium altitude situation, being diverse and banana based, but specialty crops occur as well. On the slopes of Mount Elgon also wheat and Arabica coffee are grown. Arabica coffee and also tea are grown in the West and Southwest corners (Ruwenzori and Muhabura highlands). The latter area is also the production centre of Irish potatoes and cattle and goats are important as well. (Figure 17, Figure 18).

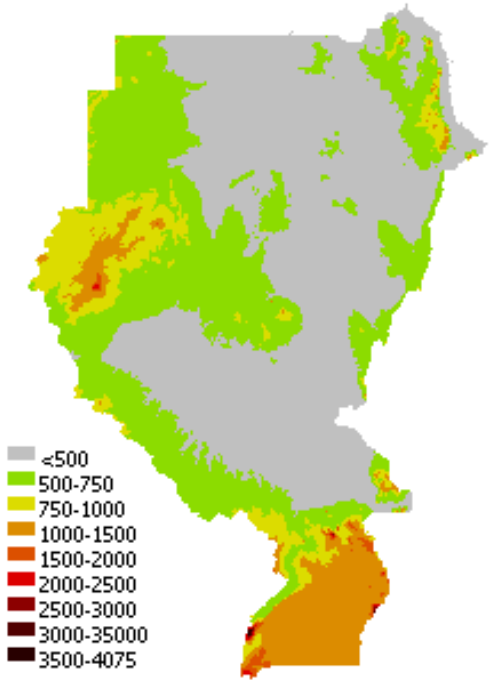


Figure 28 Altitude in meters above mean sea level

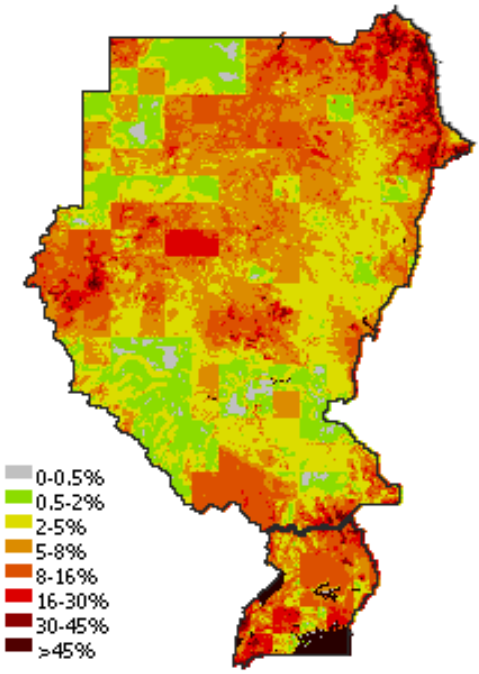


Figure 29 slope in %

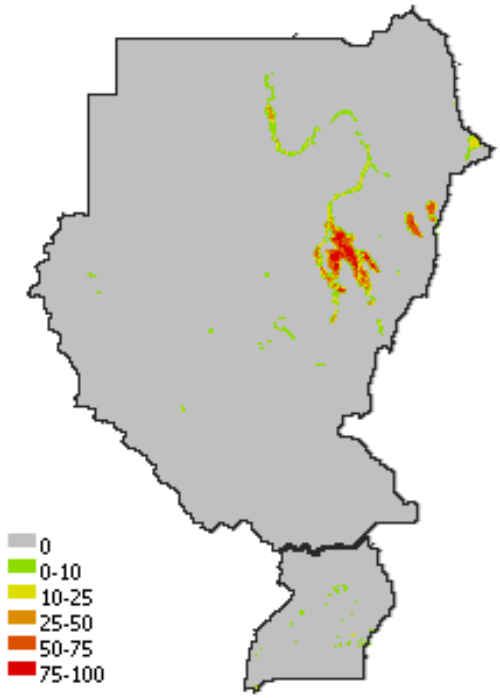


Figure 30 Irrigated areas (% of surface)

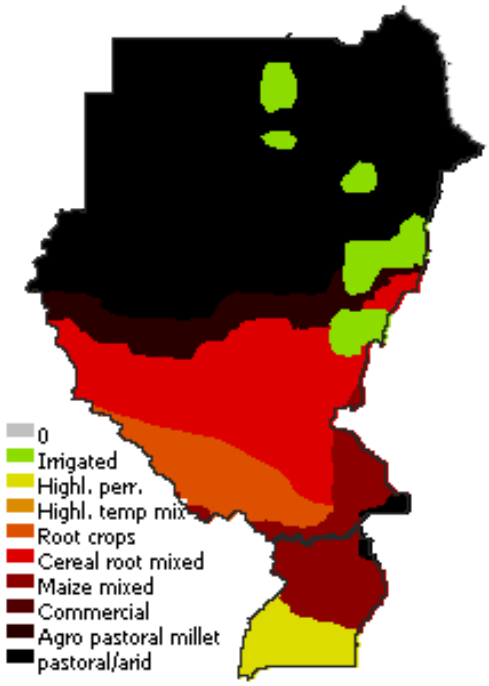


Figure 31 Farming systems

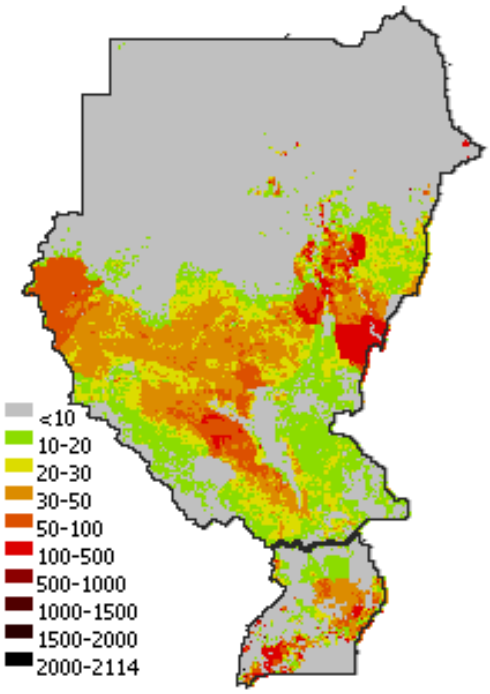


Figure 32 Tropical Livestock Unit density (TLU/ km2)

Climate

A map of mean annual precipitation for Sudan and South Sudan is presented in FAO (2006). Rainfall in the north of Sudan is less than 25 mm and it gradually increase to about 100 mm at the latitude of Khartoum. Further south rainfall increases rather rapidly up 600-700 mm at the border with South Sudan. With few exceptions the increase in rainfall in Sudan occurs with parallel isohyets in west-east direction. Rainfall further increases with decreasing latitude in South Sudan to about 1100 mm at the border with Uganda. The pattern of increase though is also influenced by the presence of the Ethiopian massif and the Congo rainforest. Compared to central South Sudan, rainfall is higher towards Ethiopia (up to 1000 mm) and towards the borders of the Central African Republic and D.R. Congo (1400-1600 mm). Being located in the rainshadow of both the Ethiopian Massif and the Uganda highlands, rainfall sharply decreases towards the south-east reaching only 400-600 mm at the Kenyan border. The LGP varies according to the pattern of rainfall. In a sizeable area in the north of Sudan the LGP is practically zero, and at the latitude of Khartoum it is still less than 30 days. Further southward The LGP increases up to 150 days at the border with South Sudan. In South Sudan the LGP further increases in south-western direction up to 270 at the border with D.R. Congo and north-west Uganda. Towards the Ethiopian border LGP's of 210 days are reached. In the south-eastern border zone the LGP decreases to less than 30 days (FAO/IIASA). Overall rainfall in Sudan and South Sudan is unimodal with the exception of Juba and Pibor in South Sudan, where the LGP contains an short intermediate period of less than 30 days (FAO, 1984).

For Uganda there exist recent maps of mean annual rainfall using different class intervals, but essentially they show the same patterns (Namanya, 2009; NEMA, 2009). The spatial patterns and detail suggest that, next to the 19 meteorological stations, data from rainfall stations have been used as well.FAO/IIASA (2000) is not as detailed, but the patterns and values are reasonably similar. In most of Uganda the mean annual rainfall is in the order of 1000-1600 mm. Dryer

exceptions are the north-east (Karamoja), central south-west Uganda (not including the lakeshore area in the east and mountainous terrain in the west) and lower lying terrain around Lake Edward and Lake Albert and further north in the Rift. In these dryer areas mean annual rainfall is 600 to 1000 mm and in Karamoja locally even below 600. Higher rainfall above 1600 mm is found on the high relief of the Ruwenzori mountains, Mount Elgon and at the shore of Lake Victoria. North of Lake Kyoga the LGP decreases from 270 days in the west to around 150 days in Karamoja. In the remainder of Uganda the LGP mostly is between 270 and 330 days, being longer at higher altitudes and shorter at lower altitudes and in rainshadow areas. On parts of the shore of Lake Victoria there is a year-round LGP (FAO/IIASA)

Bi-modality of rainfall is an important issue in Uganda and therefore we conduct again a brief analysis of station data (FAO, 1984) to spread some light on the existing LGP patterns and their length. North of Lake Kyoga there is a single LGP that is longest in the west near D.R. Congo (Arua: 265 days) and generally speaking the LGP decrease in length in northward (Kitgum 224 days) and eastward (Moroto: 175 days) direction. This zone further includes Gulu (261 days) and Lira (251 days). Although one single season Gulu and Moroto have an intra-season intermediate period of almost one month. Moroto thus combines a relatively short season that includes a dryer month. In fact, the rainfall maps suggest that Moroto is not representative for Karamoja as a whole as it is located on a mountain slope where rainfall is about 300 mm higher than its surroundings. Further southward, just like in West Africa, there is again a zone with a short intermediate period (< 30 days) when rainfall is unreliable. The LGP length varies with altitude from about 240 days in lower terrain and approximating 300 days at higher elevations. In this zone there are two deviations also related to relief. At Mbale on the slopes of Mount Elgon the pattern is clear-cut uni-modal (247 days), while in the Lake Albert depression conditions are considerably poorer: a break in the growing period, albeit very short, and both seasons are intermediate only (Butiaba, 90 and 152 days) . The poor conditions in the Rift valley depressions are further confirmed by the station Orichinga, where there are two breaks, resulting in very short seasons. With few exceptions, in the remainder of Uganda the total season length is around 300 days and above. Mostly there is a single season with a bimodal tendency resulting in an intermediate period from 50 to as long as 100 days period (Entebbe, Fort Portal, Hoima, Mpanga, Namulonge, Tororo and Kabale). In the area of Kampala and Jinja though there are two separate season with a break of about 25 days. The exceptions are that at Mubende and Mbarara the sum of the two seasons is only about 260 days, thus resulting in two rather short seasons. Both stations are located south-west Uganda in between the wetter coast of Lake Victoria and the western mountainous areas, where rainfall is substantially lower in the Ugandan maps. This greater dryness than surrounding areas is also expressed in land use, because crop production takes place primarily on slopes of drainage ways, while at the same time this is a major cattle grazing area (Wortmann and Eledu, 1999). The area with a strict bimodal LGP is presented in Figure 19 (Source FAO/IIASA, 2000).

In sum, strict bimodality of rainfall - and a tendency towards it - is widespread in Uganda and under climate change carry similar risks and opportunities as in West Africa, although less severe ones with respect to land productivity due to the currently extended LGP's. Further, three sensitive areas have been identified: first Karamoja with the shortest LGP, the basins of Lake Albert, Lake Edward and a northern extension into the eastern Rift, where the rainy season is long, but very unreliable, and the central part of south-west Uganda, extending from the Tanzanian border up to Mubende, currently with bimodal rainfall resulting in two short seasons.

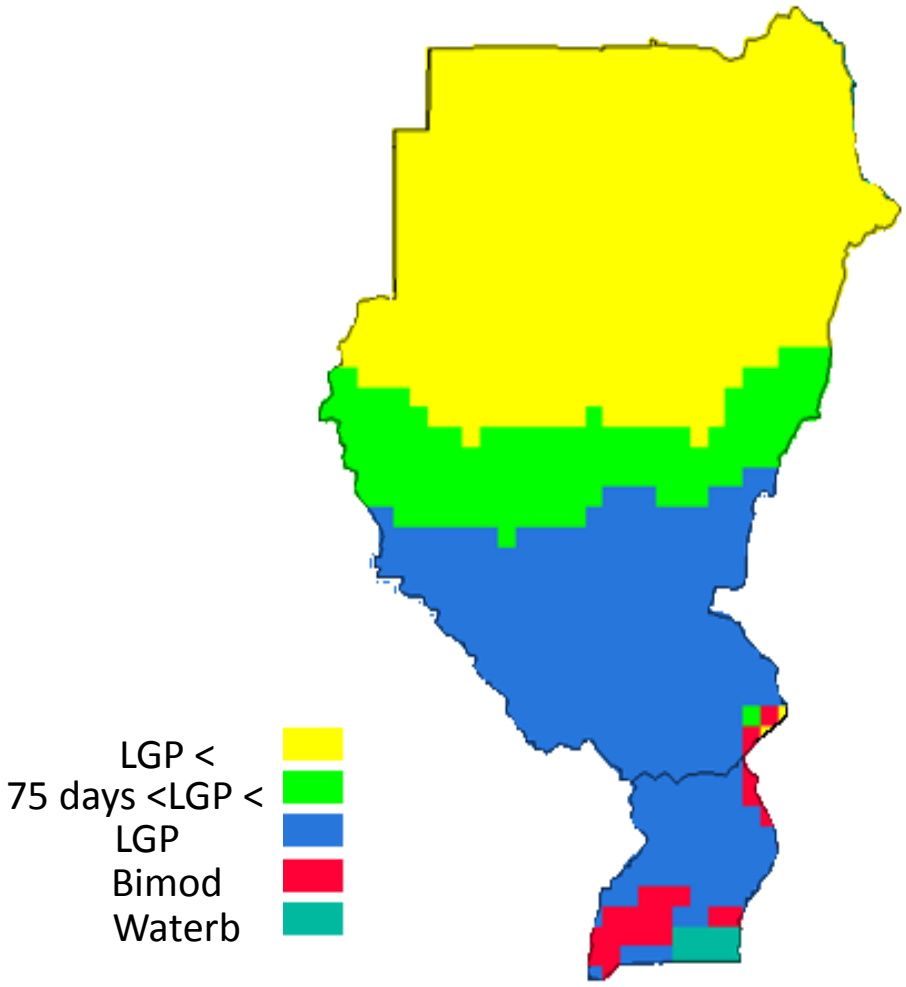


Figure 33 East Africa: areas with a distinct bimodal LGP

Population

For 2010, the total population of the countries in the selection has been estimated at 92.6 million people, 56% of whom live in rural areas. The population density equals 45 people per km^2 on average, but varies markedly across the area, as was already pointed out in the general description of the East Africa study area (Figure 21). There is a large concentration of refugees in the area, with 20 refugee camps in Sudan and South-Sudan (Figure 20) and 7 in Uganda. In addition to these camps, UNHCR officially recognizes 635400 refugees dispersed in rural areas and 77000 refugees living in urban centers (UNHCR, 2010)

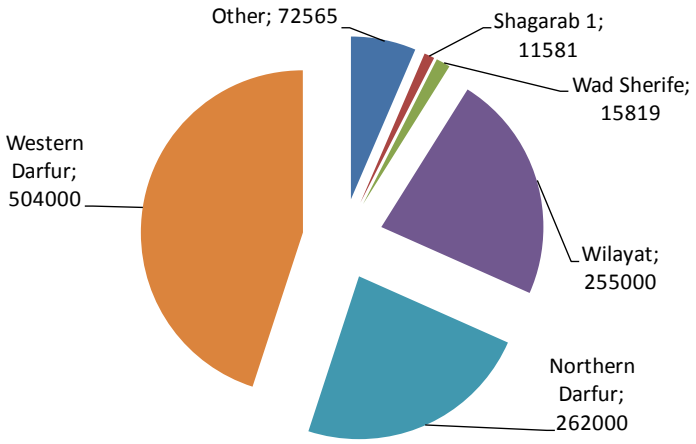


Figure 34 Refugee- and Internally Displaced Person camps in Sudan and South Sudan
Source: UNHCR (2010)

Consumption

The estimated total consumption equals 1873 kcal per capita per day for the area as a whole, with country averages being 1846 kcal for Sudan and South-Sudan jointly and 2102 kcal for Uganda, and with rural consumption in Sudan/South Sudan being 2.5% higher than urban consumption and urban consumption exceeding rural consumption in Uganda with 6.5%, reflecting substantial differences between rural and urban areas and between countries (Figure 22, for methodology see Van Wesenbeeck et al., 2009).

Production

Figure 23 depicts the spatial distribution of production of food crops, per rural head of the population. The average production per rural capita in the region is a low 397 kg cereal equivalents, with country averages being 352 kg for Sudan/South Sudan, and a high 754 in Uganda. The maximum district average (2.1 mt cereal equivalents per capita) is reached in the district of Kongasis, Uganda, while averages exceeding 1 mt per rural head are quite common in this country (source: updated from Van Wesenbeeck and Merbis, 2012).

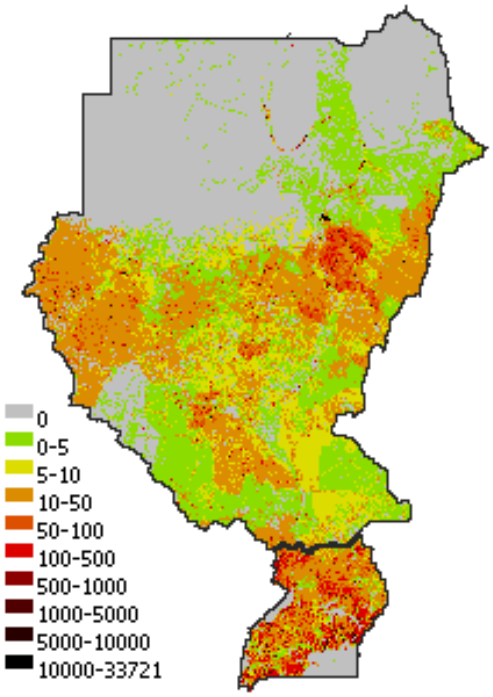


Figure 35 Population density (persons per km^2)

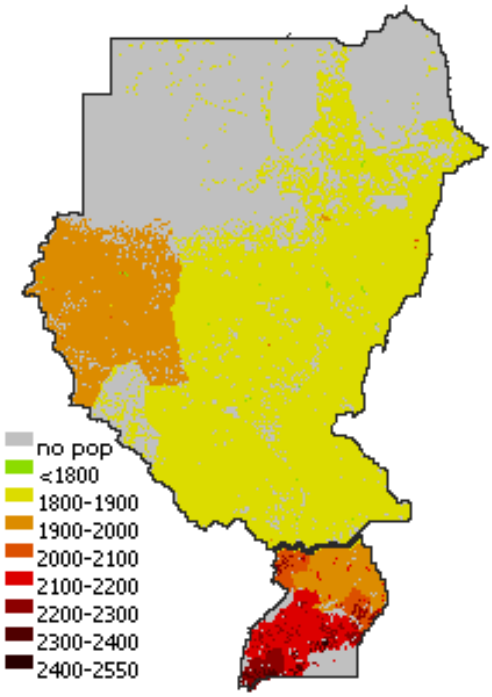


Figure 36 Per capita consumption (kcal/day)

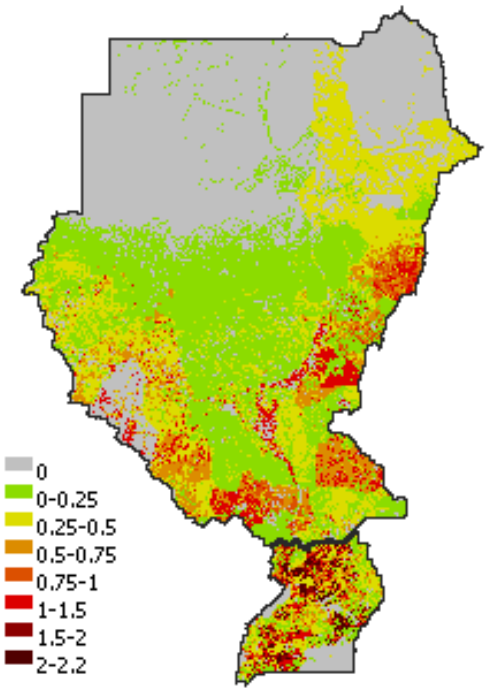


Figure 37 Production in mt cereal equivalents per rural head

Transport possibilities and costs

Availability of primary roads is very limited in Sudan and South Sudan, while Uganda is well-connected by a network of corridors (Figure 24), with low transport costs (US$ 0.14 per mtkm). The primary roads are complemented by a network of secondary roads that is relatively sparse in the whole region. Because of the relatively good infrastructure in Uganda, total transport costs are relatively low there, but high in Sudan and South Sudan (Figure 25, source: updated from Van Wesenbeeck and Merbis, 2012).

Food aid dependency

Average consumption per capita of food aid is high with 1060 kcal per capita per day (Figure 26). In addition to the food aid provisions to the many refugee camps, aid deliveries take place in response to emergencies or longer running programs. In South Sudan, general support is provided and in Sudan, general support is concentrated in Darfur, with other longer-running programs in the rest of the country. In Uganda, food aid is concentrated in the North of the country, especially in the Karamoja region. (Source: various publications by WFP).

Figure 38 Primary roads

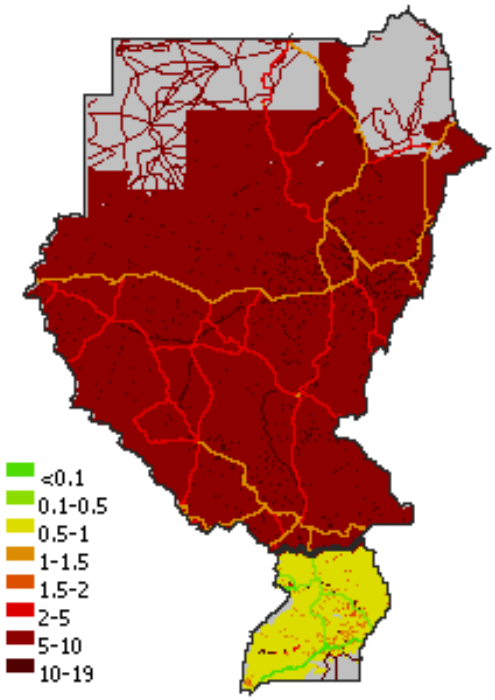


Figure 39 Transport costs in US$/mtkm

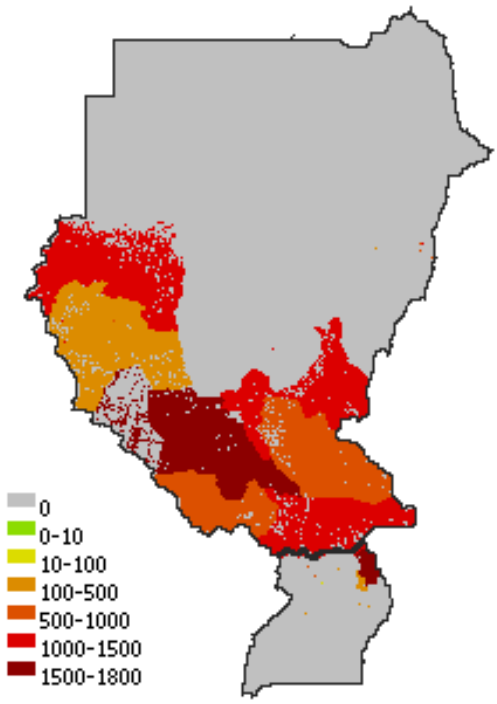


Figure 40 Food aid in kcal per capita per day

9. Data sources

This section describes the data sources that were used in the analysis. Section 3.1 starts with the geo-referenced surveys while section 3.2 describes the geographic information sources.

3.1 Surveys

Demographic and Health Surveys (DHS)

DHS surveys (http://measuredhs.com/) are nationally representative household surveys that provide data for a wide range of indicators in the areas of population, health, and nutrition. Standard DHS surveys have large sample sizes (usually between 5,000 and 30,000 households) and are typically conducted about every 5 years, to allow comparisons over time. For our analysis the following DHS surveys are used:

- Standard DHS survey for Benin (2001). The DHS survey for 2006 for Benin is not geo-referenced and is therefore not included in the analysis. Data for 2010 are not yet available.
- Standard DHS survey for Burkina Faso (2003). Data for the 2010 survey are not yet available.
- Standard DHS survey for Côte d'Ivoire (1998/1999). The DHS survey for 2005 for Côte d'Ivoire is not geo-referenced and is therefore not included in the analysis. Data for the 2012 survey are not yet available.
- Standard DHS survey for Ghana (2008).
- Standard DHS survey for Togo (1998). Data for the 2012 survey are not yet available.

- Standard DHS survey for Uganda (2006). Data for the 2011 survey are not yet available.

Multiple Indicator Cluster Survey (MICS)

MICS is an international household survey program developed by UNICEF. MICS data are collected during face-to-face interviews in nationally representative samples of households, generating one of the world's largest sources of statistical information on children and women. Since no DHS survey is available for Sudan and South Sudan, MICS surveys for 2000 for Sudan and South Sudan are used instead.

Afrobarometer data

The Afrobarometer (http://www.afrobarometer.org/) is an independent, nonpartisan research project that measures the social, political, and economic atmosphere in Africa. For our analysis, the following surveys are used:

- Benin (2008)
- Burkina Faso (2008)
- Ghana (2008)
- Uganda (2008)

3.2 Geographic Information

Spatially explicit (map) data are used to complement the survey data.

Database SOW-VU

A first group of maps derives from the database "Africa in maps" (van Wesenbeeck and Merbis, 2012). These include population maps (total, urban, rural, refugees/IDPs), food aid distribution, and estimates of total production measured in mt cereal equivalents per capita.

Tropical livestock Unit map.

The Tropical livestock Unit (TLU) expresses the grazing demand of various species in a livestock herd in a harmonized unit. The standard used for one TLU is the grazing demand of one cattle head with a body weight of 250 kg. The conversion factors used in this study area based on PADS (2004): Cattle = 0.79; Sheep =0.13; Goat = 0.10; Camel = 1.22; Equines = 0.63. This map was also used to geo-reference the data for Sudan.

Farming systems map.

A farming system is defined as a population of individual farm systems that have broadly similar resource bases, enterprise patterns, household livelihoods and constraints, and for which related development strategies and interventions would be appropriate1. Depending on the scale of the analysis, a farming system can encompass a few dozen or many millions of households. The map that is used in this exercise was presented in Dixon et al., 2001. The farming systems for Africa and their encoding are presented in Table 1.

[1] In the literature a wide variety of definitions of farm systems and farming system are found, which emphasize system components and interrelationships (see Dillon et al., 1978 and Shaner et al., 1982) and complementary biophysical and socio-economic processes (see Norman et al., 1982).

Table 3 Encoding of farming systems in Africa

Code	Farming system
1	Irrigated
2	Tree crop
3	Forest based
4	Rice-tree crop
5	Highland perennial
6	Highland temperate mixed
7	Root crop
8	Cereal-root crop mixed
9	Maize mixed
10	Large commercial & smallholder
11	Agro-pastoral millet/sorghum
12	Pastoral
13	Sparse (arid)
14	Coastal artisanal fishing

Degradation index

The degradation index is based on the Global Assessment of Human-induced Soil Degradation (GLASOD) (Oldeman et al., 1991). The UNEP-funded GLASOD project produced a world map of human-induced soil degradation. Data were compiled in cooperation with a large number of soil scientists throughout the world, using uniform guidelines and international correlation. The status of soil degradation was mapped within physiographic units, based on expert judgments, indicating the type, extent, degree, rate and main causes of the degradation process. To compare the impact of land degradation between different sites we created a land degradation index that attributes the following weights to area shares of the soil degradation classes 'light'= 1, 'moderate'=2, 'severe' = 3 and 'very severe' = 4. Next, we scaled the index between a range of 0-1. Combining classes and area shares in a single land degradation index is common practice in many other peer reviewed studies (e.g. Leiwen et al., 2005; McCoubrey, 1998; Pace at al., 2008; Safriel, 1999; Sonneveld and Dent, 2009), which gives us, sufficient confidence to apply the index for our analysis.

Dominant land cover

The dominant land cover has been derived from the Global Agro-Ecological Zones project of FAO and IIASA **http://gaez.fao.org/Main.html#)**. The Dominant Land Cover Pattern represents the land cover with the greatest extent in a grid cell. The various land cover maps were made consistent with aggregate FAO land statistics and spatial land cover patterns that were obtained from remotely sensed data and geographic datasets with calibration to UN 2000 population figures. The resulting categories of dominant land uses and their code are presented in Table 2

Table 4 Encoding of dominant land use/land cover

Code	Dominant land use
1	>75% Cultivated land
2	>75% Forest land
3	>75% Grass and woodland

4	>75% Barren land
5	50-75% Cultivated land
6	50-75% Forest land
7	50-75% Grass and woodland
8	50-75% Barren land
9	>50% Built-up land
10	Land cover associations
11	Water

Irrigated areas

Information on irrigated areas is derived from the Global Agro-Ecological Zones project of FAO and IIASA (http://gaez.fao.org/Main.html#)**.** The map of irrigation areas represents a grid with percentage of area equipped for irrigation with a spatial resolution of 5 arc minutes. The actually irrigated area is smaller, but is unknown for most countries. This dataset has been developed in the framework of the AQUASTAT-program of the Food and Agriculture Organization and the Goethe University, Frankfurt am Main, Germany.

Altitude map

The altitude dataset in (m) refers to median elevation at 5 arc-min derived from a 3 arc-seconds sub-grid of the Shuttle Radar Topography Mission (SRTM, **http://www2.jpl.nasa.gov/srtm/**).

Slope map

The slope class dataset refers to the median terrain slope class derived from a 3 arc-sec sub-grid of the Shuttle Radar Topography Mission (SRTM, **http://www2.jpl.nasa.gov/srtm/**).

Soil suitability

The soil suitability map combines various soil constraints to calculate the area share where agricultural activities are seriously restricted. The agro-edaphic suitability classification is to a large extent based on experience documented by Prof. C. Sys and others (e.g. FAO, 1978-81a; Sys and Riquier, 1980). The suitability rating is based on a comparison of a general soil requirement assessment for crop growth and prevailing edaphic conditions. Codes and corresponding classes are presented in Table 3.

Table 5 Soil suitability classes

Code	Area share with restricted soil suitability	Description
2	0	No constraints
3	0-20	Very few constraints
4	20-40	Few constraints
5	40-60	Partly with constraints
6	60-80	Frequent severe constraints
7	80-95	Very frequent severe constraints
8	100	Unsuitable for agriculture
9	Water bodies	Water bodies

Length of Growing Period.

The length of growing period (LGP) refers to the average duration when moisture availability allows crop growth**.** The calculation is based on a water balance model that compares moisture supply from precipitation, soil moisture storage and a reference evapotranspiration. The reference LGP assumes available soil moisture capacity of 100 mm per meter soil depth and a reference soil depth of one meter. LGP's were based on the baseline period of 1961-1990.

10. Methodology

In defining vulnerability, we follow WFP (2009) and IFPRI (2012) and combine indicators for food security with health indicators that signal vulnerability in a physical sense. IFPRI's Global Hunger Index uses three indicators to measure hunger: the number of adults being undernourished, the number of children that have low weight for age, and child mortality. Other classifications of food security use the variety of the diet as an indicator, combined with anthropometric data on children. However, in the DHS data there is no information available on child mortality, nor on dietary composition. Given these data limitations, we use data on the nutritional status of women (BMI) and children (weight for age) as indicators for food security. These data are combined with data on morbidity among adults and children, specifically the occurrence of malaria, cough, and diarrhea. Combinations of indicators lead to a classification of households as being very vulnerable, vulnerable, nearly vulnerable and not vulnerable. The Afrobarometer surveys do not include data on the BMI of adults nor weights for children. Here, we use the reported times the household went without food in the year prior to the date the survey was conducted as an indicator for vulnerability.

The next step is to characterize the nearly vulnerable, vulnerable and very vulnerable populations in terms of socio-economic aspects. If the vulnerability situation is seen as an outcome, then socio-economic characteristics as well as biophysical aspects of locations can be considered as explanatory variables. Common explanatory variables named in the literature are the age and gender of the head of household, number of dependent household members, wealth index, education of adult household members, type of occupation, current working situation, and distance to markets. Furthermore, characteristics of the locality are included, indicating the suitability for crop growing and vulnerability of the area to climate change (current production in cereal equivalents per capita, Length of Growing Period (LGP), dominant land use, soil suitability, land degradation index, and an indicator map for irrigated agriculture). A Digital Elevation Map (DEM) and a slope map account for the vulnerability of an area for floods and run-off. Finally, we include the extent to which households are able to cope with adverse shocks as an additional characteristic. Coping mechanisms may include deliveries of food aid, the existence of household members sending remittances to the household, and integration in the community. On the negative side, discrimination on the basis of ethnic background or religion may increase the vulnerability of specific groups.

The combination of (geo-referenced) surveys and grid-level data enhances our insights into the complex interaction of factors leading to a specific vulnerability classification as observable outcome. Joint analysis of these two types of data provides insights into the profiles of vulnerable groups, and through this identifies possible focal areas for interventions aimed at mitigating the consequences of climate change. The method we use in this report is referred to as "polling", and before we present the results, we briefly introduce and motivate this methodology.

In opinion polls, individuals are asked about their preferred candidate or party as well as about their personal situation, their motives and opinions. On the basis of this information, analysts can report on how given voters' characteristics such as age, sex, education and occupation, are distributed among candidates, and discuss changes in these distributions relative to earlier polls. Reporting will be on each characteristic separately or for two or three jointly.

More in-depth studies also indicate how characteristics *jointly* affect preference for a particular candidate or party, using statistical methods such as cluster analysis, factor analysis and logit and probit regression, and support-vector classification so as to identify major determinants. Countless findings were obtained in this way. Yet, it would seem that, between the partial, descriptive approach and the multivariate, regression-type approaches, the option of a descriptive analysis is being skipped that jointly looks at a large number of answers, aiming at comprehensiveness and understanding of the underlying mechanisms that lead to vulnerability as an outcome. This motivates the use of a methodology that is able to analyze different types of data in an integrated way. The GRCP (Gridding, Regression, Classification and Polling) software (Keyzer and Pande, 2010) developed at SOW-VU offers a platform to perform such integrated analysis.

First, the GRCP software allows the projection of data from a map to a geo-referenced survey. It assigns the numerical value of a specific map variable at a location to all the survey observations as an additional attribute. For our analysis, this option is used to complement the DHS survey information with the agro-ecological, geo-physical and climate data available as maps.

Secondly, The GRCP software allows the projection of data from a geo-referenced survey on a map. Two cases must be distinguished here: projection of available data at survey points and interpolation of results to points for which the data is missing. For categorical data on a specific variable at a survey point, the software determines the class that occurs most frequently at that point, computes its probability, and projects this as the grid value. Interpolation of data to account for missing data (either because the survey has missing data, or because there are no survey observations at this location), is done using nearest neighbor interpolation of the probability weighted mass, or by using kernel functions to define distances between points in a more comprehensive way.

Thirdly, the DHS surveys and the Afrobarometer surveys are explicitly geo-referenced. However, the MICS survey used for Sudan and North Sudan only include a district reference. Here, we have determined the conditional frequencies of variables in the survey that are also available as grid-level data, notably urban/rural indicators, livestock and land possession, and irrigation indicators, and then applied zoning to geo-reference the survey observations.

The analysis we perform uses two different types of surveys: DHS/MICS and Afrobarometer surveys. The two types of surveys are complementary to each other, but also share some common variables that make it possible to combine the two, by appending estimation results from one to the other. In our study, the two surveys both are geo-referenced, and both have data on the age of the head of household, and the educational attainment. Estimation results for an administrative unit, i.e. the most probable associations of variables in the Afrobarometer survey within such a unit are used to complement the DHS/MICS survey observations. In this way, the two types of surveys are combined and analyzed jointly – obviously, appending the raw data by location is not an option, since the two surveys represent different samples. In fact, the application of estimated relations to append the set of characteristics of individuals is also used in the large field of poverty mapping. Here, estimations based on surveys are applied to a census,

to extrapolate the findings to areas and populations that were not included in the survey (e.g. see Bedi et al., 2007 for an overview of theory and applications of poverty mapping).

One additional step could be to identify causal relations, for example by considering matching pairs of individuals that differ only in a single aspect, identifying the contribution of this difference to, say, nutritional status, and concluding that the "treatment" with this specific characteristic improves nutritional status. In this report, we do not take this step. There are two different types of reasons for this.

First, although it is possible within the given data to identify the contribution of a single characteristic to the outcome, the interpretation of such an outcome is far from straightforward. First, identification of a treatment effect presupposes a *theory* of treatment based on theoretical insights in the determinants of vulnerability, and no such clear theory exists, although there are many studies that mention possible factors contributing to vulnerability. Secondly, and related to this, is that there are many variables, say, religion or ethnic background, for which concluding that there is a treatment effect only begs the question of why this is the case, and whether or not this particular variable is in itself determined by other characteristics.

Secondly, although vulnerability is described in this report as an outcome, it is the outcome of an extremely complex interaction of different factors. Identification of a treatment effect of one or a few selected variables would deny this fact. Specifically, the interactions of households with other households and the dynamics of coping mechanisms cannot be adequately captured in such an approach. This is the reason why this exploratory study that classifies and profiles vulnerable households will be complemented by the formulation of an applied model where the effects of climate disasters, and in particular the spread of the effects throughout a society is simulated.

Hence, the current study does not claim to identify causal relations, but identifies associations of vulnerability with location – providing the link to probable locations of climate disasters, and socio-economic characteristics – to gain insight in the type of adaptation or coping strategies that may fit these profiles. We supplement the computation of marginal probability distributions for selected characteristics relevant for vulnerability with an approach that treats these characteristics as a joint empirical frequency distribution. Conditional frequency distributions can be derived from this joint distribution by partitioning the answers by say, S respondents indexed s into a vector y of K_y dependent variables and a vector x of K_x independent variables, taking the frequencies of y conditional on x. Secondly, as the conditional frequencies are naturally interpreted as probability estimates, we also compute the most probable characteristics associated to each x-value, which can be interpreted as winner of the election, as well as the runner up and so on. We report on the top-2 profiles including the frequencies of occurrence and on the top-N profiles that jointly describe half of the population under study, as an additional test on stability of the findings.

Section 5 first identifies where the vulnerable populations are located. Section 6 then uses univariate analysis and polling to profile these groups.

11. Identifying vulnerable populations

Introduction

In defining vulnerability, we follow WFP (2009) and IFPRI (2012) and combine indicators for food security with health indicators that signal vulnerability in a physical sense. IFPRI's Global Hunger Index uses three indicators to measure hunger: the number of adults being

undernourished, the number of children that have low weight for age, and child mortality. Other classifications of food security use the variety of the diet as an indicator, combined with anthropometric data on children. Yet, in the DHS data there is no information available on child mortality while our DHS and MICS surveys abstain from information on dietary composition. Given these data limitations, we use data on the nutritional status of women (BMI) and children (weight for age, weight for height) as indicators for food security. These data are combined with data on morbidity among adults and children, specifically the occurrence of malaria, cough, and diarrhea[2]. Combinations of indicators lead to a classification of households as being severely vulnerable, vulnerable, nearly vulnerable and not vulnerable. Spatially explicit representations are provided to show the locations of the different types of households. The Afrobarometer surveys do not include data on the BMI of adults nor weights for children. Here, we use the reported times the household went without food in the year prior to the date the survey was conducted. We report on the results of the different surveys separately and then comment on the differences and findings, by study area.

West-Africa

Results

First, we concentrate on the DHS survey results. For West Africa, the DHS surveys include a total of 106 368 observations, with the coverage as depicted in Figure 27. Table 4 summarizes some statistics on the variables used in the DHS as indicators for vulnerability, where the vulnerable and nearly vulnerable adults are defined by the first three columns, following the standard interpretation of BMI below 16 as being severely undernourished, and below 18.5 as being undernourished. It is clear that in the aggregate, 85% of the adult population has a BMI above the threshold level, with Burkina Faso performing worse than the other countries. Figure 28 and Figure 29 indicate where the adults with a BMI lower than 16 and the adults with a BMI between 16 and 18.3 are located in the region.

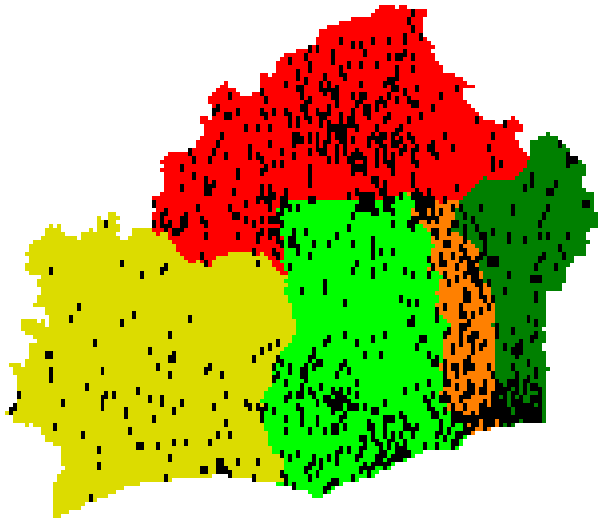


Figure 41 Location of observations

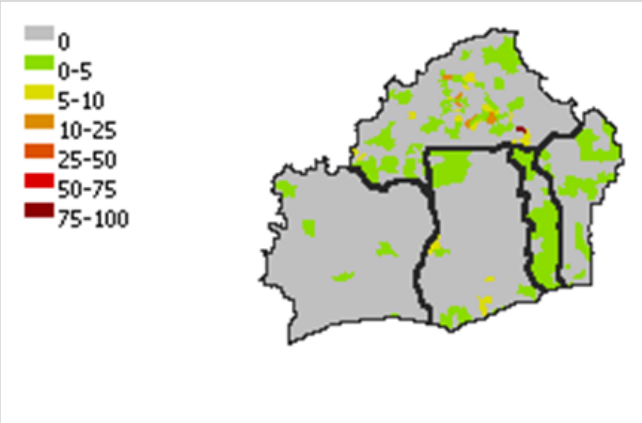
Table 6 Distribution of BMI in sample of households in West Africa study area

	BMI<16	16<=BMI<18.3	18.3<=BMI<18.6	BMI=>18.6
West	0.5%	6.6%	2.2%	90.7%
Benin	0.3%	6.1%	2.2%	91.5%

[2] The number of observations on acute respiratory infections were not sufficient for our analytical purpose

Ghana	0.3%	3.9%	1.1%	94.6%
Côte	0.1%	3.9%	1.9%	94.1%
Togo	0.9%	8.3%	2.5%	88.3%
Burkin	1.4%	14.3%	4.3%	80.1%

Note: results are population-weighted averages



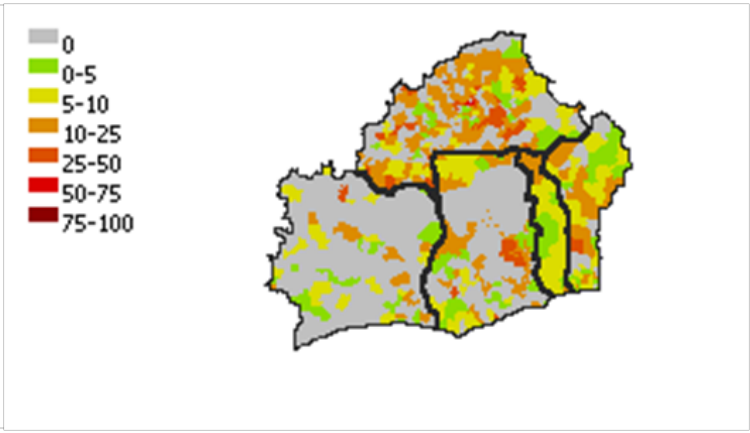


Figure 42 adults with a BMI below 16 (%) **Figure 43 adults with a BMI of 16 - 18.3 (%)**

For children, Table 5 and Table 6 provide the distribution of weight for age (a measure for long-term malnutrition) and weight for height (a measure for acute malnutrition), presented as deviations from the norm. We adopt here the general interpretation that under conditions of three deviations from the norm (-3sd) the child is severely underweight and under two deviation from the norm (-2sd) the child is underweight. The first two columns in Table 5 and Table 6 indicate an insufficient nutritional status of the child, while the third column defines a situation of near sufficient nutritional status. The nutritional status of children follows the same pattern by country, with Burkina Faso again falling behind the other countries in the region.

Table 7 Distribution of weight for age in sample of household in West Africa study area

	w/a<-3sd	**-3sd<=w/a<-2sd**	**-2sd<=w/a<0**	**w/a=>0**
West Africa	5.1%	17.2%	58.2%	19.5%
Benin	3.6%	15.4%	65.6%	15.5%
Ghana	2.6%	12.2%	60.1%	25.1%
Côte D'Ivoire	1.7%	16.9%	61.4%	20.0%
Togo	8.1%	20.7%	56.5%	14.7%
Burkina Faso	13.4%	25.1%	49.1%	12.4%

Note: results are population-weighted averages

Table 8 Distribution of weight for height in sample of households in West Africa study area

	w/h<-3sd	-3sd<=w/h<-2sd	-2sd<=w/h<0	w/h=>0
West Africa	2.1%	7.2%	56.2%	34.6%
Benin	1.3%	5.0%	57.9%	35.7%
Ghana	1.0%	5.2%	57.2%	36.5%
Côte D'Ivoire	1.1%	4.8%	52.8%	41.4%
Togo	2.7%	11.8%	62.4%	23.2%
Burkina Faso	5.3%	12.4%	55.7%	26.7%

Note: results are population-weighted averages

Figure 30 and Figure 31 indicate where the children with a weight for age below -3sd and a norm weight between -2 and -3 sd are located in the region, while Figure 32 and Figure 33 show the same for weight for height.

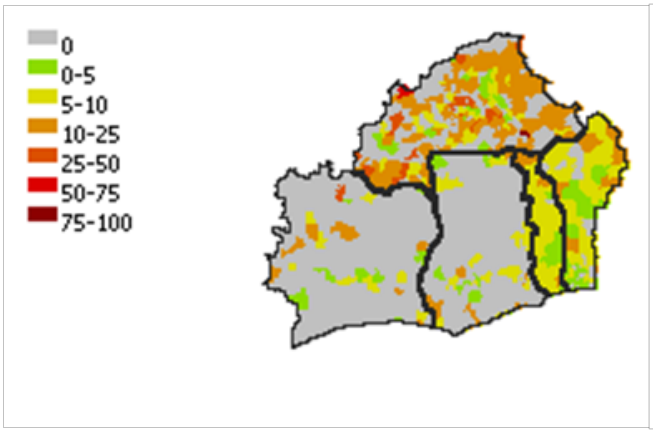


Figure 44 children with w/a < -3 sd (%)

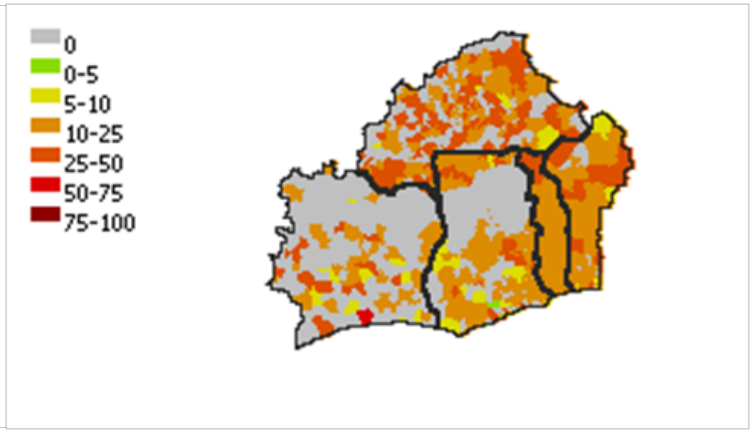


Figure 45 children with w/a of -2sd to -3sd (%)

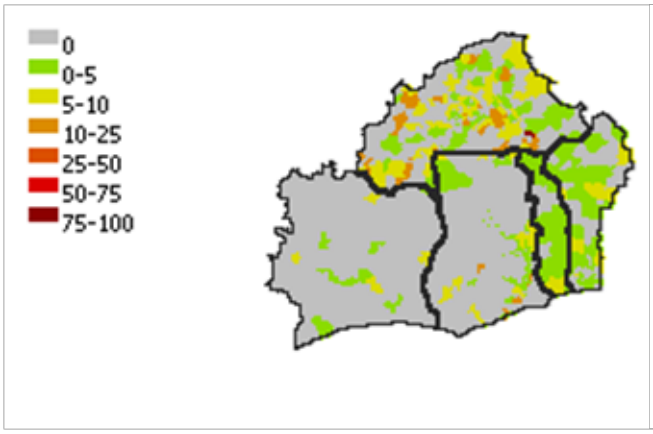


Figure 46 children with w/ h< -3sd (%)

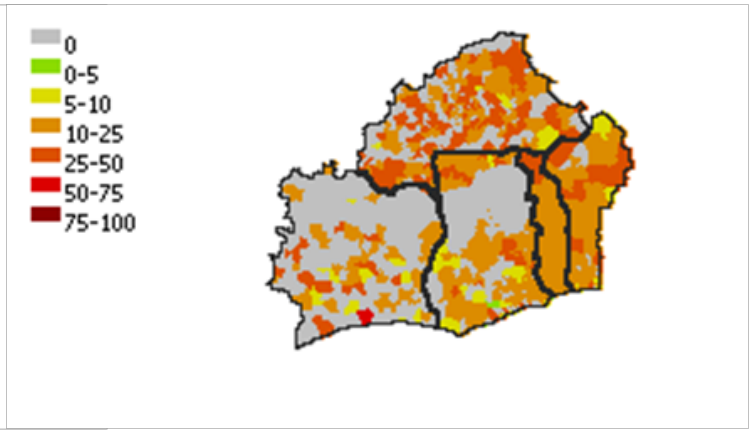


Figure 47 children with w/h of -2sd to -3sd (%)

Next, we include the data on the prevalence of malaria, cough and diarrhea in the two weeks prior to the survey. We consider the simultaneity of prevalence as a single indicator (Table 7).

Table 9 Prevalence of diseases in sample of households in West Africa study area

	All three	Two out of three	One out of three	None
West Africa	8.9%	17.6%	27.1%	46.4%
Benin	9.7%	18.0%	27.4%	44.9%
Ghana	8.2%	16.3%	28.7%	46.9%
Côte D'Ivoire	7.6%	19.5%	25.6%	47.3%
Togo	10.4%	18.2%	27.2%	44.2%
Burkina Faso	11.3%	16.9%	26.1%	45.7%

Note: results are population-weighted averages

Almost half of the households reported no illnesses in the reference period. As before, Burkina Faso performs worse than the other countries in the sample if we consider the prevalence of the diseases jointly, although also in Togo, the prevalence of disease is high. Figure 34 and Figure 35 show the location of households with 2 or 3 diseases.

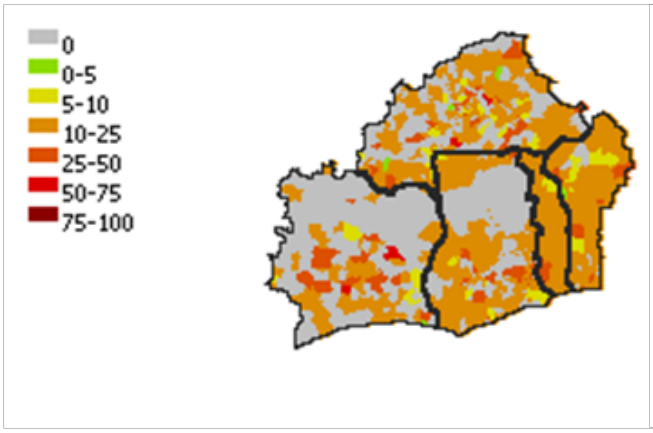


Figure 48 households with 2 diseases (%)

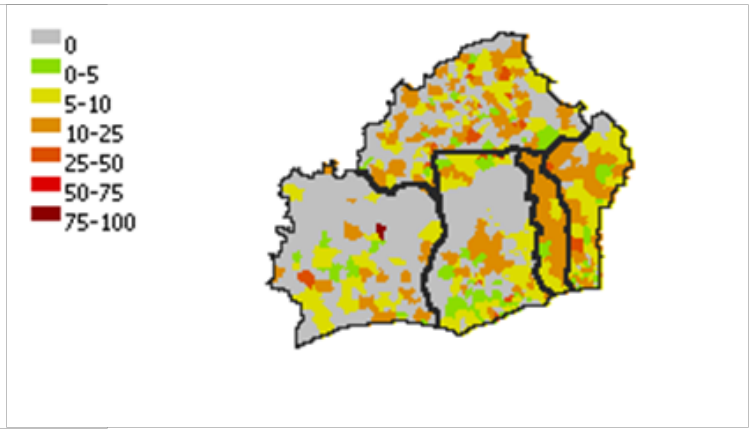


Figure 49 % of households with 3 diseases (%)

The criteria for classifying households in the various degrees of vulnerability are described in Annex A2 of this report.

Table 10 Vulnerability of households in West Africa study area

		Very vulnerable	Vulnerable	Nearly vulnerable	Not vulnerable
Total urban/rural	West Africa	0.1%	18.4%	25.6%	55.9%

	Benin	0.2%	31.8%	27.2%	40.8%
	Ghana	0.1%	13.3%	20.6%	66.0%
	Côte D'Ivoire	0.0%	19.2%	24.4%	56.4%
	Togo	0.1%	15.2%	33.3%	51.4%
	Burkina Faso	0.4%	26.7%	32.3%	40.6%
Urban	West Africa	0.0%	9.6%	20.9%	69.5%
	Benin	0.0%	46.5%	23.3%	30.2%
	Ghana	0.0%	2.2%	12.5%	85.3%
	Côte D'Ivoire	0.0%	12.0%	20.3%	67.7%
	Togo	0.0%	12.2%	33.2%	54.6%
	Burkina Faso	0.0%	8.2%	29.6%	62.2%
Rural	West Africa	0.2%	27.2%	30.3%	42.3%
	Benin	0.4%	24.9%	29.0%	45.7%
	Ghana	0.2%	22.4%	27.3%	50.1%
	Côte D'Ivoire	0.0%	31.4%	31.3%	37.3%
	Togo	0.1%	19.7%	33.5%	46.7%
	Burkina Faso	0.6%	34.1%	33.4%	31.9%

Note: results are population-weighted averages

Including data on the type of locality of the households (rural/urban) reveals that there are differences in the vulnerability between rural and urban locations, as is illustrated in Table 8, where percentages refer to the share of the reference population, with rural populations being more vulnerable than urban ones, in line with common perceptions. Furthermore, for the region as a whole and for each country separately, the percentage of very vulnerable populations is very modest (below 0.5%), but vulnerable populations comprise a substantial part of the total population, varying between 13% in Ghana to 27% in Burkina Faso.

For a more detailed analysis, Figure 36 to Figure 38 show the location of the nearly vulnerable, vulnerable and very vulnerable population in number of people per km2 affected. For comparison with the distribution of adults with low BMI, children with low weight and prevalence of diseases, Figure 39 and Figure 40 present the distribution of vulnerable and very vulnerable populations in terms of percentages of population.

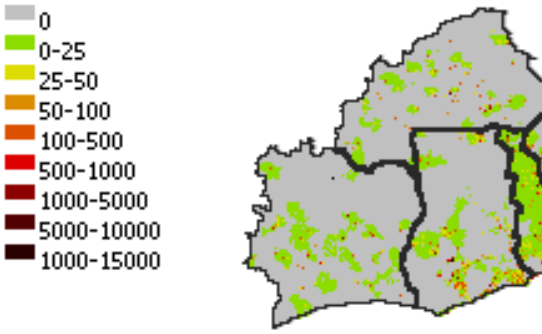


Figure 50 Nearly vulnerable persons/km2

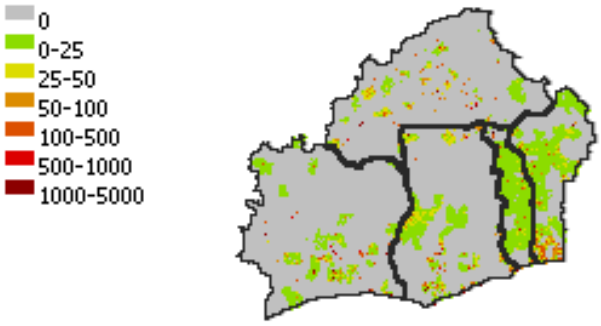


Figure 51 Vulnerable persons/km2

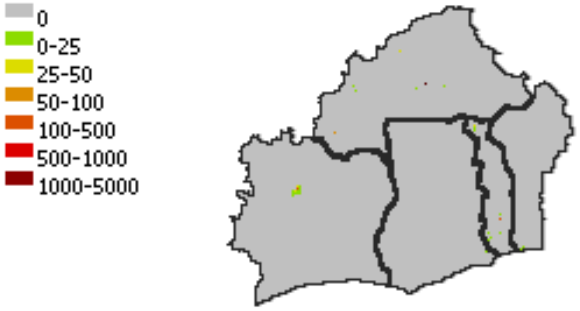


Figure 52 Very vulnerable population in persons/km2

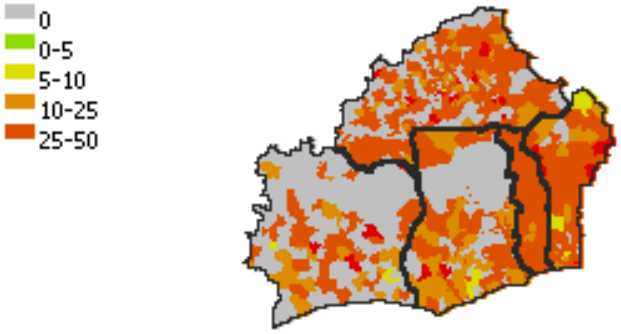


Figure 53 Nearly vulnerable population (%)

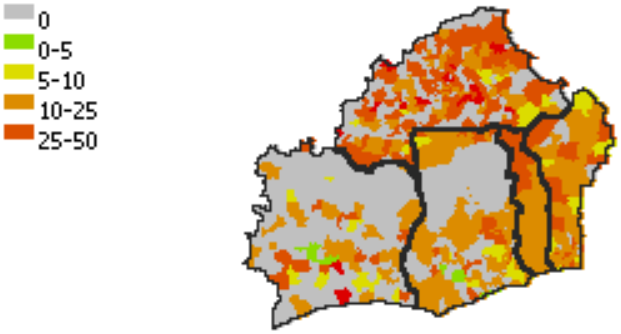


Figure 54 Vulnerable population (%)

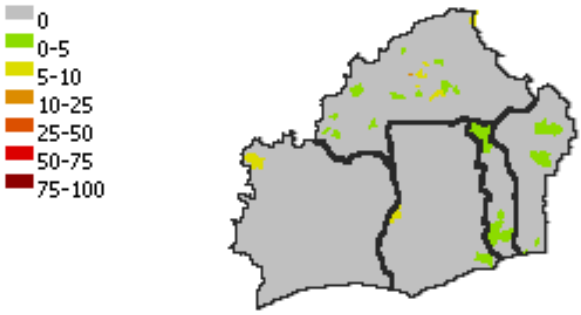


Figure 55 Very vulnerable population (%)

The next step is to check whether these areas also are identified as being vulnerable using the Afrobarometer dataset, with its indicator for vulnerability. First, Figure 42 shows the locations of the survey observations for the Afrobarometer data.

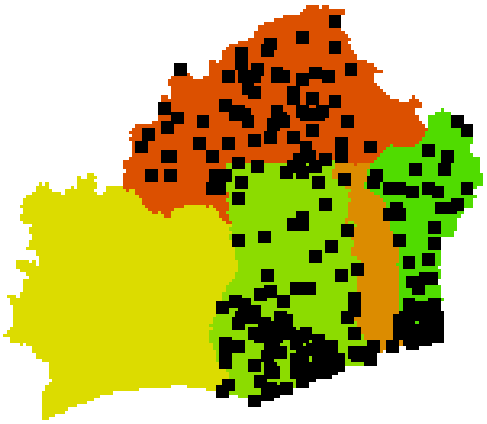


Figure 56 Survey points Afrobarometer

We compare the outcomes at country and region level, where it has to be noted that data are available only for Benin, Burkina Faso and Ghana. We interpret the answer: “always went without food” as being very vulnerable, “many times” as being vulnerable, “several times and once or twice” as nearly vulnerable, and “never” as not vulnerable. Table 9 summarizes the results.

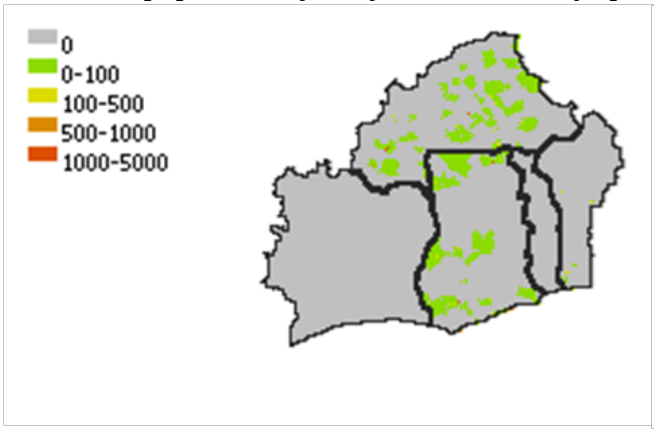
Table 11 Vulnerability of households in West Africa study area: Afrobarometer data

		Very vulnerable	Vulnerable	Nearly vulnerable	Not vulnerable
Total urban/rural	West Africa	8.6%	15.3%	28.7%	47.4%
	Benin	6.8%	16.1%	45.2%	31.9%
	Ghana	9.5%	10.8%	19.7%	60.0%
	Burkina	7.4%	23.5%	40.7%	28.4%

	Faso				
Urban	West Africa	11.0%	16.0%	25.4%	47.6%
	Benin	6.8%	10.5%	45.2%	37.5%
	Ghana	14.4%	13.7%	11.6%	60.3%
	Burkina Faso	5.2%	22.1%	49.2%	23.5%
Rural	West Africa	6.1%	14.7%	32.0%	47.2%
	Benin	6.8%	18.4%	45.2%	29.6%
	Ghana	3.7%	7.4%	29.3%	59.7%
	Burkina Faso	9.8%	25.0%	31.7%	33.5%

Note: results are population-weighted averages

Although the individual classes of very vulnerable and vulnerable differ substantially between the two surveys, taken jointly, the percentages are similar and the same holds for the classes of nearly vulnerable and vulnerable grouped together. Hence, the Afrobarometer data and the DHS based estimates seem to confirm the general picture of vulnerability. With respect to the location of the vulnerable and very vulnerable populations (Figure 43 and Figure 44), the most obvious difference is that there is more concentration in the location of the vulnerable population under the Afrobarometer estimates; especially in Benin, the difference is striking with only few hotspots in the Afrobarometer estimates and a nationwide coverage in DHS estimates. For Ghana and Burkina Faso, the differences are much less pronounced. For the very vulnerable populations, the DHS estimates are much lower and hence, there are less locations for that class than in the Afrobarometer estimates. In general we conclude that for vulnerable and very vulnerable populations jointly, the two surveys point to the same vulnerable areas.



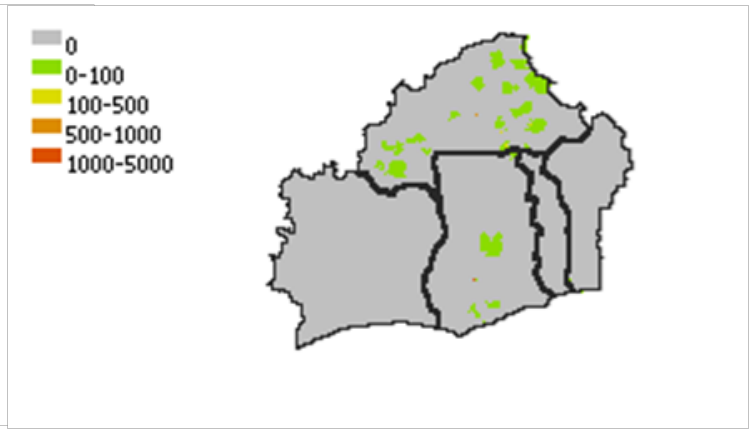


Figure 57 Vulnerable persons/km2 (Afrobar) Figure 58 Very vulnerable persons/km2 (Afrobar)

East Africa

Geo-referencing the data

For East Africa, geo-referenced data is available only for Uganda. Hence, to facilitate the combination of socio-economic data with data on location characteristics, the DHS survey data for Sudan and South Sudan have to be gridded using additional information on the households in the survey. For observations in rural areas, we use information on the amount of land in possession, the number of heads of cattle, and the number of heads of goats. Data is linked to grid-level data using as reference the distribution of Tropical Livestock Units, the location of irrigated areas, and the distribution of rural population. In five rounds of assignments, the 89495 observations have been geo-referenced. Within each administrative unit reported in the survey, the first round matches reported possession of cattle, goats and sheep to the Tropical Livestock Unit density per capita (30598 observations assigned); the second round distributed remaining households with positive land possession less than 100 ha in accordance with land suitability (45209 observations assigned); the third round places households with land possession over 100 ha in irrigated areas (45329 households assigned); the fourth round assigned the remaining households to locations with over 1000 inhabitants per km2 (84854 households assigned); while the remaining 4641 observations are assigned to the district capital. For urban households, we use the urban population map, and assign observations to the most populated urban areas in the administrative unit listed in the survey. This procedure leads to the distribution of observations over the area as in Figure 45.

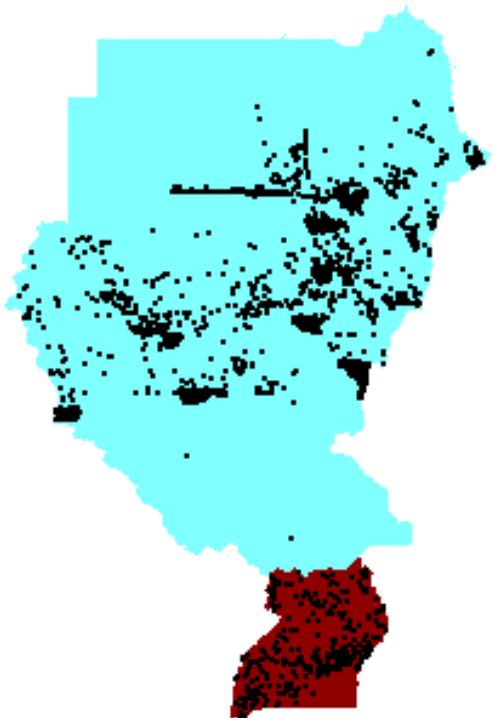


Figure 59 Location of observations

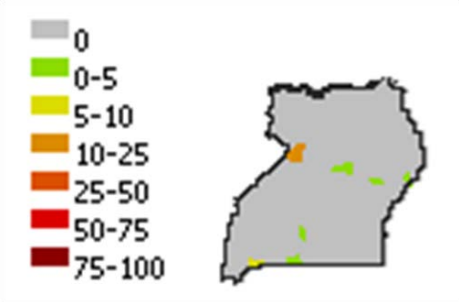
Results

Table 10 provides a summary of the results for BMI; unfortunately, data is only available for Uganda, where we conclude that the overwhelming majority of the adults have a BMI above the threshold value. Figure 47 and Figure 47 indicate where the adults with a BMI lower than 16 and adults with a BMI between 16 and 18.3 are located.

Table 12 Distribution of BMI in sample of households in Uganda

	BMI<16	16<=BMI<18.3	18.3<=BMI<18.6	BMI=>18.6
East Africa	0.8%	8.6%	3.8%	86.7%
Sudan	NA	NA	NA	NA
Uganda	0.4%	8.0%	3.5%	88.1%

Note: results are population-weighted averages



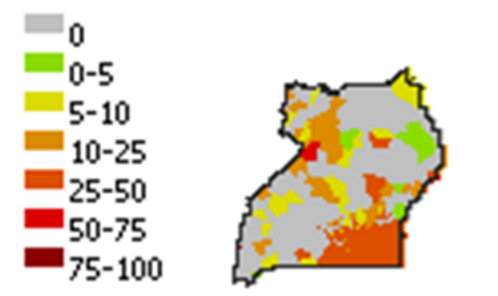


Figure 61 adults with a BMI <16 (%) Figure 62 adults with BMI of 16-18.3 (%)

For children, Table 11 and Table 12 provide the distribution of weight for age (a measure for long-term malnutrition) and weight for height (a measure for acute malnutrition), measured in deviations from the norm. We adopt here the same general interpretation as for West Africa. The first two columns indicate an insufficient nutritional status of the child, while the third column defines a situation of near sufficient nutritional status. In line with expectations, the situation of children is worse in Sudan than in Uganda for both indicators. Figure 49 and Figure 50 indicate where the children with a weight for age below -3sd and a norm weight between -2 and -3 sd are located in the region, while Figure 51 and Figure 51 show the same for weight for height.

Table 13 Distribution of weight for age in sample of household in East Africa study area

	w/a<-3sd	-3sd<=w/a<-2sd	-2sd<=w/a<0	w/a=>0
East Africa	15.5%	17.2%	43.7%	23.6%
Sudan	21.9%	18.5%	36.0%	23.4%
Uganda	4.5%	15.0%	56.8%	23.7%

Note: results are population-weighted averages

Table 14 Distribution of weight for height in sample of households in East Africa study area

	w/h<-3sd	-3sd<=w/h<-2sd	-2sd<=w/h<0	w/h=>0
East Africa	9.6%	10.4%	44.6%	35.4%

Sudan	14.4%	13.4%	39.4%	32.8%
Uganda	1.6%	5.1%	53.6%	39.8%

Note: results are population-weighted averages

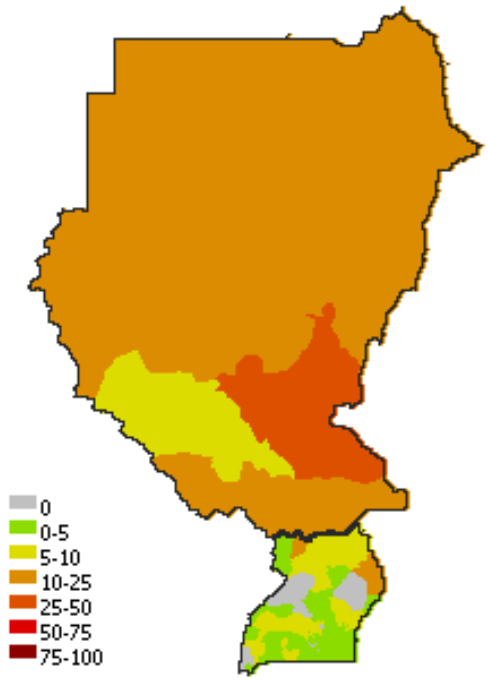


Figure 63 children with w/a < -3 sd (%)

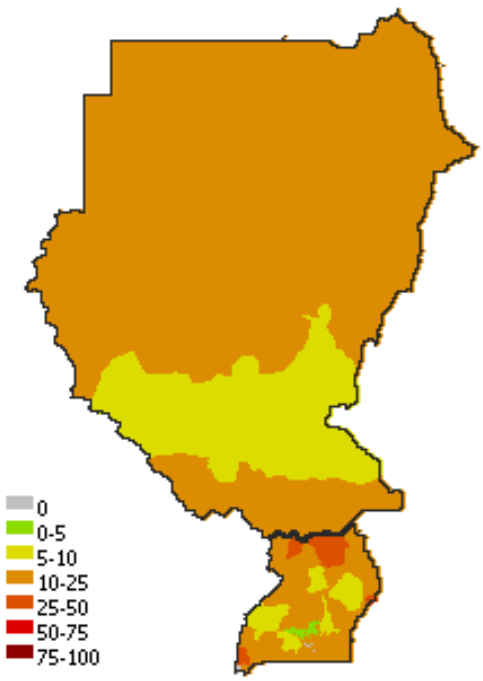


Figure 64 children with w/a of -2sd to -3 sd (%)

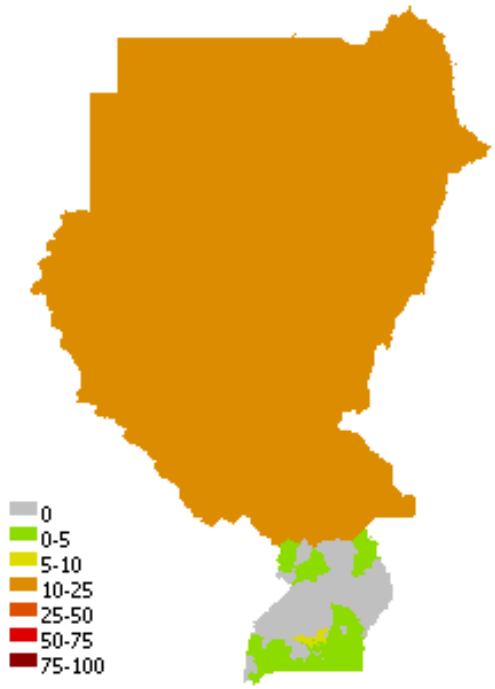


Figure 65 children with w/ h< -3 sd (%)

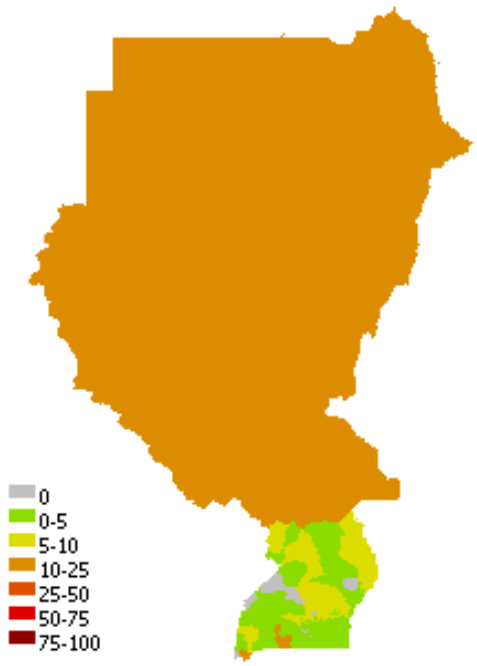


Figure 66 children with w/h of -2 sd to -3 sd (%)

Next, we include the data on the prevalence of malaria, cough and diarrhea in the two weeks prior to the survey, where we look at these tree diseases jointly and consider the simultaneity of prevalence as a single indicator (Table 13). In Uganda, more households report the prevalence of three diseases than in Sudan, while two diseases are reported by a fifth of the population in both countries. Figure 53 and Figure 53 show the location of households with 2 or 3 diseases.

Table 15 Prevalence of diseases in sample of households in East Africa study area

	All three	Two out of three	One out of three	None
East Africa	8.4%	19.1%	72.4%	0.0%
Sudan	4.0%	18.8%	77.1%	0.0%
Uganda	15.8%	19.5%	64.6%	0.0%

Note: results are population-weighted averages

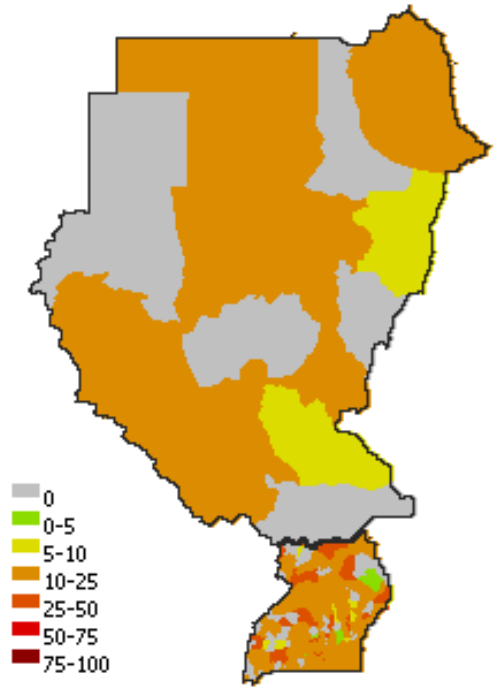


Figure 67 households with 2 diseases (%)

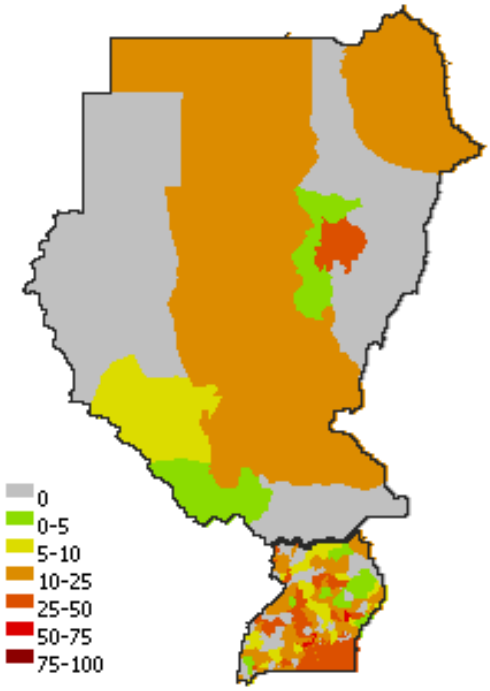


Figure 68 households with 3 diseases (%)

Table 14 summarizes the results at country and regional level. The difference between rural and urban vulnerability is clearly recognizable for the region as a whole and for the individual countries, with the share of very vulnerable rural households being much higher than for urban households, and the reverse holds for the share of non-vulnerable populations.

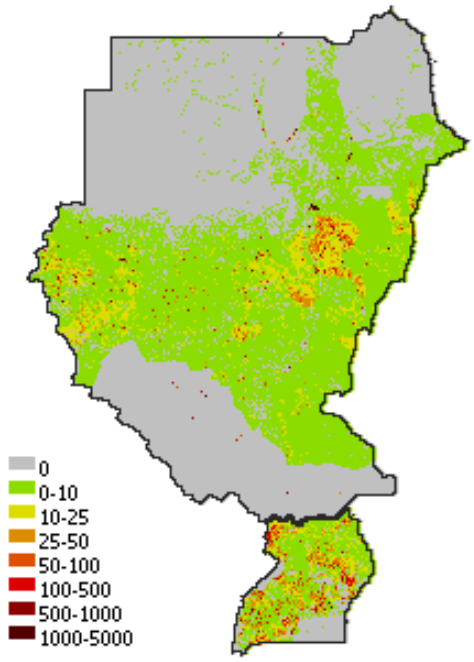
Table 16 Vulnerability of households in East Africa study area

		Very vulnerable	Vulnerable	Nearly vulnerable	Not vulnerable

Total urban/rural	East Africa	2.1%	37.2%	35.4%	25.2%
	Sudan	2.5%	37.1%	39.2%	21.2%
	Uganda	0.5%	37.6%	20.0%	41.9%
Urban	East Africa	0.4%	38.5%	30.3%	30.8%
	Sudan	0.7%	38.1%	39.7%	21.5%
	Uganda	0.0%	39.2%	13.8%	47.0%
Rural	East Africa	2.8%	36.7%	37.4%	23.1%
	Sudan	3.1%	36.8%	39.1%	21.0%
	Uganda	1.0%	36.1%	25.5%	37.4%

Note: results are population-weighted averages

Figure 55 to Figure 57 project the very vulnerable, vulnerable and nearly vulnerable population in persons per km2.



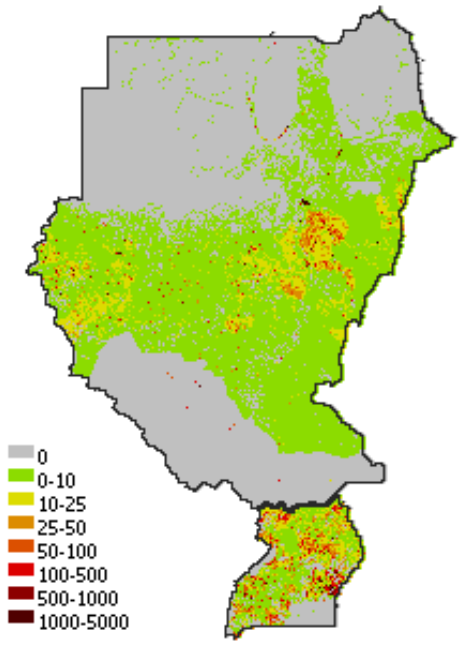


Figure 69 Nearly vulnerable persons/km2 **Figure 70 Vulnerable persons/km2**

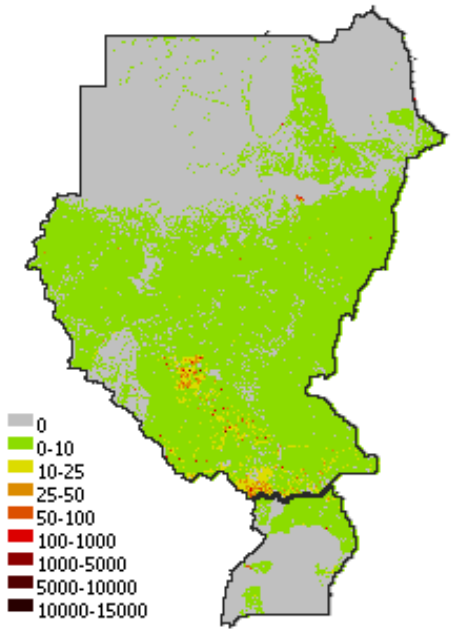


Figure 71 Very vulnerable persons/km2

The following figures (Figure 58 to Figure 60) complete the picture by displaying the percentages of the population that are vulnerable and very vulnerable. We note that the percentages are provincial averages.

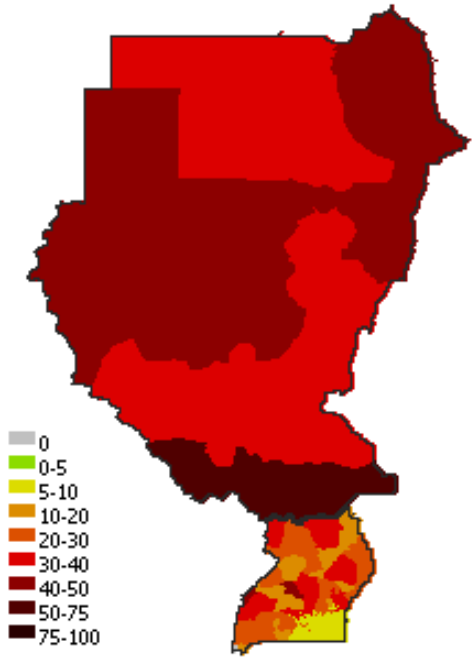


Figure 72 Nearly vulnerable population (%)

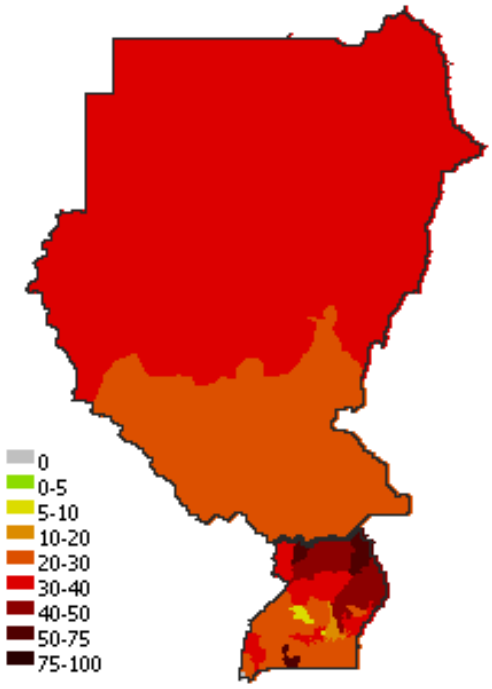


Figure 73 Vulnerable population (%)

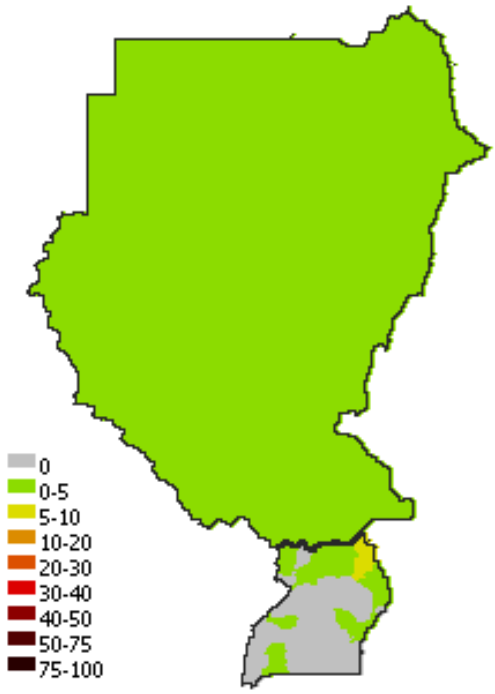


Figure 74 Very vulnerable population (%)

As for West Africa, the next step is to check whether these areas also are identified as being vulnerable using the Afrobarometer survey with its indicator for vulnerability.
First, we compare the outcomes at country and region level, where it has to be noted that data are available only for Uganda. We interpret the answer similar as in West Africa: “always went without food” as being very vulnerable, “many times” as being vulnerable, “several times and once or twice” as nearly vulnerable, and “never” as not vulnerable. Figure 61 shows the locations of the survey observations for the Afrobarometer data, and Table 15 summarizes the results.

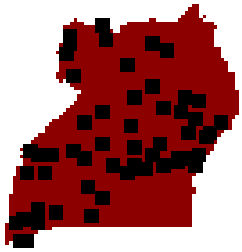


Figure 75 Survey points Afrobarometer

Table 17 Vulnerability of households in Uganda: Afrobarometer data

	Very vulnerable	Vulnerable	Nearly vulnerable	Not vulnerable
Total urban/rural	3.2%	6.3%	46.3%	44.2%

Urban	1.9%	3.9%	47.2%	46.9%
Rural	4.7%	9.4%	45.3%	40.6%

Note: results are population-weighted averages

It is clear that the Afrobarometer data provide a more positive image than the DHS based estimates, particularly in the classification of very vulnerable and vulnerable populations vis-à-vis near vulnerability. This lower estimate of vulnerability is probably largely caused by the absence of observations in the Karamojo region of Uganda, where the percentage of vulnerable households is very large. To check whether this is indeed the major explanation for the difference found, Figure 62 and Figure 62 provide the spatial dispersion of vulnerable and very vulnerable populations, to compare the locations with that of the DHS estimates.

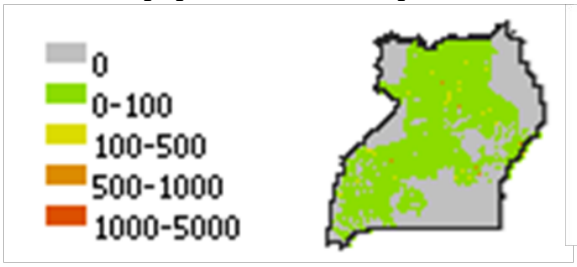


Figure 76 Vulnerable persons/km2

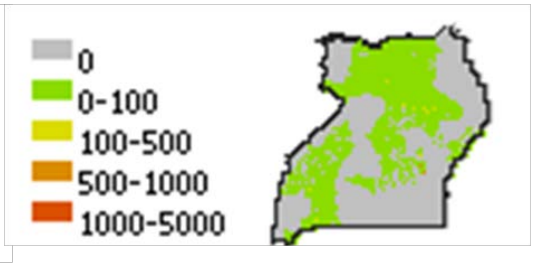


Figure 77 Very vulnerable persons/km2

For the regions that are included in both surveys, the location and magnitude of the vulnerable population is very similar, while for the very vulnerable share, more areas are included in the Afrobarometer estimates than in the DHS based ones, consistent with the higher share of very vulnerable households in the Afrobarometer data. Overall, we conclude that the differences between the two surveys can be explained largely by the absence of observations in the Afrobarometer survey in a vulnerable area (the Karamoja region).

12. Characterizing vulnerable populations

The next step is to characterize the nearly vulnerable, vulnerable and severely vulnerable populations in terms of socio-economic aspects. If the vulnerability situation is seen as an outcome, then socio-economic characteristics as well as biophysical aspects of locations can be considered as explanatory variables. Common explanatory variables named in the literature are the age and gender of the head of household, number of dependent household members, wealth index, education of adult household members, type of occupation, current working situation, and distance to markets. Furthermore, characteristics of the locality are included, indicating the suitability for crop growing and vulnerability of the area to climate change (current production in cereal equivalents per capita, Length of Growing Period (LGP), dominant land use, soil suitability, land degradation index, and an indicator map for irrigated agriculture). A Digital Elevation Map (DEM) and a slope map account for the vulnerability of an area for floods and run-off. Finally, we include the extent to which households are able to cope with adverse shocks as an additional characteristic. Coping mechanisms can include deliveries of food aid, the existence of household members sending remittances to the household, and integration in the community. On the negative side, discrimination on the basis of ethnic background or religion may increase the vulnerability of specific groups.

West-Africa

Estimating the wealth index

For West Africa, wealth index data is available for Burkina Faso and Ghana only, Therefore, before we proceed with the analysis of characteristics, we estimate the wealth index for households in Benin, Côte d'Ivoire and Togo. Rutstein and Johnson (2004) discuss the construction of the wealth index in DHS surveys, but do not propose a specific method, nor specific items that should always be included in the estimation. Rutstein (2008) comments on the methodology used by the DHS, and highlights the urban bias in the estimation of the index, yet, does not provide a specific method for estimating the wealth index. Hence, our approach is identifies the most common sets of associations of wealth quintiles with variables commonly associated with wealth that are available in all surveys. In Annex A, we list the combinations of assets, water source, toilet facility and flouring material that are associated with specific wealth quintiles, for rural and urban areas separately. Applying these associations to Burkina Faso and Ghana and comparing the predicted wealth quintiles with the actual reported ones gives a hit ratio of 80%, with under- and overestimation being 11% and 9%, respectively.

Table 18 Performance of estimated relation of wealth index for Burkina Faso and Ghana

	1 quintiles	2 quintiles	3 quintiles	4 quintiles	Total
Overestimation	4.7%	3.8%	0.8%	0.01%	9.3%
Underestimation	9.2%	1.5%	0.5%	0.005%	11.2%

Applying the estimated relation to Benin, Côte D'Ivoire and Togo provides the data for the wealth index that is subsequently used in the analysis of the characteristics of the vulnerable population.

Univariate analysis rural households: DHS

For rural areas, Figure 64 and Figure 65 summarize the main distinguishing characteristics of households, focusing on those that are particularly relevant for the very vulnerable (for a complete overview, see Annex B). For the very vulnerable, it follows that, on average, they are more likely to remain in the same residence, to receive no payments for work, have no education and are agricultural self-employed. They are much more likely to be employed as household and domestic servants, and have an older head of household. Very vulnerable households are more likely to have sons and daughters outside the households than any other class; implying that in times of need, they can call upon relatives outside their own location for assistance, which is one important transmission channel for (climate induced) hardship to spread over a larger area.

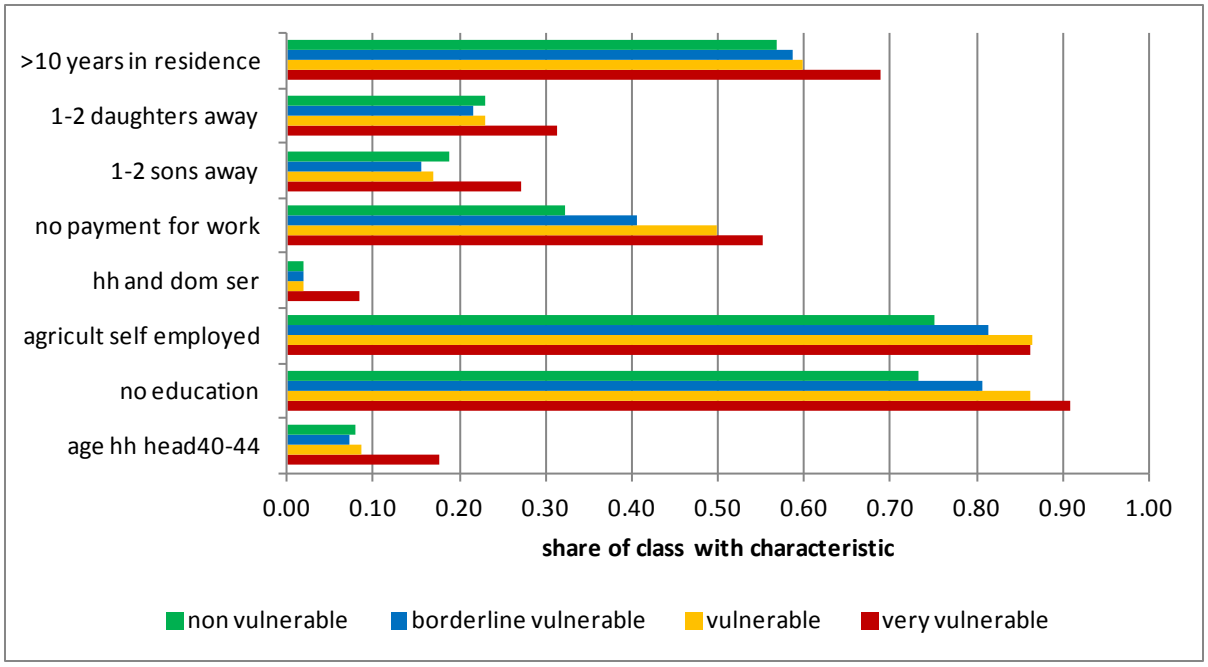


Figure 78 Socio-economic characteristics, rural areas

Special attention should be given here to the role of religion; whereas Islam is the religion of 48% of the very vulnerable households and 45% of the vulnerable ones, only 29% of nearly vulnerable households are Islamic and Islam is totally absent among the non-vulnerable ones. Non-vulnerable households are predominantly (50%) Protestant Presbyterian or Methodist (only 6% of very vulnerable have this religion) while nearly vulnerable are predominantly Roman Catholic (43% against 27% of very vulnerable households and non for vulnerable ones). It is difficult to interpret these outcomes, as they may point to discrimination of groups based on religion, but may also be associated with the geographical spreading of the vulnerable population.

Univariate analysis rural households: Agro-ecological indicators

The very vulnerable are more likely to be agro-pastoralists or working in mixed cereal-root crop systems. The areas where they live are very likely to be 50-75% grass and woodlands, with slopes between 5-8% with 20-40% of the area being characterized by constraints (Figure 65). Climatically, most very vulnerable households are located in dry sub-humid areas: while almost 65% of the very vulnerable live in these areas, the share of vulnerable households is 46%, that of the nearly vulnerable almost 40% and of the non-vulnerable households only 31% are located in these areas.

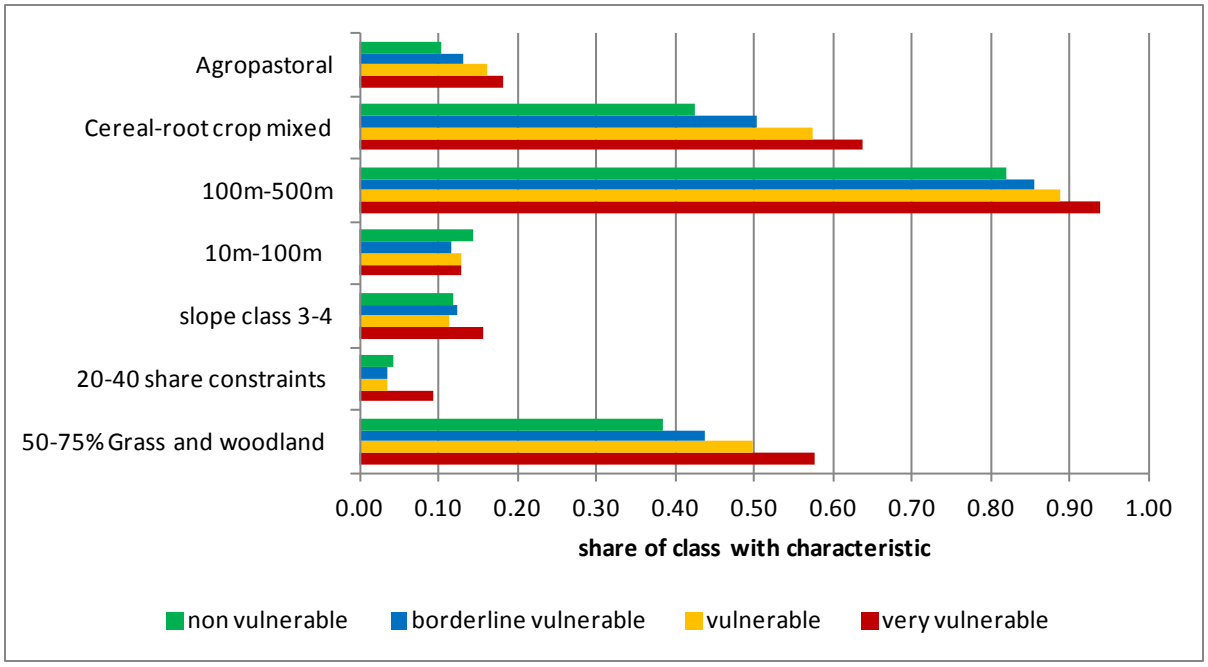


Figure 79 Farming systems and area characteristics, rural areas

Univariate analysis rural households: Afrobarometer survey

Additional insights into the characteristics of rural vulnerable populations may be obtained from the Afrobarometer survey, since data collected in this survey are partly complementary to that in the DHS. Again, the full analysis of the data is included in the Annex B of this report. For education and the age of the head of households, two variables included in both types of surveys, results are similar: more vulnerable populations are relatively less educated and have an older head of household. Whereas for the DHS surveys, no association could be found between vulnerability and wealth index, for the Afrobarometer data, self-reported perceptions on the economic situation are related to the vulnerability status: the more vulnerable the household is, the more likely it reports the economic situation as being very bad. The Afrobarometer survey also provides some support for ethnic discrimination: at least the perception of being treated unfair because of ethnic background is related to vulnerability status. In line with the DHS results on the number of sons and daughters away from home, remittances received by very vulnerable households are important. Very vulnerable households report more often than any other class in rural areas, including the non-vulnerable ones, to receive remittances at least once a year. As such this stresses the fact that local (climate) disasters may spread over a larger area through the use of social networks as coping mechanisms.

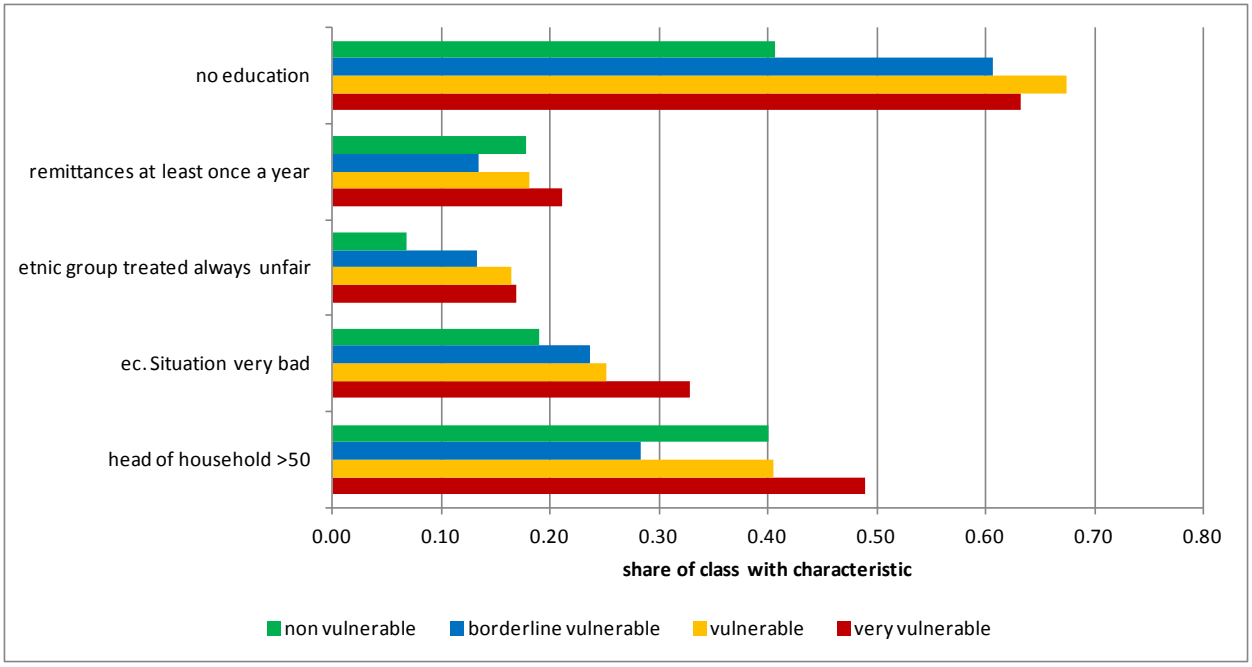


Figure 80 Socio economic characteristics rural population, Afrobarometer

Profiles rural households: results of joint analysis

As explained in section 4 above, DHS en Afrobarometer surveys can be jointly analyzed by appending estimated characteristics from one survey to the other, in this case from the Afrobarometer survey to the DHS. For this, we use the fact that there are common variables in the two surveys, notably the age of the head of household and the educational attainment, which allows the coupling of estimated associations of characteristics at province level to households in the same provinces included in the DHS surveys. Data on agro-ecological and climatic circumstances have been appended by geo-reference.

Since Afrobarometer data are available only for Benin, Ghana and Burkina Faso, we first report on the results for the region as a whole without including the estimates from the Afrobarometer survey, and then include these for the three countries for which they are available.

For the very vulnerable, there are two profiles that are equally likely when age of the head of household, education, occupation, payment for work, and farming system are included[3], both representing 9.5% of the total number of very vulnerable households. Table 17 summarizes these two "winning" profiles.

Table 19 top-2 profiles very vulnerable population, DHS and map data

Variable	Number 1	Number 2
Age head of household	25-30	20-24
Education	No education	No education
Occupation	Agricultural self-employed	Agricultural self-employed
Payment for work	Not paid	Not paid
Farming system	Cereal-root crop mixed	Cereal-root crop mixed

[3] Other potential variables suggested by the univariate analyses proved not to lead to distinctive differences between the very vulnerable, vulnerable and other groups.

This profile confirms the analysis above for education, occupation, payment for work and farming system. The age of head of household, however, is lower than suggested in the univariate analysis. For a coverage of half of the population, 7 profiles are needed (55% of very vulnerable in rural areas are then included; for a full description, see annex B). If we consider the profile based on the partial analysis, then Table 18 reports on the number of times the characteristics occur in the top-7 profiles. This confirms the top-2 analysis, except for the age of head of households, where older head of households are reported in 3 out of 7 profiles, confirming the earlier univariate analysis.

Table 20 Frequency of occurrence of characteristics in top-7 for very vulnerable

Characteristic	Times occurring in top-7
Age head of household 40-44	3
No education	7
Agricultural self-employed	6
Household and domestic services	1
No payment for work	5
Agro-pastoral millet	1
Cereal-root crops mixed	6

For the vulnerable population, there are two profiles that are almost equally likely when age of the head of household, education, occupation, payment for work, and farming system are included, 7.3%, 7.1% of the total number of vulnerable households, respectively. Table 19 summarizes these two "winning" profiles. As can be seen, the profiles of the vulnerable rural households and the very vulnerable are very similar for these characteristics. To check these results, we also include the frequency with which characteristics identified in the analysis of the very vulnerable also enter in the profiles of the vulnerable population for the 12 profiles that are required to describe 50% of the population (Table 20). From this it follows that the main difference between the profiles of the very vulnerable and the vulnerable rural population is the age of the head of household, with older heads being more associated with very vulnerable households, and the association with the agro-pastoral millet farming system, which is more pronounced among the vulnerable population.

Table 21 top-2 profiles vulnerable population

Variable	Number 1	Number 2
Age head of household	25-30	31-35
Education	No education	No education
Occupation	Agricultural self-employed	Agricultural self-employed
Payment for work	Not paid	Not paid
Farming system	Cereal-root crop mixed	Cereal-root crop mixed

Table 22 Frequency of occurrence of characteristics in top-12 for vulnerable

Characteristic	Times occurring in top-12
Age head of household 40-44	1
No education	12
Agricultural self-employed	12
Household and domestic services	0
No payment for work	9
Agro-pastoral millet	4
Cereal-root crops mixed	8

For Benin, Ghana and Burkina Faso, we include the estimates from the Afrobarometer surveys. For the very vulnerable population, no joint analysis is reported upon because the number of remaining observations is too low to draw any meaningful conclusions.

For the vulnerable population, there are two profiles that are equally likely when age of the head of household, education, occupation, payment for work, farming system, perceived economic situation, perceived ethnic discrimination and remittances received are included, each covering 10.6%, of the total number of vulnerable households. Table 23 summarizes these two "winning" profiles. In addition to the characteristics already identified above, the vulnerable households characterize their economic situation as fairly good or fairly bad, do not feel that their ethnic group is discriminated against, and receive no remittances. To check these results, we again include the frequency with which characteristics identified in the univariate analysis of the vulnerable enter in the profiles of the vulnerable population for the 6 profiles that are required to describe 50% of the population (Table 22). From this we may infer that being vulnerable is associated with having a young head of household, no education, being agricultural self-employed, within agro-pastoral millet or cereal root crops mixed farming systems, bad economic circumstances and little or no remittances from outside the households. Ethnic discrimination does not seem to figure as a distinguishing feature.

Table 23 top-2 profiles vulnerable population including Afrobarometer estimates

Variable	Number 1	Number 2
Age head of household	20-24	20-24
Education	No education	No education
Occupation	Agricultural self-employed	Agricultural self-employed
Payment for work	Not paid	Not paid
Farming system	Cereal-root crop mixed	Cereal-root crop mixed
Economic situation	Fairly good	Fairly bad
Ethnic group discriminated against	Never	Never
Frequency of received	Never	Never

remittances

Table 24 Frequency of occurrence of characteristics in top-6 for vulnerable population including Afrobarometer estimates

Characteristic	Times occurring in top-6
Age head of household 20-24	6
No education	6
Agricultural self-employed	6
No payment for work	5
Agro-pastoral millet	3
Cereal-root crops mixed	3
Economic situation bad	4 (and 1 very bad)
Ethnic group discriminated against	Never (1 occasional)
Never received remittances	5 (1 less than once a year)

Concluding remarks on rural West Africa

Very vulnerable and vulnerable households are characterized by a lack of education, lack of payment for work, and a concentration in agro-pastoral millet and cereal-root crops farming systems. Including Afrobarometer data reveals that vulnerable households perceive their economic situation as bad or very bad and never or only occasionally receive remittances. Near-vulnerable populations differ mainly in their more positive perception of their economic situation, and more frequent remittances (although still,5 of the top-7 profiles report no remittances).

Non vulnerable populations are paid more often than near-vulnerable populations, and report even more positive on their economic situation.

Univariate analysis urban households: DHS

For urban areas, the main distinguishing socio-economic characteristics of households are summarized in Figure 67 (in Annex B, the full analysis of variables is included). Since the share of the very vulnerable in urban areas is very low, we do not include this class in the analysis. In contrast to the findings for the rural population, for urban areas, a clear association is found between vulnerability and the wealth index, with the poorest quintile being overrepresented in the class of vulnerable households. As for rural households, the share of uneducated persons is higher among vulnerable households, not being paid for services provided is also more frequently reported among this class, and vulnerable households are more likely to have lived longer in the present place of residence. Combined with the higher share of the vulnerable that reports to be agriculturally self-employed, this may point to the fact that the urban vulnerable live in the outskirts of the cities without many opportunities to move to more profitable occupations: less vulnerable households are more engaged in sales and the non-vulnerable ones also in services.

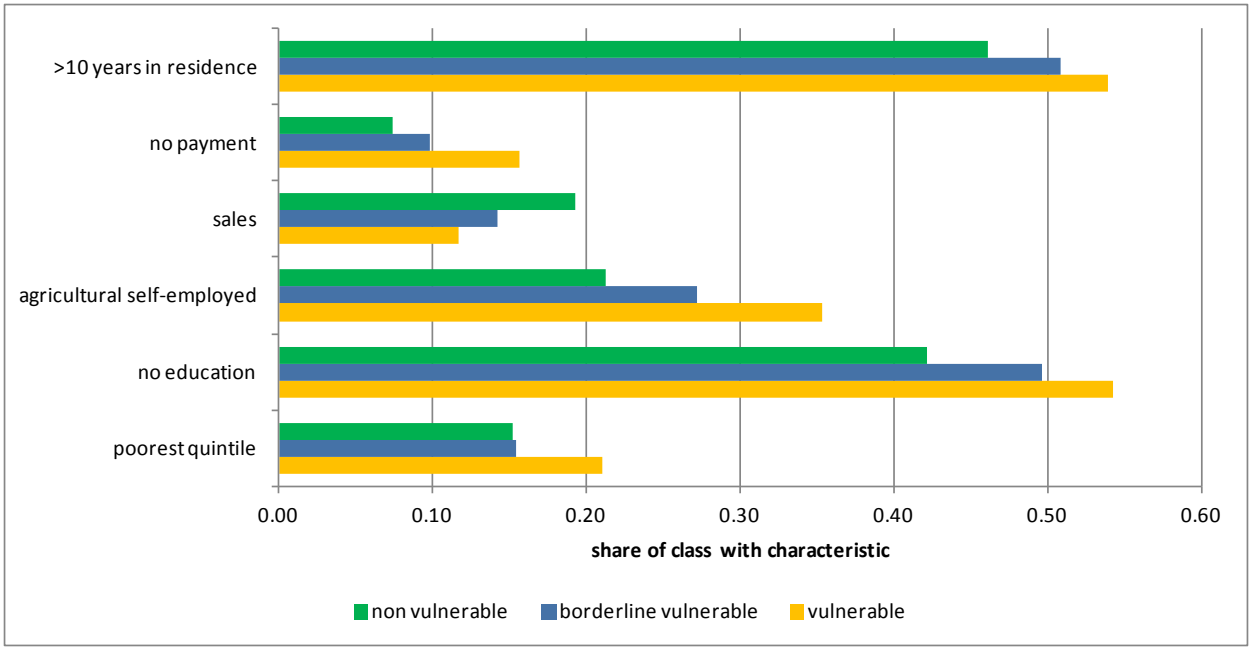


Figure 81 Socio economic characteristics, urban population

Again, we pay special attention to the role of religion; similar to rural areas, vulnerable populations are much more likely to report Islam as their religion (65% of vulnerable households report to be Islamic, against 44% of nearly vulnerable and non-vulnerable households). As for rural areas, this result may point to discrimination of groups based on religion, but any interpretation must be done with care.

For urban households, the impact of local circumstances is much less pronounced than for rural ones, and hence, we do not include local characteristics in the profile for urban households.

Univariate analysis urban households: Afrobarometer survey

As for the urban populations, additional insights may be obtained from the Afrobarometer data. Again, complete analysis of the data is included in Annex B. For education and the age of the head of households, two variables included in both types of surveys, results are similar: more vulnerable populations are relatively less educated and have an older head of household. Self-reported perceptions on the economic situation are related to the vulnerability status, similar to the relation between wealth quintiles and vulnerability in the DHS. The Afrobarometer survey also provide some support for ethnic discrimination: at least the perception of being treated unfair because of ethnic background is related to vulnerability status. In contrast to rural areas, remittances received by vulnerable households are less frequent than those received by less vulnerable ones, indicating that urban poor do not have access to a large social network in times of need.

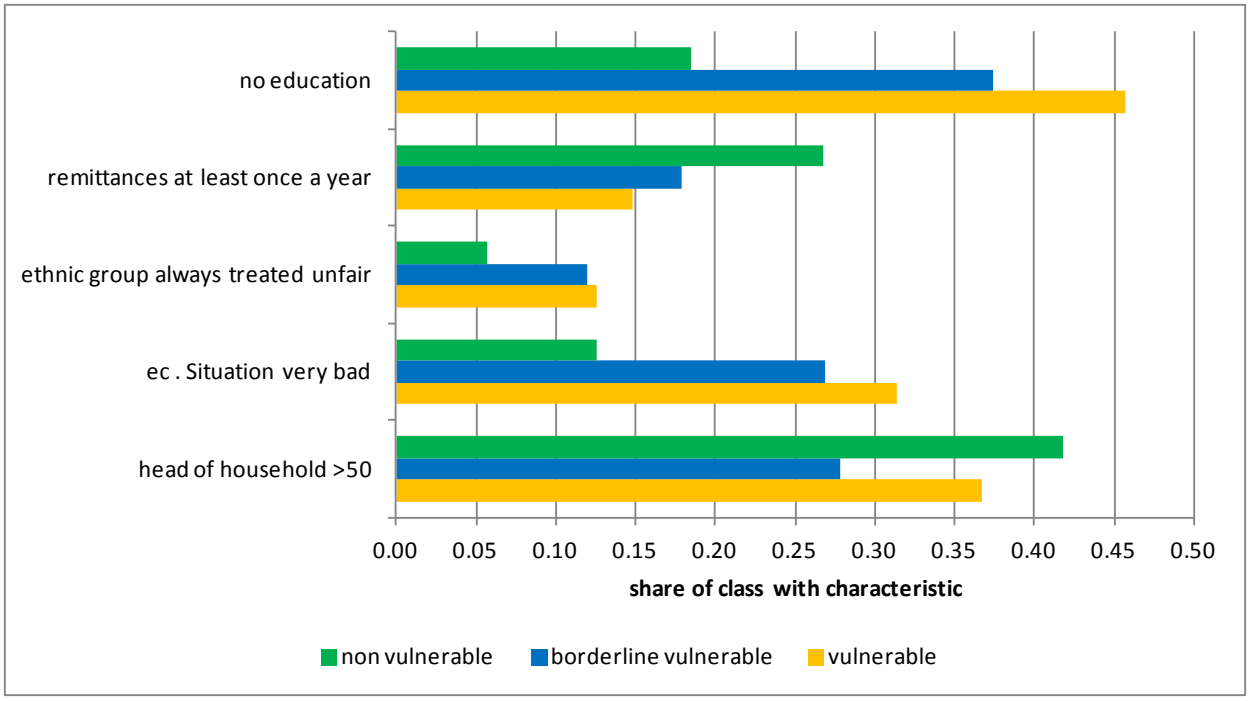


Figure 82 Socio economic characteristics urban population Afrobarometer data

Profiles urban households: results of joint analysis

For the vulnerable urban populations, the final step is to check whether the associations found indeed distinguish these populations from other ones. For this group, the most common profile (characterizing 6.2% of the class) and the runner up (2.7% of the class) are summarized in Table 23. The table confirms the characteristics of the vulnerable urban households for the time lived in the current residence, occupation, and education. However, for the wealth quintile, results for the top-2 profiles do not confirm the findings in terms of relative frequencies, and for payments received for work, the result is ambiguous.

Table 25 top-2 profiles vulnerable population

Variable	Number 1	Number 2
Wealth quintile	Middle	Middle
Education	None	None
Occupation	Agricultural self-employed	Agricultural self-employed
Payment for work	Cash only	None
Lived in residence	more than 10 years	more than 10 years

For the vulnerable population, 36 profiles are needed to cover 50% of the population. Table 24 presents the number of times the characteristics of the top-2 profiles or the analysis appear in this set of profiles. From the table, we conclude that the “poorest”, “poorer” and “middle” wealth quintiles characterize a large part of the vulnerable in terms of wealth. A large majority of the top-36 profiles has no education, half is agricultural self-employed, and the majority of

households receive cash for work. Finally, for the time lived in the residence, the earlier results are confirmed.

Table 26 Frequency of occurrence of characteristics in top-36 for vulnerable

Characteristic	Times occurring in top-36
Wealth quintile poorest or poorer	16
Wealth quintile middle	13
No education	25
Agricultural self-employed	18
No payment for work	5
Cash payment for work	22
Lived in residence more than 10 years	24

For Benin, Ghana and Burkina Faso, we may include the estimates from the Afrobarometer surveys.

For the vulnerable population, the "winning" profile covers 14% of the vulnerable urban population, while all other profiles are equally likely (covering 7.2% of the population). Hence, there is no clear "runner up" that characterizes the urban vulnerable, and we report here only on the frequencies with which characteristics identified in the univariate analysis of the vulnerable enter in the profiles of the vulnerable population for the 6 profiles that are required to describe 50% of the population (Table 25).

From this we may infer that being vulnerable is associated with having no education, receiving cash payments for work, having lived in the current residence for a long time, and receiving no remittances (or only limited remittances) from outside the household. Near-vulnerable households distinguish themselves mainly by being more occupied as skilled manual laborers, living less long in the present residence, and having a more positive report on their economic situation. Finally, non-vulnerable households more often occupied as skilled manual laborers, but also as managers and in services. For all classes, remittances are hardly ever received, which confirms the idea that remittances largely flow from urban areas to rural ones.

Table 27 Frequency of occurrence of characteristics in top-6 for vulnerable population including Afrobarometer estimates

Characteristic	Times occurring in top-6
Wealth quintile poorest or poorer	1
Wealth quintile middle	4
No education	5
Agricultural self-employed	3
Skilled manual	1
No payment for work	0
Cash payment for work	5
Lived in residence more than 10 years	5
Economic situation bad (very bad)	1 (2)
Ethnic group discriminated against	Never (5), occasionally

	(1)
Never received remittances	4

Concluding remarks on urban West Africa

Vulnerable households are characterized by a lack of education, and being located in their current residence for a long time, Combined with the higher share of the vulnerable that reports to be agriculturally self-employed, this may point to the fact that the urban vulnerable live in the outskirts of the cities without many opportunities to move to more profitable occupations. This is confirmed by the fact that near-vulnerable populations differ mainly in the occupation, with skilled labor being much more common in this group than among the vulnerable one, and by being more flexible in moving from one residence to another. Non vulnerable populations are occupied as skilled laborers, but also as managers and active in the services sector.

Results: East-Africa

Univariate analysis rural households: DHS

For rural areas, Figure 69 summarizes the main distinguishing socio-economic characteristics of the rural population in East Africa (a full analysis of the dataset is included in the Annex B). It follows that the most vulnerable group is also the poorest one, the least educated and the one with the least sure employment. They are more likely than other groups to have daughters away from home, which could point to daughters working as housemaids in urban areas or abroad. Furthermore, a very high share of the very vulnerable households is agricultural self-employed. On average, the very vulnerable are less rooted in their current residence. The combination of characteristics could point to the fact that part of this population consists of internally displaced persons or refugees, but there is no data in the survey available to corroborate this hypothesis.

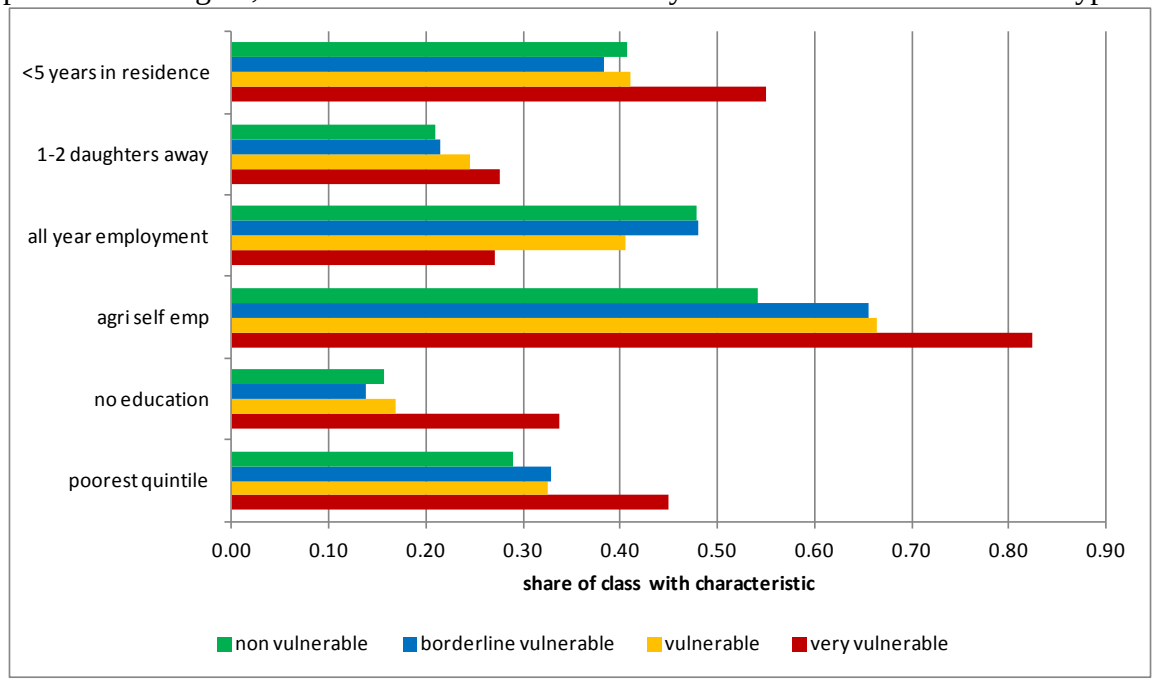


Figure 83 Socio economic characteristics, rural population

Univariate analysis rural households: agro-ecological indicators

The very vulnerable are much more likely to be located in sub-humid arid areas with 14.5% of living in these areas - for the vulnerable, this is 8%, while it is even lower for the nearly vulnerable and non-vulnerable rural households (7% and almost 6%, respectively). In addition, the very vulnerable are more likely to be located in areas covered for more than 75% with grass and woodland than other groups, and are more likely than vulnerable and nearly vulnerable populations to be in the maize-mixed farming system (Figure 70)

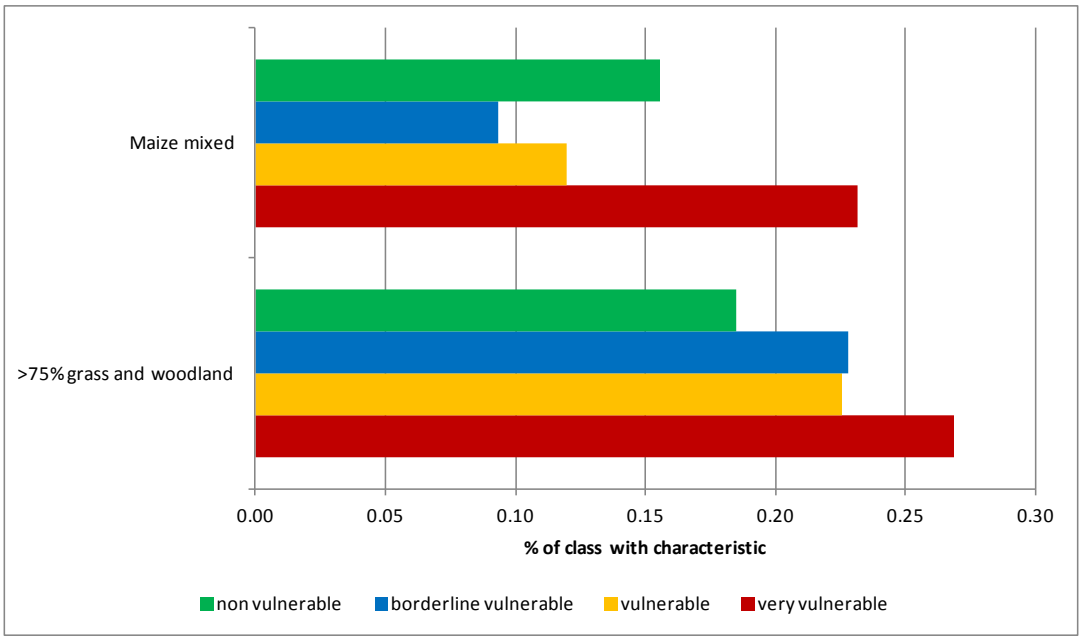


Figure 84 Biophysical and farm system characteristics, rural population

Univariate analysis rural households: Afrobarometer survey

For Uganda, the Afrobarometer survey may provide additional insights into the characteristics of the rural vulnerable and very vulnerable population (Figure 71).

Low education and a relatively old head of household characterize vulnerable and very vulnerable populations. In addition, the self-reported economic status is associated with vulnerability similar to the association with wealth quintiles in the DHS. The limited involvement of the very vulnerable in religious or community groups could again point to fact that these households are internally displaced persons or refugees, although data on this is not available in the Afrobarometer survey.

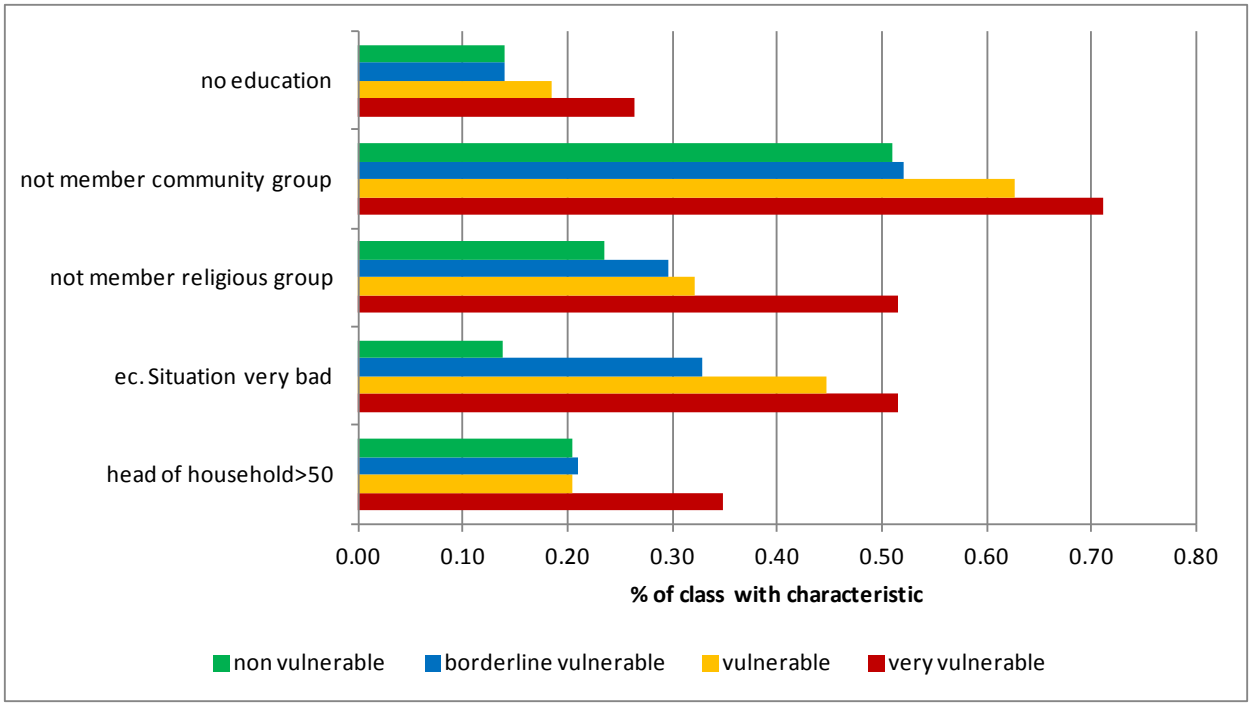


Figure 85 Socio economic characteristics, rural population, Afrobarometer

Profiles rural households: results of joint analysis

For the very vulnerable and vulnerable rural populations, the final step is to check whether the associations found indeed distinguish these populations from other ones. For the very vulnerable, the most common profile (characterizing 9.9% of the class) and the runner up (4.5% of the class) are summarized in Table 26. The poorest quintile is represented in the profile of the runner-up, but not in the winning one; education levels are low, the very vulnerable are agricultural self employed or are engaged in professional technical management; employment is less secure in the top-2 than the above analysis suggests, and results on the number of daughters from home and the time lived in the current residence are not conclusive. Dry sub-humid areas are included in the top-2 profiles, but the land use in both cases differs from than identified in the analysis above. The very vulnerable are either involved in maize-mixed farming, or are pastoralists, which is in line with expectations, but did not directly follow from the analysis above.

Again, we consider the top profiles that jointly describe 50% of the relevant population. Table 27 presents the frequency of occurrence of the characteristics identified as being relevant for very vulnerable households for the 9 profiles needed. From this, it follows that the very vulnerable are in the poorest wealth quintile, have no or incomplete primary education, are agricultural self employed or (often) unemployed, and if employed, the employment is seasonal or occasional. They have at least 1 or more daughters away from home, and predominantly have lived in the current residence less than 5 years. They reside in arid sub-humid areas, which are either grasslands or largely cultivated, and are either engaged in maize-mixed farming or pastoralists. As before, we note that many of these characteristics could point to the fact that at least part of the very vulnerable population are internally displaced persons or refugees.

Table 28 top-2 profiles very vulnerable population

Variable	Most frequent	Runner up
Wealth quintile	Richer	Poorest
Education	Incomplete primary	None
Occupation	Agricultural self employed	prof tech manag
Employment type	Occasional	Occasional
Number of daughters elsewhere	3-4	1-2
Lived in residence	1-5 years	>10 years
LGP	270-365	120-180
Land use	50-75% Cultivated land	50-75% Cultivated land
Farming system	Maize mixed	Pastoral

Table 29 Frequency of occurrence of characteristics in top-9 for very vulnerable

Characteristic	Times occurring in top-9
Poorest wealth quintile	6
Incomplete primary education	5
No education	3
Agricultural self-employed	7
Unemployed	1
Occasional work	2 (7 seasonal)
1-2 daughters elsewhere	5
3-4 daughters elsewhere	2
Lived in residence between 1 and 5 years	5 (2 less than 1 year)
Lived in residence more than 10 years	2
LGP between 270-365	1
LGP between 120-180	5
Land use: 50-75% cultivated land	3
Land use: >75% grass and woodland	4
Maize mixed farming system	9
Pastoralist farming system	1

For the vulnerable population, education, occupation, LGP, duration of work, LGP, land use, and farming system are included, based on the univariate analysis (see annex A for the presentation of the complete results for the univariate analysis). It follows that they are lowly education, agricultural self-employed, and are located in maize mixed farming systems (see Table 28 that summarizes the characteristics included in top-2 profiles, which cover 6.9% and 4.3% of the vulnerable rural population). An analysis of the frequency with which characteristics occur in the top-27 profiles for vulnerable households (50% of class) reveals that the picture of the top-2 is largely confirmed, although the association with LGP and land use is less clear.

Table 30 top-2 profiles vulnerable population

Variable	Most frequent	Runner up
Education	Incomplete primary	Incomplete primary
Occupation	Agricultural self employed	Agricultural self employed
Duration of work	Occasional	Occasional
LGP	180-270	270-360
Land use	50-75% Grass and woodland	50-75% Cultivated land
Farming system	Maize mixed	Maize mixed

Table 31 Frequency of occurrence of characteristics in top-27 for vulnerable

Characteristic	Times occurring in top-27
Incomplete primary education	17
No education	9
Agricultural self employed	20
Occasional work	25
LGP between 180-270	9
LGP between 270-360	14
Land use: 50-75% cultivated land	9
Land use: 50-75% grass and woodland	7
Maize mixed farming system	12

For Uganda, estimates from the Afrobarometer data are appended to the DHS data for a joint analysis. In the joint analysis, education, employment duration, farming system, economic situation, membership of religious organizations and membership of community organizations were included – other variables suggested in the univariate analysis did not provide additional differentiation between the different vulnerability groups. Since there are too few observations for very vulnerable groups in the joint analysis, we only report on vulnerable groups here. For this group, the most common profile (characterizing 7.6% of the population) and the two "runners up", each characterizing 6.1% of the class are summarized in Table 30. The winning profile is characterized by low education, a fairly bad economic situation, isolation within the community and relatively safe employment, while the numbers 2 and 3 provide a mixed picture of these characteristics. Hence, we also consider, as before, the frequency with which observed characteristics in the top-3 appear in the 12 profiles needed to cover 50% of the vulnerable household class. From this, we infer that the rural vulnerable population is characterized by low education, occasional employment, a fairly bad economic situation, low involvement in the community, but a fairly high involvement in religious groups. This implies that the network of the rural vulnerable appears to be mainly associated with a common religious background.

Table 32 top-3 profiles vulnerable population including Afrobarometer estimates

Variable	Most frequent	Number 2	Number 3
Education	Incomplete primary	Incomplete secondary	Incomplete primary
Duration of employment	All year	occasional	All year
Farming system	Cereal-root crops mixed	Cereal-root crops mixed	Cereal-root crops mixed
Economic situation	Fairly bad	Fairly good	Fairly good
Member religious group	Not a member	Active member	Active member
Member community group	Not a member	Active member	Active member

Table 33 Frequency of occurrence of characteristics in top-12 for vulnerable including Afrobarometer estimates

Characteristic	Times occurring in top-12
Incomplete primary education	6 (2 no education)
Incomplete secondary education	2
All year employment	3
Occasional employment	8
Cereal-root crops mixed farming system	12
Fairly bad economic situation	8
Fairly good economic situation	4
Not a member religious group	4
Active member religious group	6 (2 inactive member)
Not a member community group	7
Active member community group	5

Concluding remarks on rural East Africa

From this, it follows that the very vulnerable are in the poorest wealth quintile, have no or incomplete primary education, are agricultural self-employed or (often) unemployed, and if employed, the employment is seasonal or occasional. They have at least 1 or more daughters away from home, and predominantly have lived in the current residence less than 5 years. They reside in arid sub-humid areas, which are either grasslands or largely cultivated, and are either engaged in maize-mixed farming or pastoralists. Vulnerable households are largely agricultural self-employed. They have no daughters outside the households, they have lived relatively long in the current residence, in maize-mixed farming systems.

For Uganda, we combined the DHS survey data with estimates from the Afrobarometer and find that the rural vulnerable population is characterized by low education, occasional employment, a fairly bad economic situation, low involvement in the community, but a fairly high involvement in religious groups. The main difference with nearly vulnerable households is that they are better educated, and more often have all year employment. In addition, these households depend less

on religious communities as they are equally involved in community groups or religious groups. Non-vulnerable households in Uganda are even higher educated, report a better economic situation and are equally involved in community and religious groups.

Univariate analysis urban households: DHS survey

For urban areas, Figure 72 summarizes the main distinguishing socio-economic characteristics of the urban population in East Africa (a full analysis of the dataset is included in the Data Annex to this report). We only report results for the vulnerable, the nearly vulnerable and non-vulnerable population here, since the sample of very vulnerable urban households is very small. It follows that for urban areas, the vulnerable group has a very young head of household (younger than 19). The vulnerable are less likely to have sons outside the household, which partly is related to the age of the head of households. A very high share of the vulnerable households reports "sales" as the major occupation. Although the vulnerable report to be employed more often than nearly vulnerable households, they receive no payment for the work done in a much higher share of the cases. The combination of very young heads of households with the employment characteristics leads us to conclude that the vulnerable urban population has very little power in the labor market, and can be easily abused, which is to some extent corroborated by the fact that, on average, the vulnerable are less rooted in their current residence than less vulnerable classes.

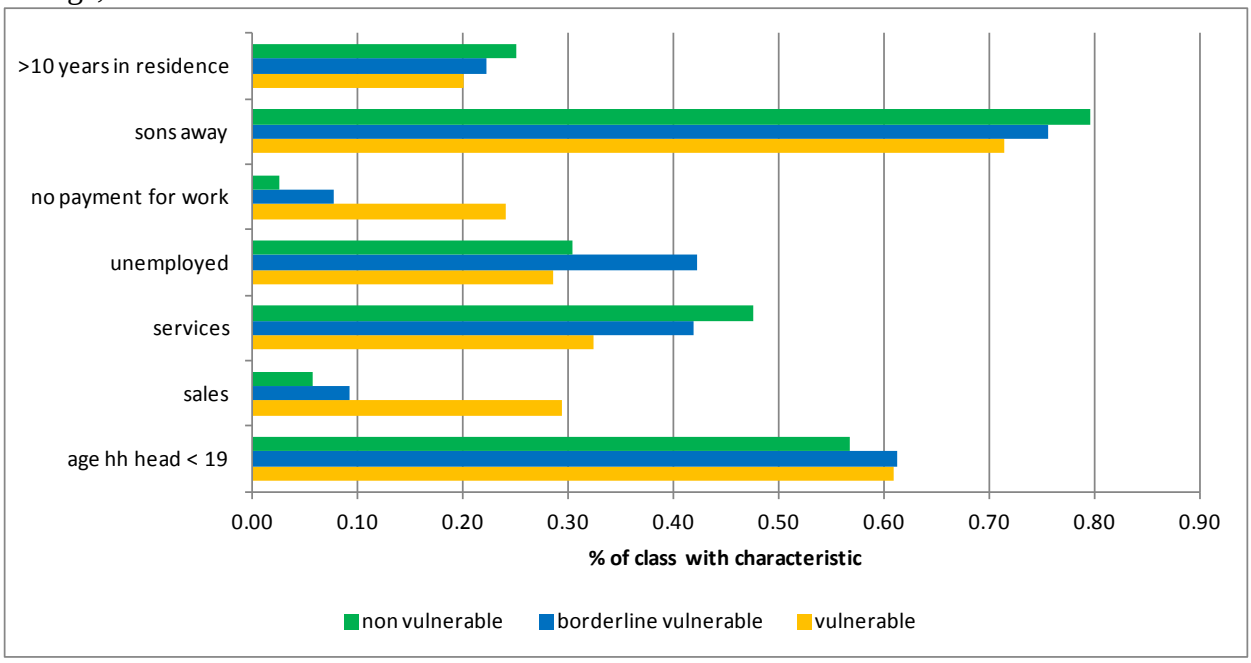


Figure 86 Socio economic characteristics, urban population

For urban households, the impact of local circumstances is much less pronounced than for rural ones, and hence, we do not report on these characteristics here.

Univariate analysis urban households: Afrobarometer survey

For Uganda, the Afrobarometer survey may provide additional insights into the characteristics of the urban vulnerable population (Figure 73)

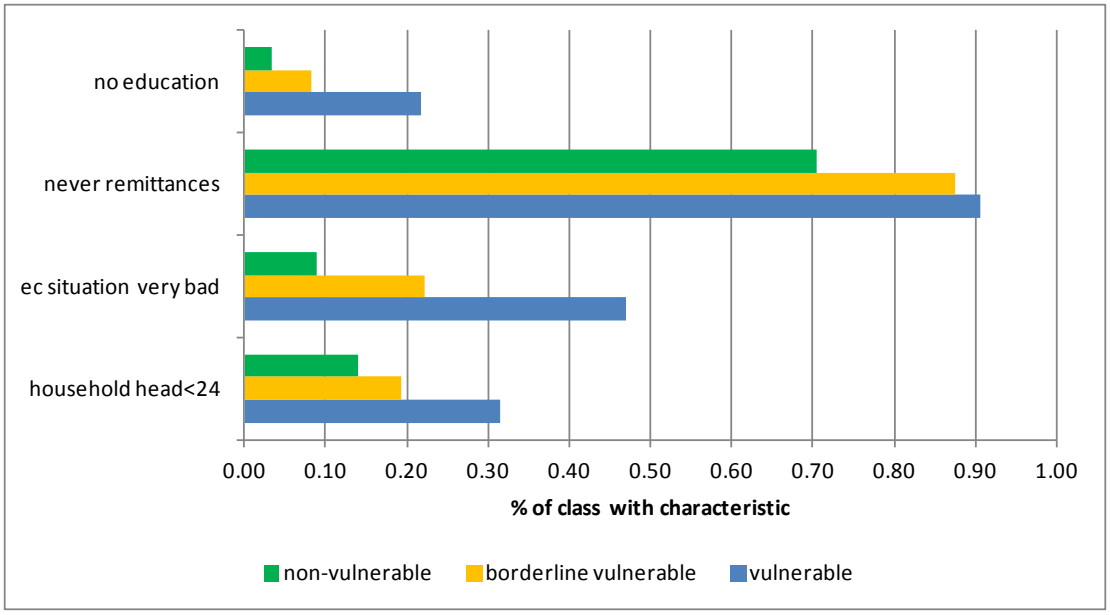


Figure 87 Socio-economic characteristics, urban population, Afrobarometer

A relatively young head of household characterizes vulnerable populations. In contrast to the DHS-based analysis, in the Afrobarometer survey, a clear connection with educational levels and self-reported economic status is found, which was not present in the DHS data. The results on remittances highlight the fact that the vulnerable population cannot rely on an external network to cope with shocks.

Profiles urban households: results of joint analysis

For the vulnerable urban populations, the final step is to check whether the associations found indeed distinguish these populations from other ones. For this group, the most common profile (characterizing 8.3% of the class) and the runner up (also 8.3% of the class), Table 32 summarizes the characteristics. The table confirms the characteristics of the vulnerable urban households for the number of sons away, the time lived in residence, the occupation, and that no payment is received for work. For the age of head of household, the results are markedly different.

Table 34 top-2 profiles vulnerable population

Variable	Most frequent	Runner up
Age of household head	35-39 years	25-29
Occupation	Sales	Sales
Payment for work	No payment	No payment
Sons away	1-2	None
Lived in residence	< 1 year	1-5 years

For the vulnerable population, 9 profiles are needed to cover 50% of the population. Table 33 presents here the number of times the characteristics of the top-2 profiles or the analysis appear in this set of profiles. From the table, we conclude that the age of head of household is not a determining factor. Occupation in sales, receiving no payments for work, having no or few sons

away from home, and being relatively new in the residence are factors that characterize the vulnerable households in urban areas.
Joint analysis of DHS and Afrobarometer data is not reported upon here, since the number of observations for the vulnerable population was too low.

Table 35 Frequency of occurrence of characteristics in top-9 for vulnerable

Characteristic	Times occurring in top-9
Age of household head 35-39	2 (3 40-44)
Age of household head 25-29	2
Sales	4
No payment for work	2 (5 cash only)
No sons away	3 (1-2 sons, 6)
Lived in residence < 1 year	1
Lived in residence 1-5 years	6

Concluding remarks on urban East Africa

From the above analysis, we conclude that occupation in sales, receiving no payments for work, having no or few sons away from home, and being relatively new in the residence are factors that characterize the vulnerable households in urban areas. Nearly vulnerable households are more often occupied as unskilled or skilled manual workers and almost always receive cash or kind payments for work. Their sons live at home and they are much more rooted in their communities than vulnerable households. Non-vulnerable households are occupied predominantly as skilled manual laborers, but also are employed as managers. They are always paid (almost always in cash), their sons live at home and they are mobile with respect to their residence.

13. Climate disasters: preliminary discussion of possible hotspots

This section presents a preliminary assessment of the degree of vulnerability of crop production for climate change and its spatial extent for the two study areas. The possible effects that climate change can have on land productivity and, consequently, livelihoods, calls for an attentive preparedness in terms of knowledge on which areas will be most vulnerable and what in such cases appropriate mitigation and adaptation strategies may be. Such knowledge can be gained by starting from the baseline climate (current conditions) and then apply the deviations as produced by General Circulation Models (GCM), followed by a comparison of crop suitability and land productivity in both cases. In the following we therefore discuss the nature of GCM's, their outcomes in terms of possible climate change events and the implications that follow for the present study. At this stage in this project GCM outcomes are yet to be produced and, therefore, we use a stylized approach of climate change events, merely to get a feel of what the impact of climate change can be and which areas are likely to be most vulnerable. Quite naturally any impact of climate change is strongly dependent both on the kind of climate change event and on current climatic conditions. Next, we discuss the various aspects in which agricultural production may be affected by climate change, either negatively or positively, as depending on current

climatic conditions. Based on this, stylized climatic change events will be defined and their implications will be assessed again in dependency on current climate conditions. Because of the preliminary nature of this study, it is restricted to the impact of changing climatic conditions, while the role of soils in land productivity under conditions of climate change will not be considered. The impact of soils is also not particularly relevant at this stage, because fertilizer use in Sub-Sahara Africa is practically nil, and in many circumstances the impact of climate change would, therefore, be dwarfed by increased fertilizer use. Furthermore, although bimodality of rainfall is an important issue in both study areas, this preliminary assessment will be restricted to uni-modal rainfall conditions. Finally, we present the preliminary insights on the vulnerability of African livelihoods for climate change that could be obtained with this exploratory assessment.

The fourth assessment of the Intergovernmental Panel on Climate Change (IPCC), as published in 2007, used a 22-member ensemble of climate models (General Circulation Models: GCM) to explore the possible spatial extent and magnitude of climate change during the course of the 21st century. These models can be run under four different standardized conditions as characterized for instance in terms of economic growth and associated CO_2 emissions. The outcomes indicate the changes in monthly temperature and rainfall by quarterly periods for 10-year average time slices. The results of 15 GCM's for a number of countries are available from internet sources at a spatial resolution of 2.5^{o} only (roughly 275 X 275 km at the equator), as median values over all 15 models, as well as the minimum and maximum values (McSweeney et al., 2010. The data refer to the SRES A2 scenario and storyline, which is at the higher line of emissions and it corresponds to the current actual trajectory of emissions (Nakicenvoic et al., 2000).

The authors of the Climate Change Country Profiles suggest that inherent to any application, such as Climafrica, 'is a necessary understanding and acknowledgement of the limitations of climate model projections' (McSweeney et al., 2010). Deficiencies derive from the coarse spatial resolution (e.g. Tabor and Williams, 2010; Fowler et al. 2007), but also due to limitations in the understanding of some of the processes involved. The spatial resolution is unable to capture more localized variations deriving from the combination of the prevailing direction of moisture bearing winds in combination with the relief properties, commonly resulting in higher rainfall on windward slopes in combination with lower rainfall in so-called rainshadow areas behind such relief formations. With respect to processes for instance, there are difficulties in reproducing the characteristics of the El Niño/Southern Oscillation and there are also deficiencies in reliably simulating tropical precipitation, in particular with respect to the movement and position of the Inter-tropical Convergence Zone (ITCZ). The latter is the principal driver of seasonal rainfall in the tropics, while the former exerts a strong influence on inter-annual and multi-year variability of climatic conditions in many regions (McSweeney et al., 2010). Because of these limitations, the results of GCM experiments are generally considered as possible ranges of outcomes of climate change events, but not as reliable predictions.

The outcomes of the 15-model ensemble show a very wide spread, notably for rainfall, which is considered indicative of the level of uncertainty in the set of projections (McSweeney et al., 2010). With respect to temperature, all models show an increasing trend as time proceeds through the 21st century roughly up to 3-4^{o} C in the 2090's and the spread around the median usually does not exceed + or – 1^{o} C. The case of precipitation is entirely different though. For instance in Northern Ghana with a uni-modal rainfall pattern, the change in median monthly rainfall during July –September does not exceed + or – 10 mm up to the 2090, which will hardly affect agricultural potentials. However, the model spread is from -143 to +70 mm. The negative

extremes would result in poor crop growth conditions The positive extremes, on the other hand would extend the season length an improve conditions for crops to growth. The observed wide spread in model outcomes confirm earlier and recent studies (Fischer and van Velthuizen, 1999; Voortman et al., 1999; Nelson et al., 2010; Kirono and Kent, 2011).

In Section 2 the mean length of the LGP and the patterns of the growing periods have been discussed. In essence adaptation implies that the growth cycle of crops/varieties needs to be comfortably contained in the duration of the LGP in order to ensure that they produce their economic yield. Failing to do so implies that yield losses are incurred. A shortening/increase of the LGP can be the result of two phenomena. First, obviously changes of rainfall, notably in the period when the LGP usually starts and ends, can significantly impact on the growing period duration. However, also the rise in temperature that the GCMs consistently produce, will affect growing period length. Higher temperatures will increase the water demand to satisfy evapotranspiration. The systematic effect, all other things being equal, will cause a later start and earlier end of the LGP, thus reducing the length. In addition, rising temperatures will also reduce the ratio of precipitation over potential evapotranspiration (P/PET) during the growing period, increasing the chances for drought stress to occur. Increased temperatures do not only affect the LGP duration, but obviously also affect the temperatures in which the plants will grow. This is particularly relevant in highland conditions, where currently temperate crops (wheat, Phaseolus beans, potato) or highland varieties (maize, sorghum) are grown. Rising temperature can make the cultivation of these crops impossible or their yields may be reduced. Under such conditions farming systems may require considerable change in terms of crops and varieties, but land productivity is not necessarily affected. Similar observations can be made for cash crops such as Arabica coffee and tea that equally perform better in cooler thermal regimes. But also in this case, shifting to other species or other cash crops is possible. In any case, actual outcomes of climate change on agricultural production depend on the joint effect of changing temperatures, changing rainfall patterns and changing rainfall amount.

The mean LGP is calculated using time series of monthly rainfall data and the average is usually depicted in a map. It is further of particular importance that a number of climatic properties relevant for crop growth vary with the mean duration of the LGP (Kassam et al.,1982). From a mean LGP duration of 150 days onwards the coefficient of variation of the length hardly increases, but below 150 day it increases with decreasing mean length. Furthermore, the P/PET ratio of the LGP generally decreases when the LGP becomes shorter, but, not surprisingly, below a mean duration of 120 days also the percentage of the LGPs that are intermediate increases. Thus, if below a LGP of 150, the length would further decrease, crop yields will be more severely affected than the linear decrease in LGP duration itself. The variability of LGP length and risk of moisture stress are taken into account in the assessment of yield potentials in AEZ. Furthermore, AEZ relates the LGP length to the severity of the impact of pests and diseases, the conditions for handling and storage of produce and conditions for mechanized farming. Such conditions generally worsen when the season becomes longer and improve when the season shortens. Hence, AEZ integrates various aspects that impact on crop yield, choice of crops/varieies and farming circumstances, thus allowing a comprehensive assessment of stylized climatic change events linked to the length of the LGP.

In this preliminary study, we will restrict ourselves to day-neutral rainfed cereal crops under uni-modal rainfall and low input conditions, whereby only a shortening or increasing length of the LGP is considered. We do not consider irrigated crops as they largely will remain unaffected by climate change. Equally rainfed *photosensitive* crops, prevalent in West Africa (millet and sorghum) are not considered because it would require a precise assessment of what the impact would be of changing date for the end of season. For similar reasons bimodal LGP conditions (extensive areas in coastal West Africa and Southern Uganda) are not considered, because any effect on crop yield and variety choices depends on when in the cropping period rainfall increases or decreases, thus requiring detailed calculations and, consequently, making the application of stylized climate change events unwieldy. Table 34 presents the conditions we consider. These conditions are characterized first of all by the length of the LGP and also by the variability of the length, the percentage of the LGP's that are intermediate and the ratio of rainfall (P) over potential evapotranspiration (PET). For each zone we discuss the effects of climate change that is such that the conditions move one class downward. The zone of 120-150 days is mentioned thrice on the basis of different adaptation strategies in terms of crop choice. An LGP of 75 days is generally considered the limit of cultivation, because of the inherent variability of the length of the season and the chances of intra-seasonal drought, which, in combination result in frequent crop failure. In the LGP zone of 75-90 days the highest yielding cereal is short-duration millet at 350 kg/ha. Falling back to less than 75 days would imply no yield at all, thus calling for either a change to livestock production or migration. In the 90-120 days LGP, millet reaches its maximum yield at 650 kg/ha. A reduced LGP length would imply a 45% yield reduction. In the zone of 120-150 days, maize produces the highest yield, and under dryer conditions (90-120 days) yields would also decrease with 45 percent. However, in this case farmers may opt for growing millet instead of maize, thus reducing yield losses to 25 percent only. The highest maize yields can be obtained in the LGP zone of 150-180 days and falling back to 120-150 days would again cause a yield reduction of 45 percent. However, in this case farmers can diversify into relatively high yielding short-duration tuber crops such as sweet potato. We therefore estimate that overall the quantities of food produced will not decrease more than 10 percent. Where currently the LGP is 180-210, a shortening of the season with one month would have no effect on maize yield at all. It follows that generally speaking food production systems become increasingly less vulnerable to a shortening of the LGP with increasing length of the current LGP.

Table 36 Climate change impacts by LGP zone when LGP shortens one class

LGP	P/PET ratio	Crops	Initial yield	Kg yield decrease	Vulnerability
<75	extremely low	none	0	0	limit of cultivation
75-90	very low	mil→mil	350	350	very high
90-120	Low	mil→mil	650	300	high

120-150	medium	mil→mil	650	0	medium
120-150	medium	maize→mil	850	200	medium
120-150	medium	maize→maize	850	400	medium
150-180	High	maize→maize/div	1500	150	low
180-210	very high	maize→maize	1500	0	very low

As earlier observed, among the ensemble of GCM models there is a wide spread in outcomes also including substantial increases in rainfall. As will be evident from Table 34 this will result in yield increases when the LGP length increases one class. These yield increases will be largest when the current LGP is short. From 75 days onwards, first cultivation becomes possible with average yields at 350 kg/ha, then the yield increases from one zone to the next higher gradually decline, followed by a large yield leap when moving from 120-150 days to 150-180 days. This phenomenon is related to the growth cycle of maize and sensitivity of maize to moisture stress. In the LGP of 150-180 days the yield potential of varieties with a long growth cycle can be fully exploited, while the chances of moisture stress are minimal. From 150-180 day onwards there are no further yield increases on the basis of cereals, but diversification into long duration root crops such as cassava and yams may increase food availability. We thus observe that from a current LGP of 150 days onwards, the food production system is not vulnerable for a climate change shock, independent of whether the season increases one month or decreases one month. In case of decreasing season length the vulnerability is more severe when the current LGP is shorter. When the season increases in length, the yield increases that can be obtained are related to the yield potential of crops/varieties as related to their growth cycle.

Hitherto, we have accounted for the impact of increasing temperature through the effect it has on the season length and the ensuing moisture stress. Yet we have to consider also the effect of temperatures during the growing period for some specialty crops. Both, in West Africa and in Uganda, Robusta coffee yields may be affected by higher temperatures. In the highlands of Uganda, the growth and yield of Arabica coffee, tea, wheat and white potato may be reduced, whereby the higher quality Arabica variety possibly can be replaced with Robusta coffee.

A summary of the various grades of vulnerability to a reduced length of the LGP as discussed above and their spatial extent in West Africa and East Africa are depicted in Figure 74 and Figure 75, respectively. Once more it is emphasized that the figures presented refer to low input use before and after the climate change event. However, for example in the 90-120 days LGP zone for millet a shift from low to high inputs would increase climatically attainable yields from 650 to 2600 kg (300%), and in the 150-180 days LGP zone for maize the same shift would increase climatically attainable yields from 1500 to 6000 kg (also 300%). Hence, any negative climate change impacts would in such cases be dwarfed by increased input use.

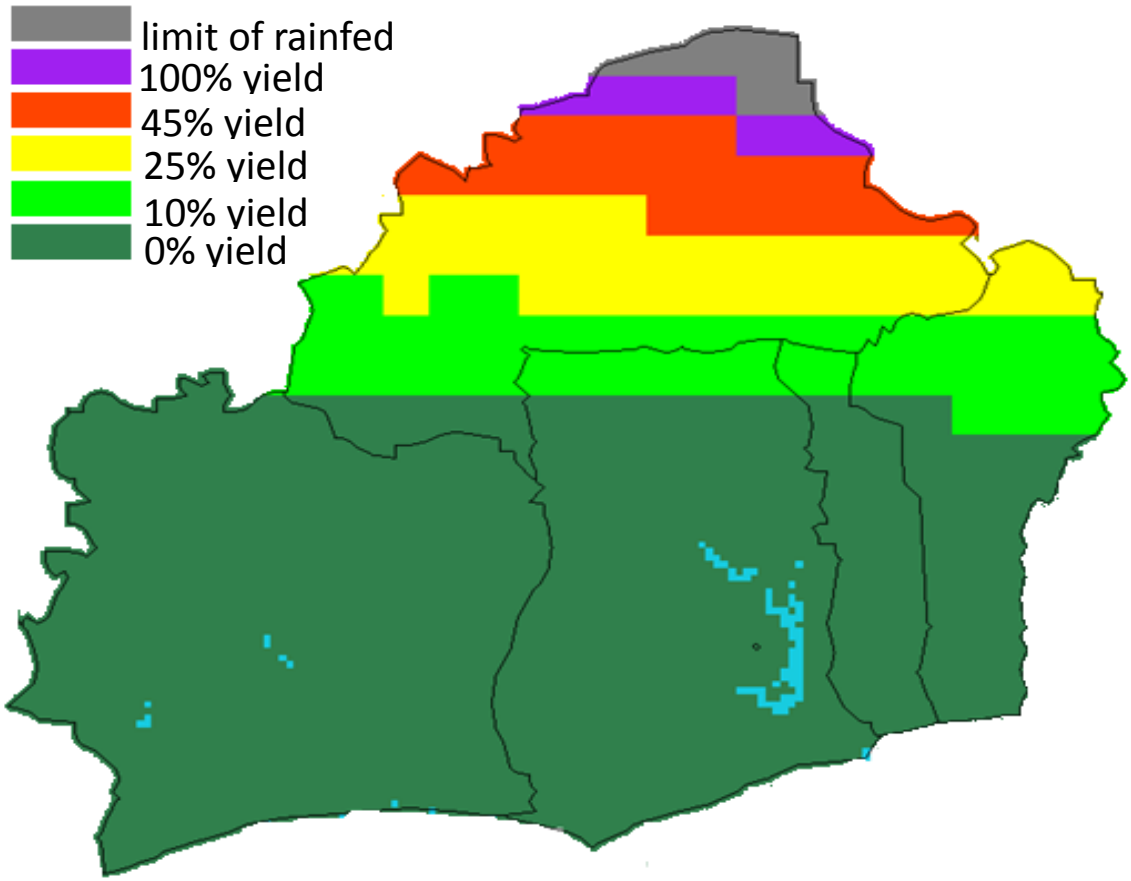


Figure 88 West Africa: vulnerability of food production system, shortening season of 1 LGP class

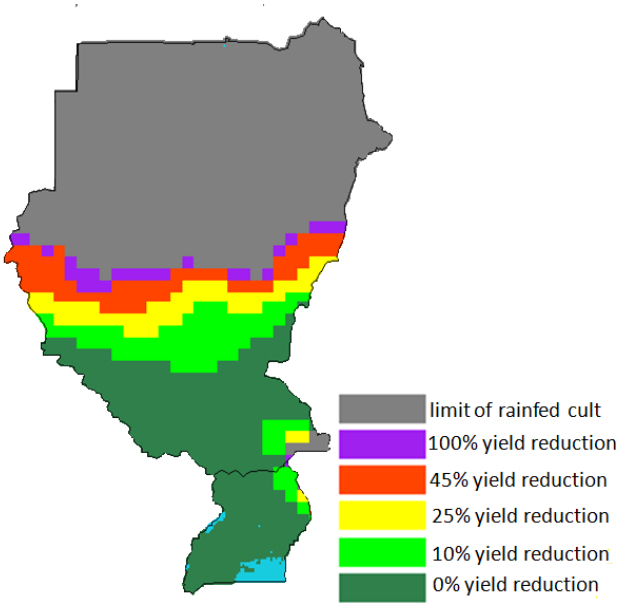


Figure 89 East Africa: vulnerability of food production system, shortening season of 1 LGP class

14. Concluding remarks

This report is the first deliverable of WP5-2 under the Climafrica project. It identifies the various vulnerable populations in West and East Africa and characterizes these groups by creating a socio-economic and natural resource profile.

Method

Our approach to analyze these vulnerable groups in relation to climate change is as follows. As our data are of an observational nature beset with unobserved heterogeneity we abstain from formal regression analysis. Instead we apply polling techniques which calculate conditional frequencies for our, mostly integer-valued, data that can be interpreted as probability estimates for specific combinations of variables. These combinations show the associative patterns between the vulnerability groups and selected socio-economic and geographical characteristics. The analysis we perform uses two different types of surveys: DHS/MICS and Afrobarometer surveys. The two types of surveys are complementary to each other, but also share some common variables that make it possible to combine the two, by appending estimation results from one to the other. In our study, the two surveys both are geo-referenced, and both have data on the age of the head of household, and the educational attainment. Estimation results for an administrative unit, i.e. the most probable associations of variables in the Afrobarometer survey within such a unit are used to complement the DHS/MICS survey observations. In this way, the two types of surveys are combined and analyzed jointly – obviously, appending the raw data by location is not an option, since the two surveys represent different samples. We presented individual factors that show a clear distinctive character by vulnerable group for both survey types and the location-specific data separately. Next, we combined these different types of data to define the most probable combinations of characteristics associated to vulnerability. Third, these computations generate two results that are used to analyze the profiles, a) the 'winners' and 'runners up' and b) the frequency of occurrence of variables in the profiles that characterize 50% of the vulnerable group.

Results: rural West Africa

For rural West Africa, univariate analysis reveals that the very vulnerable, on average, are more likely to remain in the same residence, to have more adult children away from home, to receive no payments for work, have no education and are agricultural self-employed. Very vulnerable households are much more likely to be employed as household and domestic servants, and have an older head of household. They are more likely to have sons and daughters outside the households than any other class; implying that in times of need, they can call upon relatives outside their own location for assistance, which is one important transmission channel for (climate induced) hardship to spread over a larger area.

Very vulnerable are more likely to be agro-pastoralists or working in mixed cereal-root crop systems. The areas where they live are very likely to be 50-75% grass and woodlands. Furthermore, they live in areas with slopes between 5-8% with 20-40% of the area being characterized by constraints. Climatically, most very vulnerable households are located in dry sub-humid areas: while almost 65% of the very vulnerable live in these areas, the share of vulnerable households is 46%, that of the nearly vulnerable almost 40% and of the non-vulnerable households only 31% are located in these areas. for the Afrobarometer data, self-reported perceptions on the economic situation are related to the vulnerability status: the more vulnerable the household is, the more likely it reports the economic situation as being very bad.

Special attention should be given here to the role of religion; whereas Islam is the religion of 48% of the very vulnerable households and 45% of the vulnerable ones, only 29% of nearly vulnerable households are Islamic and Islam is totally absent among the non-vulnerable ones. Non-vulnerable households are predominantly (50%) Protestant Presbyterian or Methodist (only 6% of very vulnerable have this religion) while nearly vulnerable are predominantly Roman Catholic (43% against 27% of very vulnerable households and non for vulnerable ones). It is difficult to interpret these outcomes, as they may point to discrimination of groups based on religion, but may also be an outcomes of the geographical spreading of the vulnerable population, with historical determinants of religious beliefs.

The Afrobarometer survey also provides some support for ethnic discrimination: at least the perception of being treated unfair because of ethnic background is related to vulnerability status. In line with the DHS results on the number of sons and daughters away from home, remittances received by very vulnerable households are important. Very vulnerable households report more often than any other class in rural areas, including the non-vulnerable ones, to receive remittances at least once a year. As such this stresses the fact that local (climate) disasters spread over a larger area might use social networks as coping mechanisms.

The polling analysis that considers the characteristics jointly reveals that the profile of the very vulnerable includes the following characteristics: no education, agricultural self-employed, no payment for work, an older head of household, and involved in the cereal-root crops farming system.

For the vulnerable population, there are two profiles that are almost equally likely when age of the head of household, education, occupation, payment for work, and farming system are included, 7.3%, 7.1% of the total number of vulnerable households, respectively.The profiles of the vulnerable rural households and the very vulnerable are very similar for these characteristics. From an analysis of most common characteristics in profiles covering 50% of the class, it follows that the main difference between the profiles of the very vulnerable and the vulnerable rural population is the age of the head of household, with older heads being more associated with very vulnerable households, and the association with the agro-pastoral millet farming system, which is more pronounced among the vulnerable population.

For Benin, Ghana and Burkina Faso, estimates from the Afrobarometer survey have been appended to the DHS survey and yield the following insights for the vulnerable households in these countries (the limited number of observations for very vulnerable households does not allow for an analysis of profiles). From the analysis, we infer that being vulnerable is associated with having a young head of household, no education, being agricultural self-employed, within agro-pastoral millet or cereal root crops mixed farming systems, bad economic circumstances and little or no remittances from outside the households. Ethnic discrimination does not seem to figure as a distinguishing feature.

Results: urban West Africa

The most common profile of very vulnerable groups in the urban areas of West Africa is characterized by a low wealth index, a high share of uneducated persons, not being paid for services provided, and a higher probability to have lived longer in the present place of residence. Combined with the higher share of the vulnerable that reports to be agriculturally self-employed, this may point to the fact that the urban vulnerable live in the outskirts of the cities without many opportunities to move to more profitable occupations: less vulnerable households are more engaged in sales and the non-vulnerable ones also in services.

Again, we pay special attention to the role of religion; similar to rural areas, vulnerable populations are much more likely to report Islam as their religion (65% of vulnerable households report to be Islamic, against 44% of nearly vulnerable and non-vulnerable households). As for rural areas, this result may point to discrimination of groups based on religion, but any interpretation must be done with care.

Analysis of the Afrobarometer data reveals that more vulnerable populations are relatively less educated and have an older head of household. Self-reported perceptions on the economic situation are related to the vulnerability status, similar to the relation between wealth quintiles and vulnerability in the DHS. The Afrobarometer survey also provide some support for ethnic discrimination: at least the perception of being treated unfair because of ethnic background is related to vulnerability status.

The findings from the univariate analysis are confirmed in a polling analysis combining characteristics into profiles. The two most common profiles (characterizing 6.2% and 2.7% of the class as a whole) confirm all but the association with the wealth index and the non-payment for work. However, in the wider analysis of the top-36 profiles that jointly characterize 50% of the urban vulnerable population in West Africa, the relation with the lowest wealth indices is again restored.

For Benin, Ghana and Burkina Faso, we may include the estimates from the Afrobarometer surveys. From this we infer that being vulnerable is associated with having no education, receiving cash payments for work, having lived in the current residence for a long time, and receiving no remittances (or only limited remittances) from outside the household.

Results: rural East Africa

For rural areas in East Africa we find that the most vulnerable group is also the poorest one, the least educated and with the least sure employment. Furthermore, a very high share of the very vulnerable households is agricultural self-employed. On average, the very vulnerable are less rooted in their current residence (which may point to the fact that part of this population consists of internally displaced persons or refugees, but there is no data in the survey available to corroborate this hypothesis).

The very vulnerable are much more likely than other groups to be located in sub-humid arid areas, in areas covered for more than 75% with grass and woodland, and to be in the maize-mixed farming system, which are dominant farming systems in South East Sudan and Northen Uganda.

For Uganda, Afrobarometer data is available and confirms the findings from the DHS surveys: Low education and a relatively old head of household characterize vulnerable and very vulnerable populations. In addition, the self-reported economic status is associated with vulnerability similar to the associated with wealth quintiles in the DHS. The limited involvement of the very vulnerable in religious or community groups could again point to fact that these households are internally displaced persons or refugees, although data on this is not available in the Afrobarometer survey.

The results from the univariate analysis are partly confirmed in the polling analysis that includes the characteristics jointly. The two most frequently occurring profiles for this group represent 9.9% and 4.5% of the population. The poorest wealth quintile is represented in the profile of the runner-up, but not in the winning one; education levels are low, the very vulnerable are agricultural self employed or is professional technical management; employment is less secure in the top-2 than the univariate analysis suggests, and results on the number of daughters from

home and the time lived in the current residence are not conclusive. Dry sub-humid areas are included in the top-2 profiles, but the land use in both cases differs from than identified in the analysis above. The very vulnerable are either involved in maize-mixed farming, or are pastoralists, which is in line with expectations, but did not directly follow from the analysis above. The wide analysis of the top-9 profiles that jointly describe 50% of the rural very vulnerable population reveals that the very vulnerable are in the poorest wealth quintile, have no or incomplete primary education, are agricultural self-employed or (often) unemployed, and if employed, the employment is seasonal or occasional. They have at least 1 or more daughters away from home, and predominantly have lived in the current residence less than 5 years. They reside in arid sub-humid areas, which are either grasslands or largely cultivated, and are either engaged in maize-mixed farming or pastoralists. As before, we note that many of these characteristics could point to the fact that at least part of the very vulnerable population are internally displaced persons or refugees.

For the vulnerable population, education, occupation, LGP, duration of work, LGP, land use, and farming system are included, based on the univariate analysis (see annex A for the presentation of the complete results for the univariate analysis). It follows that they are lowly educated, agricultural self-employed, and are located in maize mixed farming. An analysis of the frequency with which characteristics occur in the top-27 profiles for vulnerable households (50% of class) reveals that the picture of the top-2 is largely confirmed, although the association with LGP and land use is less clear.

For Uganda, we combine DHS data with Afrobarometer estimates. For the very vulnerable households, too few observations are available to draw any conclusions. The vulnerable rural households are characterized by low education, occasional employment, a fairly bad economic situation, low involvement in the community, but a fairly high involvement in religious groups. This implies that the network of the rural vulnerable appears to be mainly associated with a common religious background.

Results: urban East Africa

For urban areas of East Africa, univariate analysis of the vulnerable population suggests that these households have a very young head of household. The vulnerable are less likely to have sons outside the household, which partly is related to the age of the head of households. A very high share of the vulnerable households reports “sales” as the major occupation. Although the vulnerable report to be employed more often than nearly vulnerable households, they receive no payment for the work done in a much higher share of the cases. The combination of very young heads of households with the employment characteristics leads us to conclude that the vulnerable urban population has very little power in the labor market, and can be easily abused, which is to some extent corroborated by the fact that, on average, the vulnerable are less rooted in their current residence than less vulnerable classes.

Analysis of the Afrobarometer data for Uganda reveals that vulnerable households are characterized by a young head of household, low levels of education, a bad economic situation and almost no remittances, which highlights the fact that the vulnerable population cannot rely on an external network to cope with shocks.

Combining the different characteristics into profiles using the polling approach reveals that in the top-2 profiles (characterizing 8.3% of the population each), all results from the univariate analysis are confirmed, except for the result on the age of the head of household, and the same result follows from the wider analysis of the top-9 profiles that jointly cover 50% of the

households in the relevant group. Hence, we conclude that occupation in sales, receiving no payments for work, having no or few sons away from home, and being relatively new in the residence are factor that characterize the vulnerable households in urban areas.

Effects of climate change

A preliminary analysis of the likely effects of climate change on these populations reveals that for West Africa, especially the vulnerable and very vulnerable populations in Burkina Faso and the northern areas in Benin, Ghana and Togo may experience climate shocks, in the case of declining rainfall. For Burkina Faso, effects on yields range from 10% in the South to 100% in the north, and given that the very vulnerable and vulnerable are agricultural self-employed, yield decreases translate almost one-to-one to increases in vulnerability. For northern Ghana, yield decreases of 10% may result from climate change, impacting on the vulnerable population there, and the same holds for northern Benin, where also very vulnerable populations are in the zones where yield decreases of 10% are to be expected, and Togo, where vulnerable population may experience yield decreases up to 25%. In the case of increasing rainfall, however, these areas will benefit most.

For Uganda, the Karamojo region, already home of many vulnerable and very vulnerable households, is the area where the largest negative effects of climate change may occur, with yield decreases of 10%-25% in case of declining rainfall, and vulnerable populations being largely agricultural self-employed. For South Sudan, the South East part is likely to experience the same magnitude of yield decreases with similar effects on the very vulnerable population located there. For Sudan, the northern areas are already unsuited for crop cultivation, and hence, climate change must be understood as bringing more hardship to the pastoralists residing here, but quantification is not possible in this preliminary analysis. For the middle part, yield decrease may range between 10% to 100%, impacting on the very vulnerable and vulnerable populations located there. Also here, in the case of increasing rainfall these areas will benefit most.

For both regions, we stress that our analysis is necessarily preliminary, as results on the effects of climate change in yields will follow from other Work Packages in the Climafrica project in the coming months. Yet, the results point to the fact that many already vulnerable populations are at risk and they highlight the need to identify possible coping mechanisms, including relying on relatives or a larger circle of people to cushion shocks.

Indeed, this report also provides the background for our further analysis of the indirect effects of climate disasters. The inclusion of specific variables indicating the routing in the local community, the number of household members who are outside the households and the possibility to rely on remittances to cope with shocks already presents one step in the direction of modeling the spatial and social networks connecting the vulnerable and very vulnerable populations to others. Further analysis of these networks clearly lies beyond the scope of the present report, but is envisaged in the further course of our Work Package, which explicitly focuses on modeling the domino effects of climate change.

Technical annex A

In this annex, we present background information on the data used in the analysis presented in the main text.

Survey data

First, as was indicated in the main text, three different surveys are used in the analysis of causes of vulnerability: the DHS, MICS and Afrobarometer surveys. Table A 1 summarizes the availability of data in the different survey

Table A 1 Availability of data in DHS, MICS and Afrobarometer surveys

	DHS	MICS	Afrobarometer
Age of Household head	BE,BF,CI,GH,TO, UG	SU	BE,BF,GH,UG
Sex of Household head	BE,BF,CI,GH,TO, UG	SU	BE,BF,GH,UG
Number of dependent household members	BE,BF,CI,GH,TO, UG	SU	BE,BF,GH,UG
Wealth index	BF,GH,UG	SU	
Owns television	BE,BF,CI,GH,TO, UG	SU	BE,BF,GH,UG
Owns radio	BE,BF,CI,GH, TO,UG	SU	BE,BF,GH,UG
Has electricity	BE,BF,CI,GH, TO,UG	SU	
Owns bicycle	BE,BF,CI,GH, TO,UG	SU	
Owns motorcycle	BE,BF,CI,GH,TO ,UG	SU	
Owns car/truck	BE,BF,CI,GH,TO ,UG	SU	BE,BF,GH,UG
Has telephone	BE, BF,CI,GH,UG		
Type of toilet	BE, BF,CI,GH,TO,U G	SU	
Type of Water source	BE, BF,CI,GH,TO,U G	SU	BE,BF,GH,UG
Main floor material	BE, BF,CI,GH,TO,U G	SU	
Main wall material	BE, GH,UG		
Education of respondent	BE, BF,CI,GH,TO,U G	SU	BE,BF,GH,UG
Education of partner	BE,BF,GH,TO,U G		
Type of occupation head of household	BE,		

	BF,CI,GH,TO,UG	
Working status of head of household	BE,BF, CI,GH,TO,UG	BE,BF,GH,UG
Employment duration of head of household	BE, BF,CI, H,TO,UG	
Employment type of head of household	BE,BF,CI,GH,TO ,UG	
Sons or daughters outside household	BE,BF,CI,GH, TO,UG	BE,BF,GH,UG
Years lived in community	BE,BF,CI,GH, TO,UG	
Member of community group		BE,BF,GH,UG
Ethnicity of respondent	BE, BF,CI,GH, TO	BE,BF,GH,UG
Religion of respondent	BE,BF, CI,GH,TO,UG	BE,BF,GH,UG

Notes: BE=Benin, BF=Burkina Faso, CI=Côte d'Ivoire, GH=Ghana, SU=Sudan, TO=Togo, UG=Uganda

Criteria for classification of households

The degree of vulnerability of households from the DHS is based on the combination of indicators on Body Mass Index for the adult members of the household, the weight for age indicators for children in the household and the number of diseases that has occurred in the household in the two weeks preceding the survey. First, we recode the BMI, weight for age and disease indicators. Next, the unweighted average of the scores on these three items is used to classify the vulnerability (Table A 2)

Table A 2 Characterizations of vulnerability classes

BMI	Weight for age	disease	Vulnerability score
<16: code = 4	<-3sd code = 4	3 code = 4	>3 : very vulnerable
16-18.5: code = 3	-2sd - -3sd code = 3	2 code = 3	2-3: vulnerable
18.5-21: code = 2	0- -2sd code = 2	1 code = 2	1.7-2: nearly vulnerable
>21: code = 1	>0 code = 1	0 code = 1	<1.7: not vulnerable

Estimation of wealth index

For Benin, Cote d'Ivoire and Togo, the wealth index is estimated based on associations of the wealth index with underlying indicators of wealth. Table A 3 presents the outcomes of the

analysis of the determinants of the wealth index outcomes for the two countries for which data on the wealth index is available (Burkina Faso and Ghana).

Table A 3 Profiles of wealth indices

locality	electricity	radio	tv	refrigerator	bicycle	motor	Car	water	toilet	floor	wealth index
2	1	1	1	1	1	1	1	2	3	1	1
2	1	1	1	1	1	1	1	2	3	4	1
2	1	1	1	1	1	1	1	3	2	1	1
2	1	1	1	1	1	1	1	3	3	1	1
2	1	1	1	1	1	1	1	4	3	1	1
2	1	1	1	1	1	1	1	4	3	3	1
2	1	1	1	1	1	1	1	7	3	1	1
2	1	1	1	1	1	2	1	3	3	1	1
2	1	1	1	1	2	1	1	2	3	1	1
2	1	1	1	1	2	1	1	2	3	2	1
2	1	1	1	1	2	1	1	3	3	1	1
2	1	1	1	1	2	1	1	7	3	1	1
2	1	1	2	1	2	1	1	2	3	3	1
2	1	2	1	1	1	1	1	1	3	1	1
2	1	2	1	1	1	1	1	2	2	1	1
2	1	2	1	1	1	1	1	2	4	1	1
2	1	2	1	1	1	1	1	3	2	1	1
2	1	2	1	1	1	1	1	3	3	3	1
2	1	2	1	1	2	1	1	2	4	1	1
2	1	2	1	1	2	1	2	3	2	3	1
2	1	2	1	1	2	1	2	3	3	3	1
2	2	1	1	1	1	1	1	3	3	1	1
2	2	1	1	1	2	1	1	1	3	1	1
2	2	1	1	1	2	1	1	2	3	1	1
2	2	2	1	1	1	1	1	2	3	1	1
2	2	2	1	1	1	1	1	2	3	3	1
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1	1	2	1	1	2	1	1	3	3	1	1
1	1	2	1	1	2	1	1	3	3	3	1
1	1	2	1	1	2	1	1	5	2	3	1
2	1	1	1	1	1	1	1	1	2	3	2
2	1	1	1	1	1	1	1	1	3	3	2

2	1	1	1	1	1	1	1	2	2	3	2
2	1	1	1	1	1	1	1	3	2	3	2
2	1	1	1	1	1	1	1	7	2	3	2
2	1	1	1	1	1	2	2	2	3	3	2
2	1	1	1	1	2	1	1	1	2	3	2
2	1	1	2	1	1	1	1	2	2	3	2
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2	1	2	1	1	2	1	1	3	4	3	2
2	1	2	1	1	2	1	1	5	2	3	2
2	1	2	1	1	2	1	1	7	3	1	2
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2	2	2	1	1	1	1	1	3	2	3	2
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The codes used in the above table represent the following entries in the survey (Table A.4)

Table A.4 Coding of wealth index estimation

	locality	electricity	radio	Tv	refrigerator	bicycle	motor	car
1	urban	no	no	No	no	no	no	no
2	rural	yes	yes	Yes	yes	yes	yes	yes
3		not resident	not resident	not resident	not resident	not resident	not resident	not resident
	water	**toilet**	**floor**	**wealth**				
1	piped water	flush toilet	natural	poorest				
2	well water	pit toilet/latrine	rudimentary	poorer				
3	surface water	no facility/bush	finished	middle				
4	rainwater	other	other	richer				
5	tanker truck	not resident	not resident	richest				
6	bottled water							

7	other
8	not resident

Data annex B

B.1 Survey data representation

In this data, the complete analysis of the survey data is included, also for variables that did not prove to be important in distinguishing the different vulnerability classes. DHS data include:

- the wealth index
- the age of the head of household
- the sex of the head of household
- the number of household members under the age of 5 (dependent household members)
- the educational attainment of the respondent
- the occupation of the respondent
- the current employment status of the respondent
- the type of employment of the respondent
- the payment received for work by the respondent
- the number of sons away from home
- the number of daughters away from home
- the number of years the respondent lived in the current residence
- the religion of the respondent

Afrobaromenter data include

- age of the head of household
- subjective report of economic situation
- membership of religious group
- membership of community group
- subjective report on degree to which ethnic group of respondent is treated
- frequency with which remittances are received by household
- educational attainment

Rural West Africa: DHS data

Figure A 1 to Figure A 13 present the relative frequencies of different characteristics over the four vulnerability classes defined for the West Africa study area, for rural households.

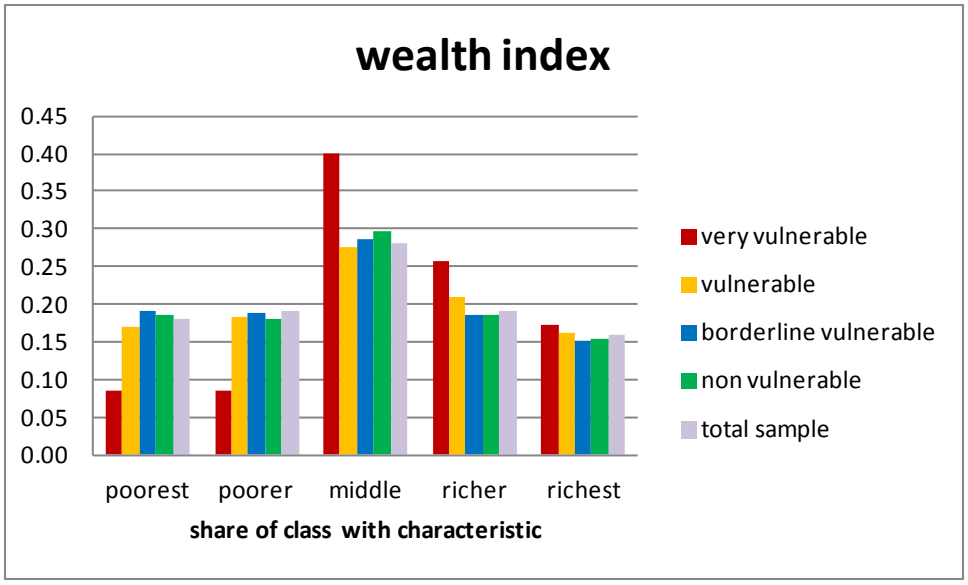

Figure A 1 Wealth index, rural West Africa

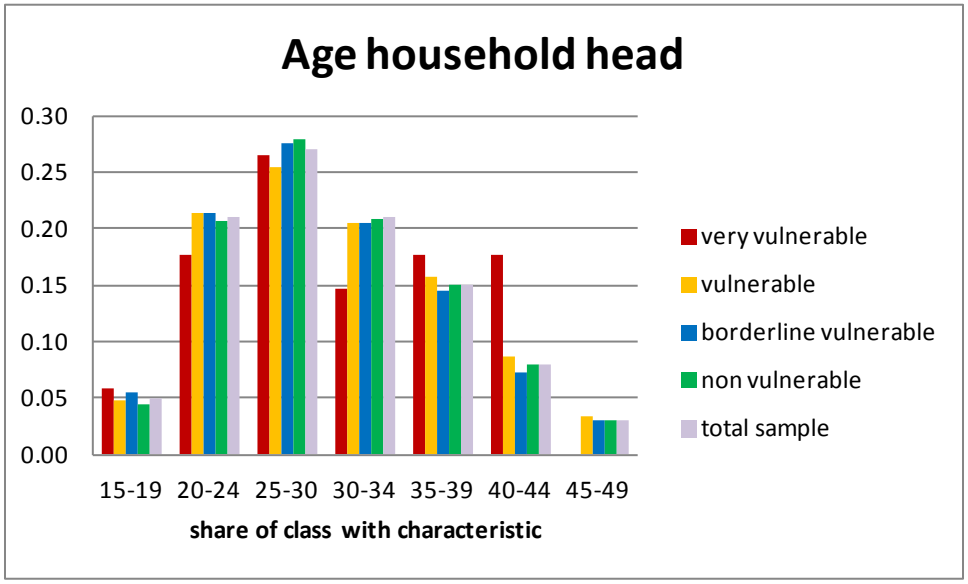

Figure A 2 Age of household head, rural West Africa

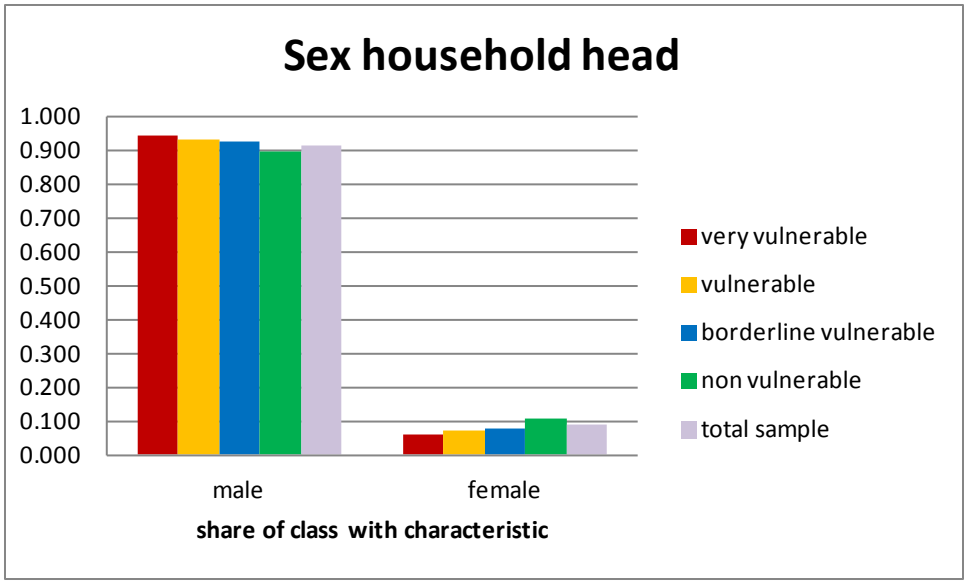

Figure A 3 Sex of household head, rural West Africa

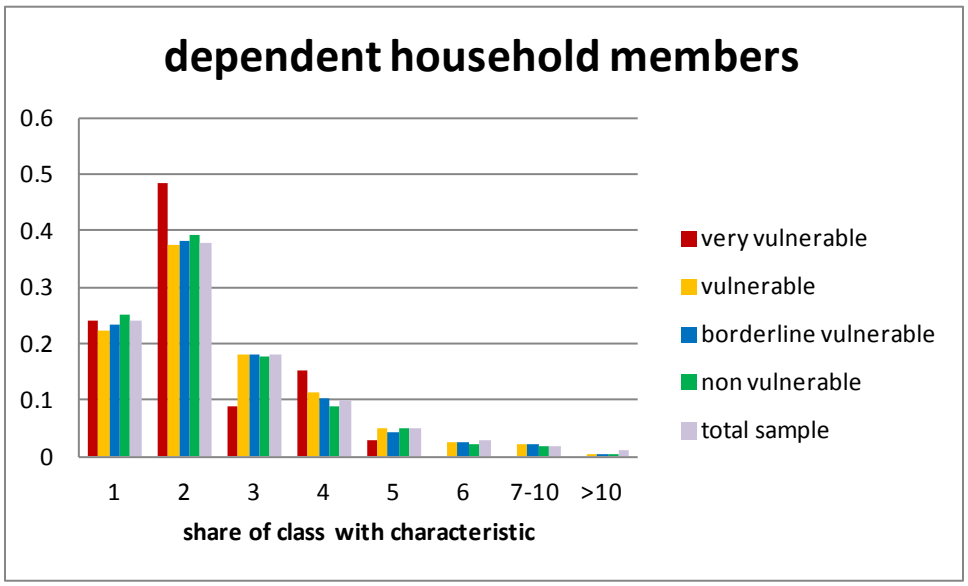

Figure A 4 Number of dependent household members, rural West Africa

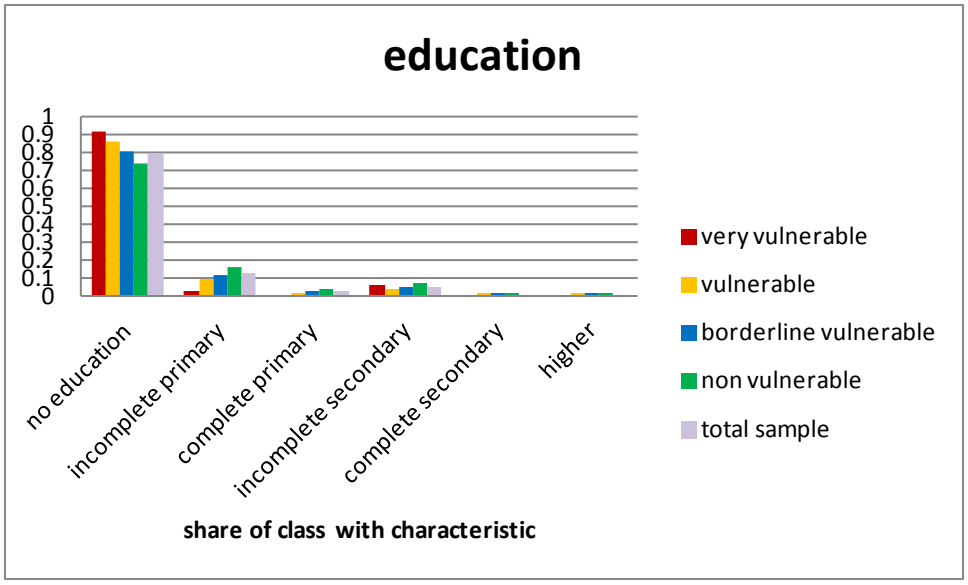

Figure A 5 Education of respondent, rural West Africa

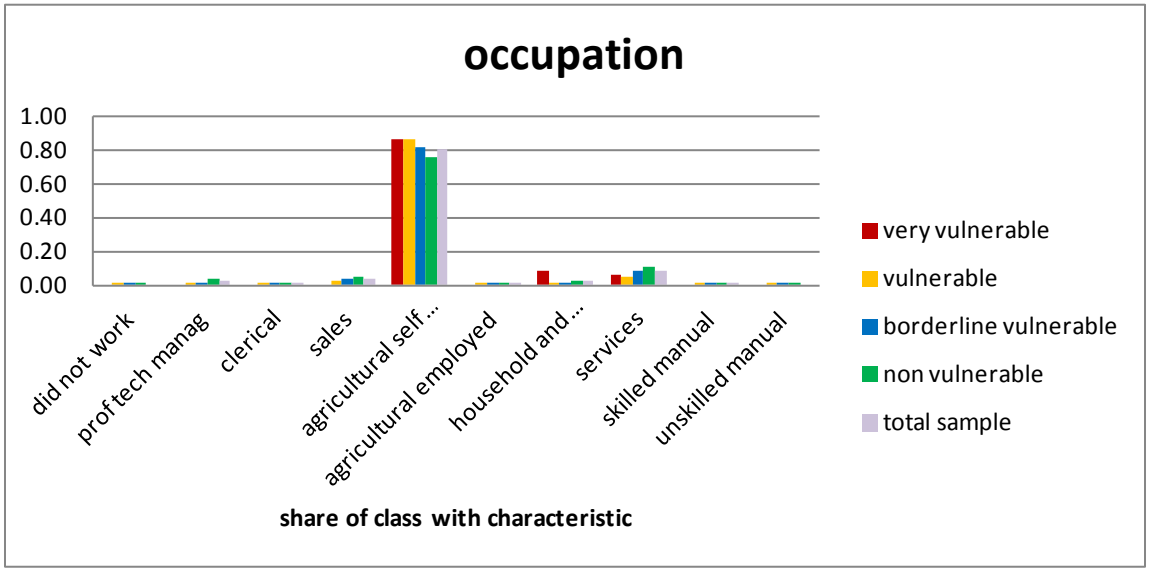

Figure A 6 Occupation of respondent, rural West Africa

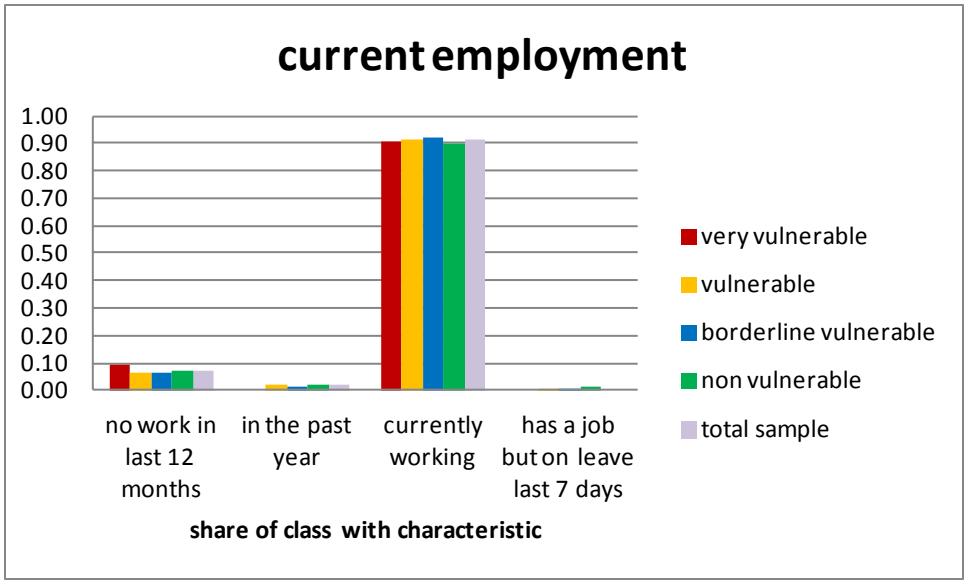

Figure A 7Current employment status respondent, rural West Africa

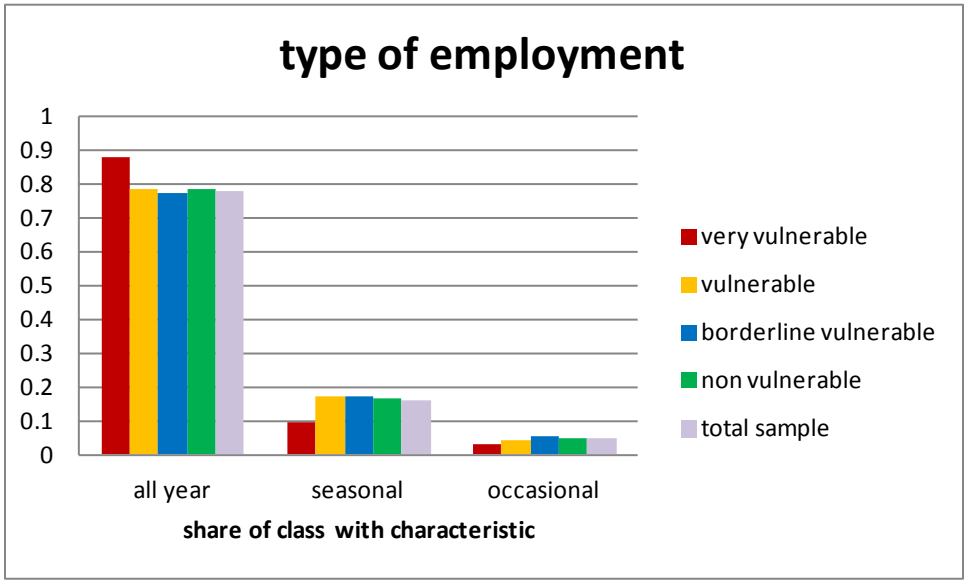

Figure A 8 Type of employment respondent, rural West Africa

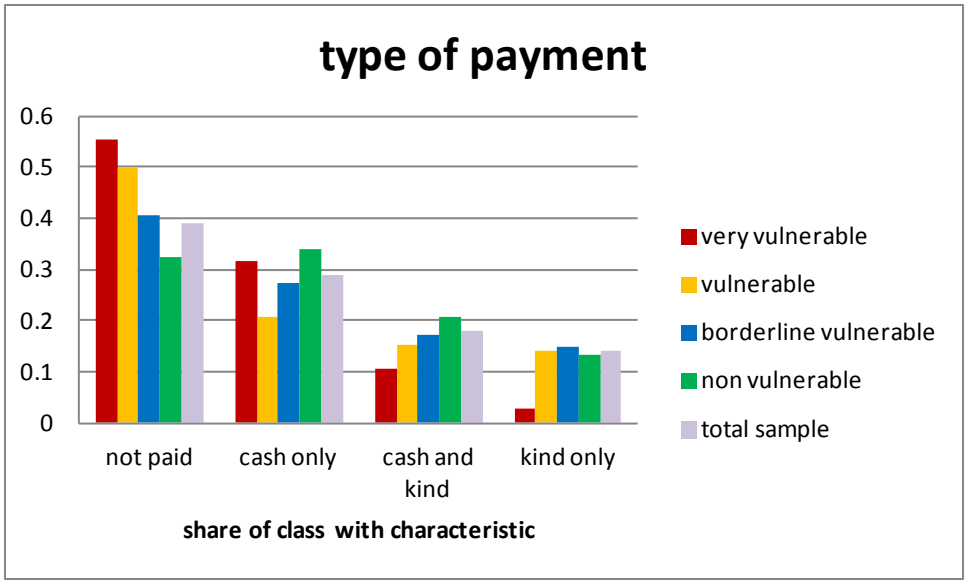

Figure A 9 Type of payment of respondent, rural West Africa

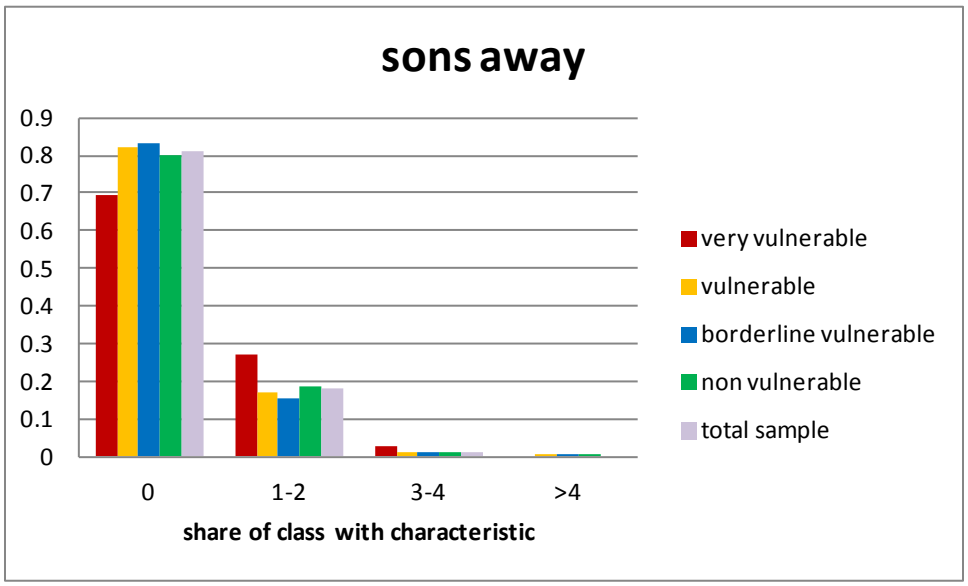

Figure A 10 Sons away from home, rural West Africa

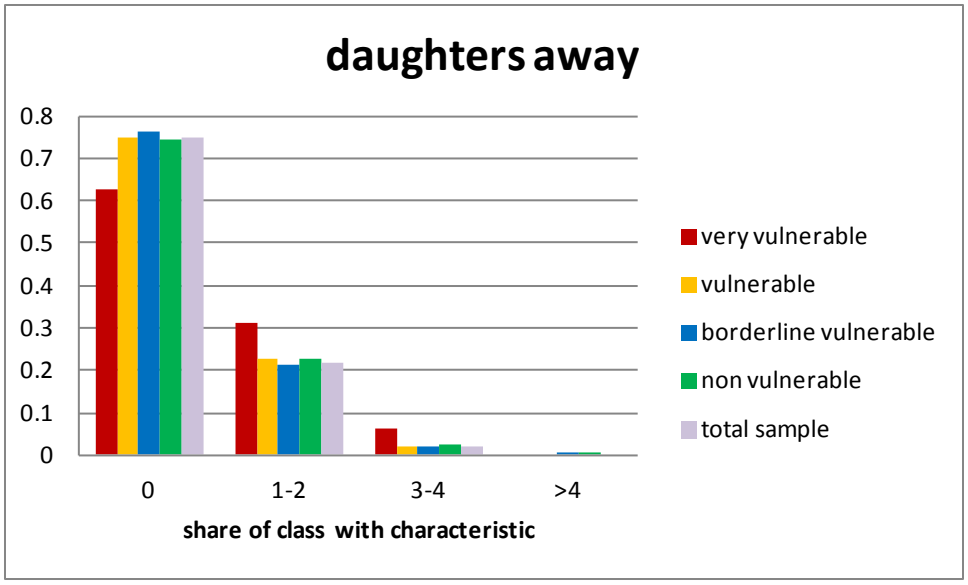

Figure A 11 Daughters away from home, rural West Africa

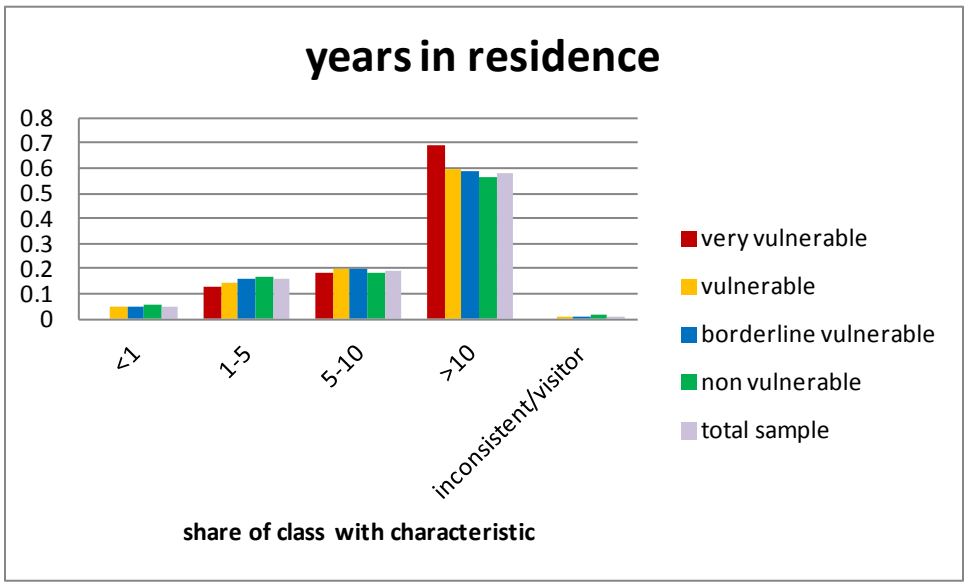

Figure A 12Years lived in residence, rural West Africa

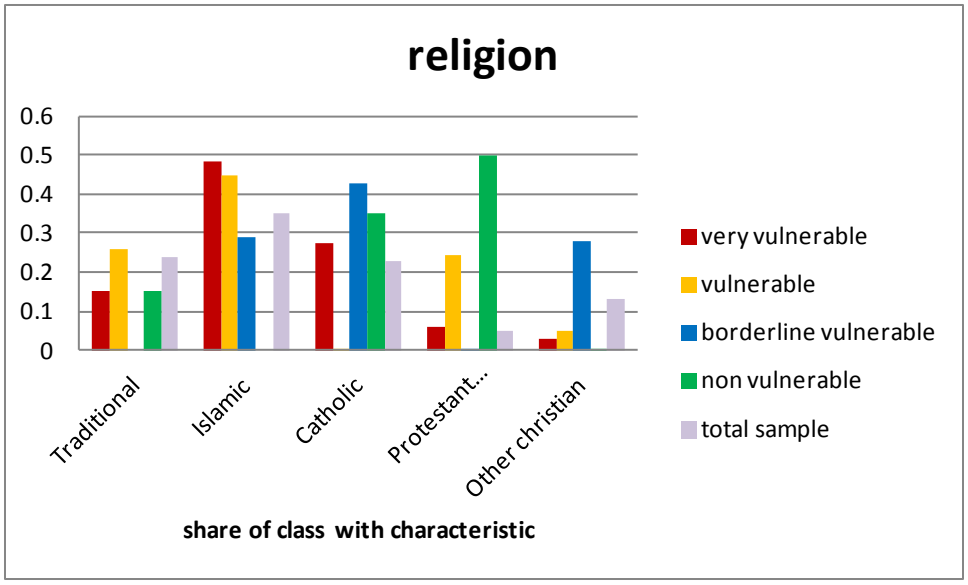

Figure A 13 Religion of respondent, rural West Africa

Rural West Africa: Afrobarometer data

Figure A 14 to Figure A 20 present the relative frequencies of different characteristics over the four vulnerability classes defined for the West Africa study area, for rural households for the Afrobarometer data.

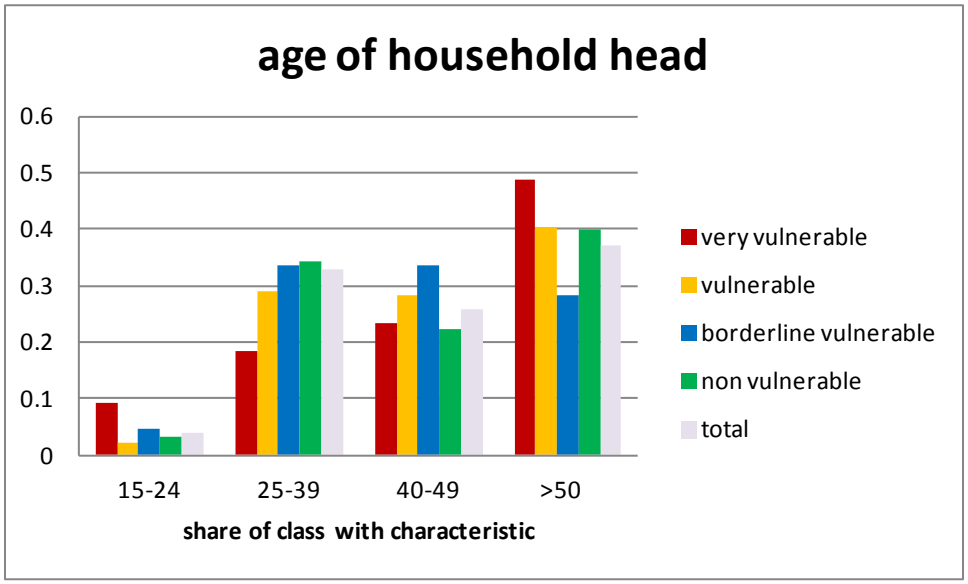

Figure A 14 Age of household head, rural West Africa

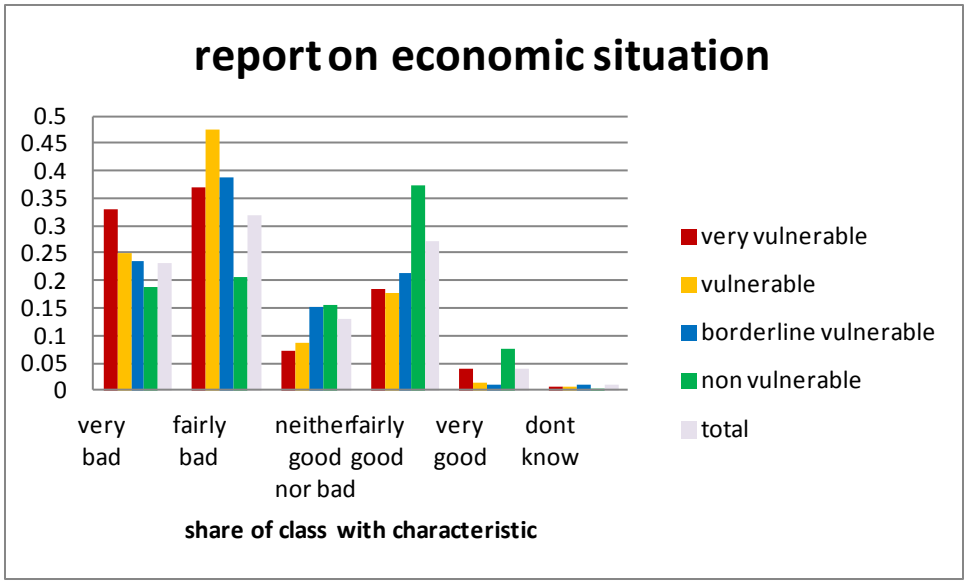

Figure A 15 Report on economic situation, rural West Africa

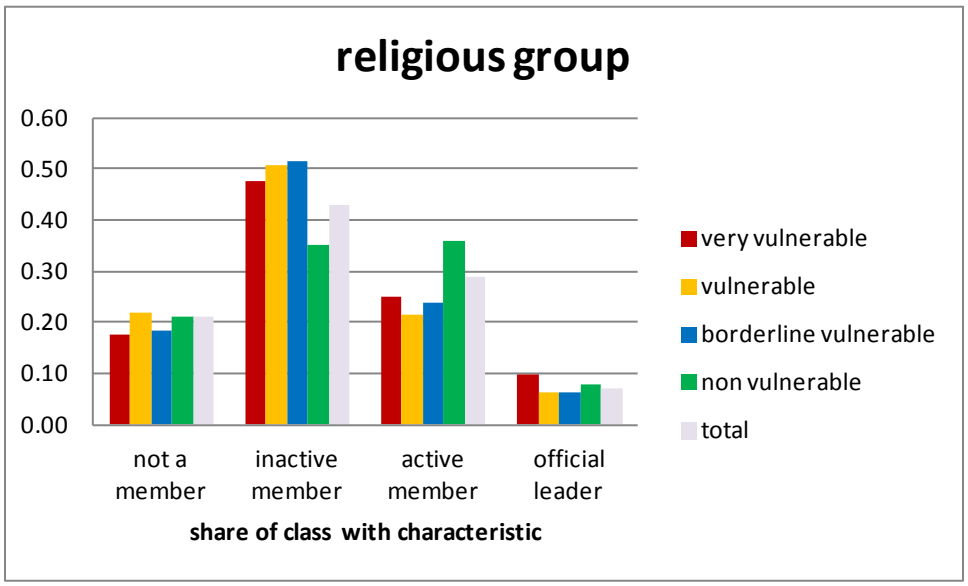

Figure A 16 Membership of religious group, rural West Africa

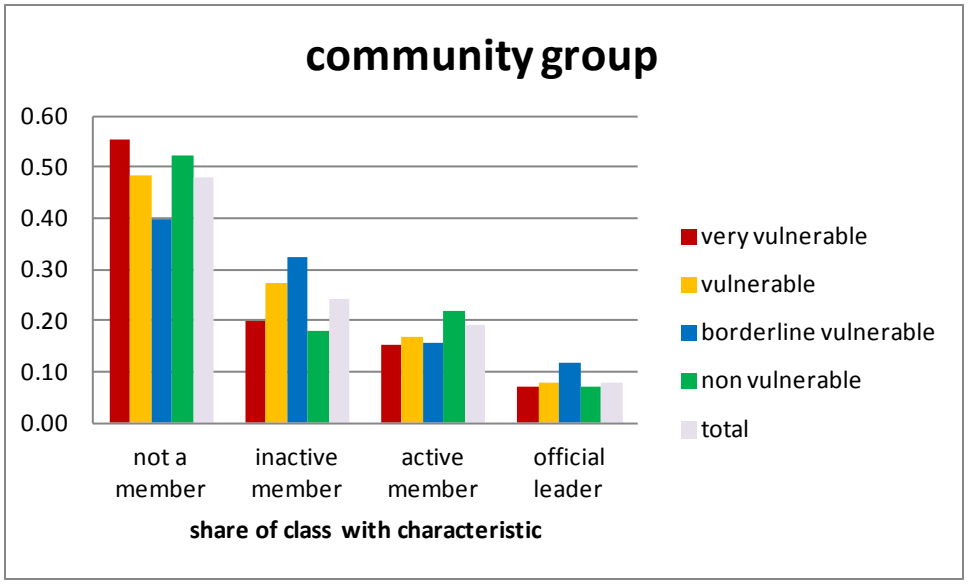

Figure A 17 Membership of community group, rural West Africa

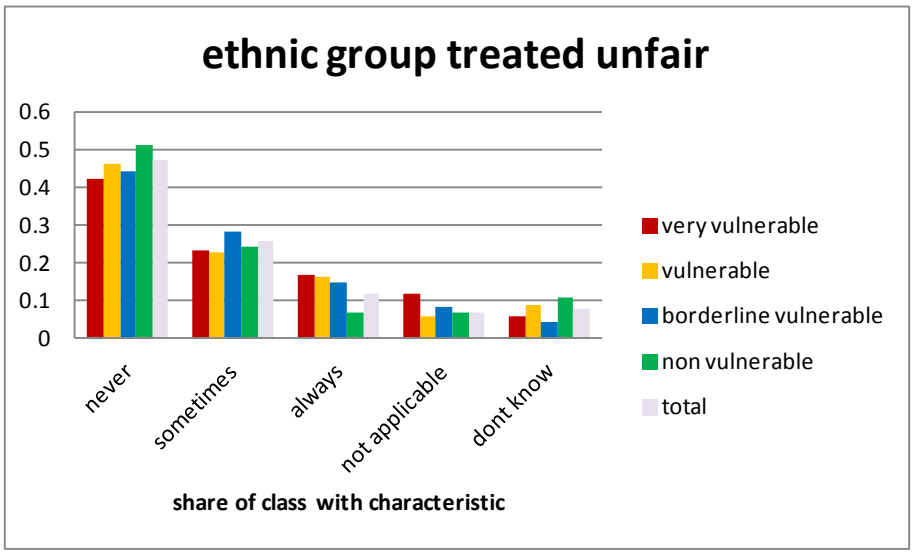

Figure A 18 Report on unfair treatment of respondent's ethnic group, rural West Africa

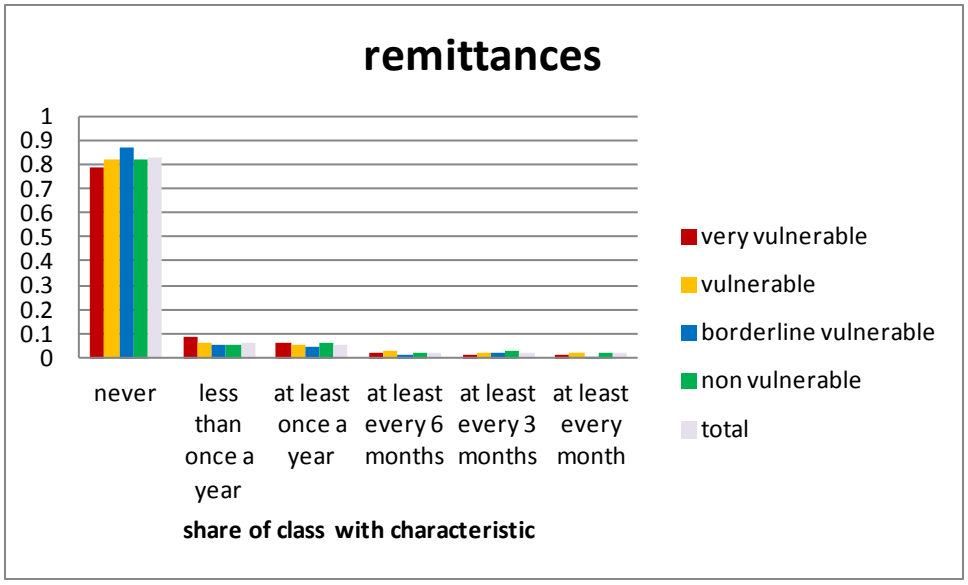

Figure A 19 Frequency of remittances received by household, rural West Africa

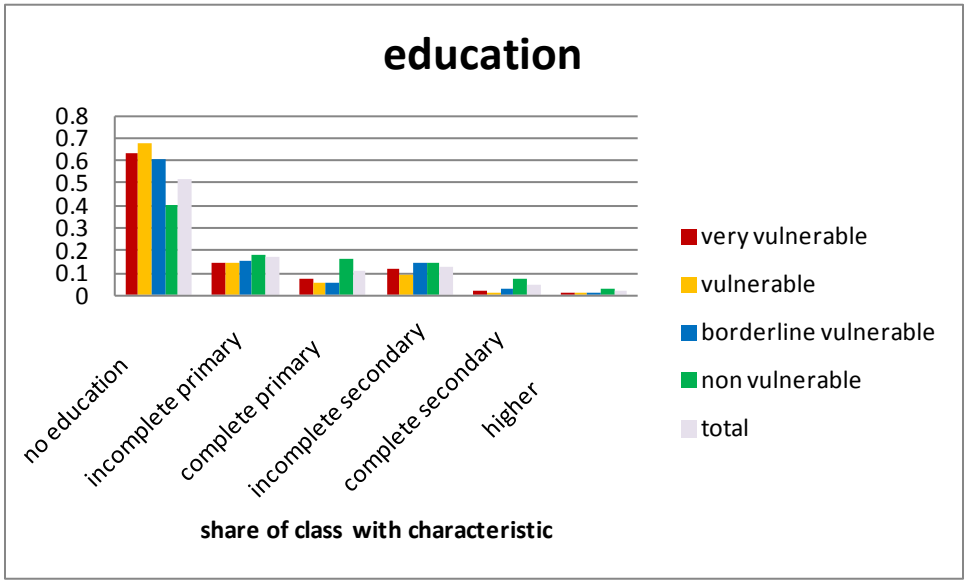

Figure A 20 Educational attainment of respondent, rural West Africa

Urban West Africa: DHS data

Figure A 21 to Figure A 33 present the relative frequencies of different characteristics over three of the four vulnerability classes defined for the West Africa study area, DSH data, urban households. The group of very vulnerable households is too small to be included.

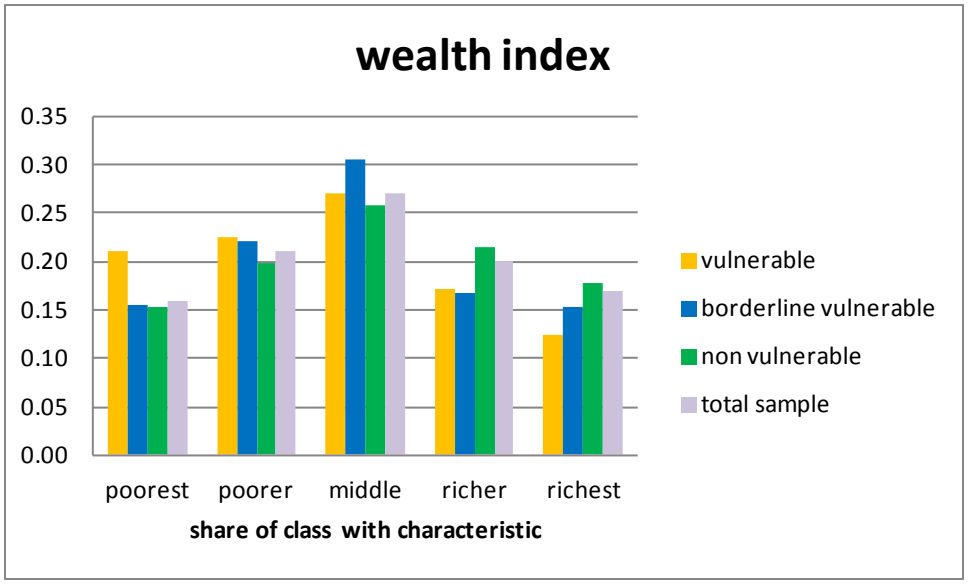

Figure A 21 Wealth index, urban West Africa

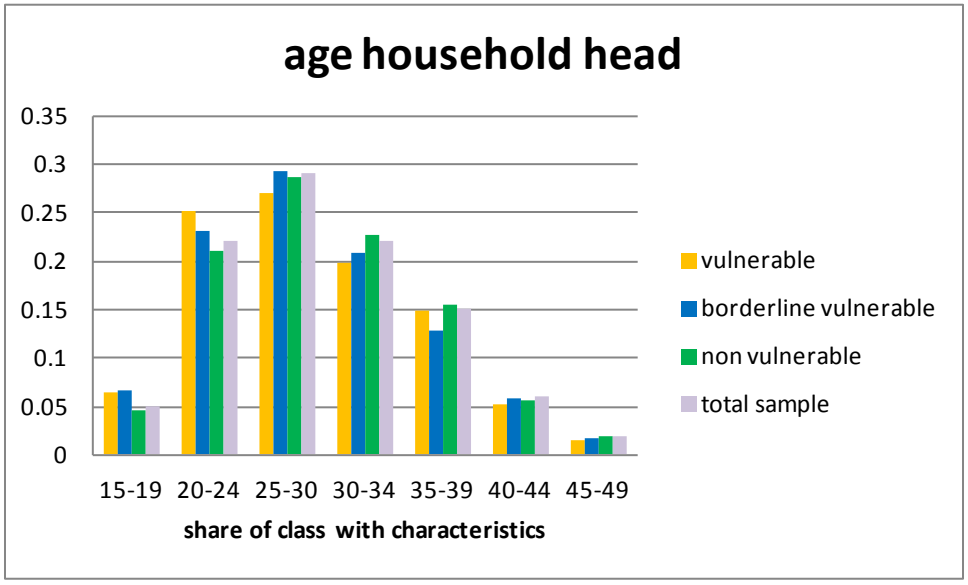

Figure A 22 Age of head of household, urban West Africa

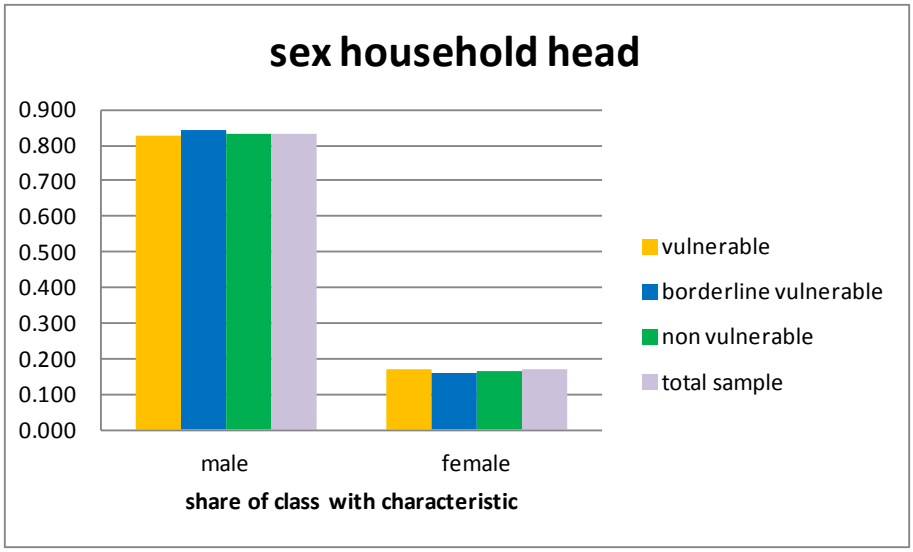

Figure A 23 Sex of household head, urban West Africa

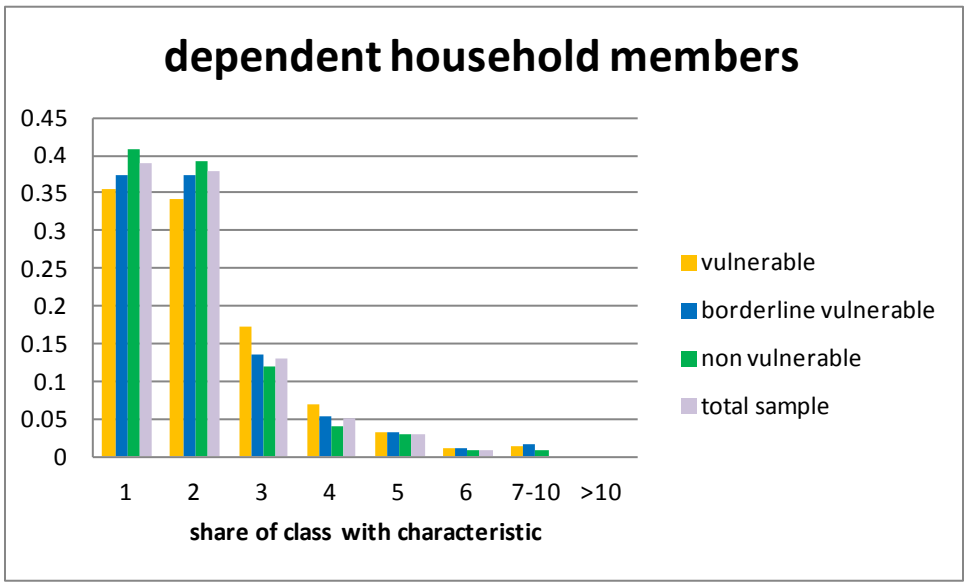

Figure A 24 Number of dependent household members, urban West Africa

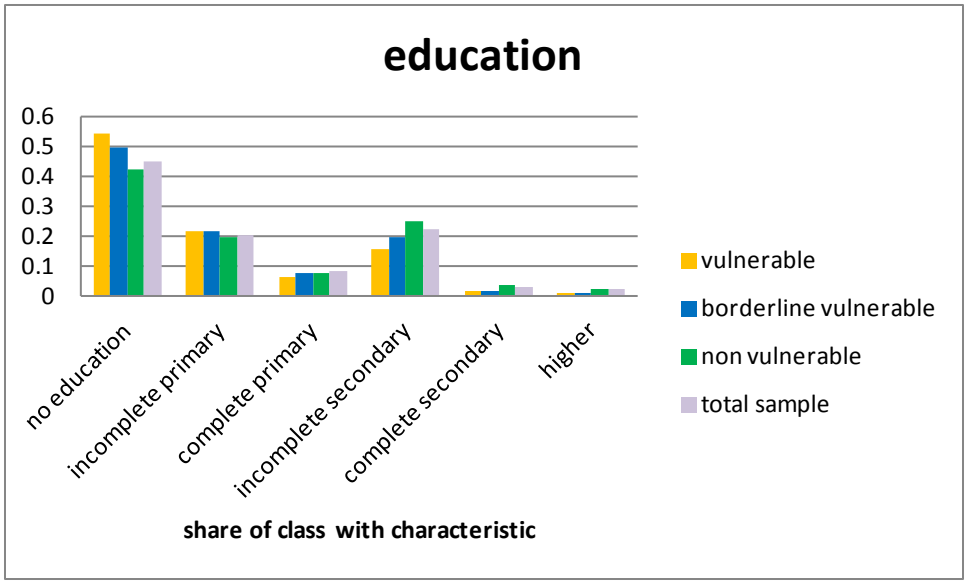

Figure A 25 Educational attainment of respondent, urban West Africa

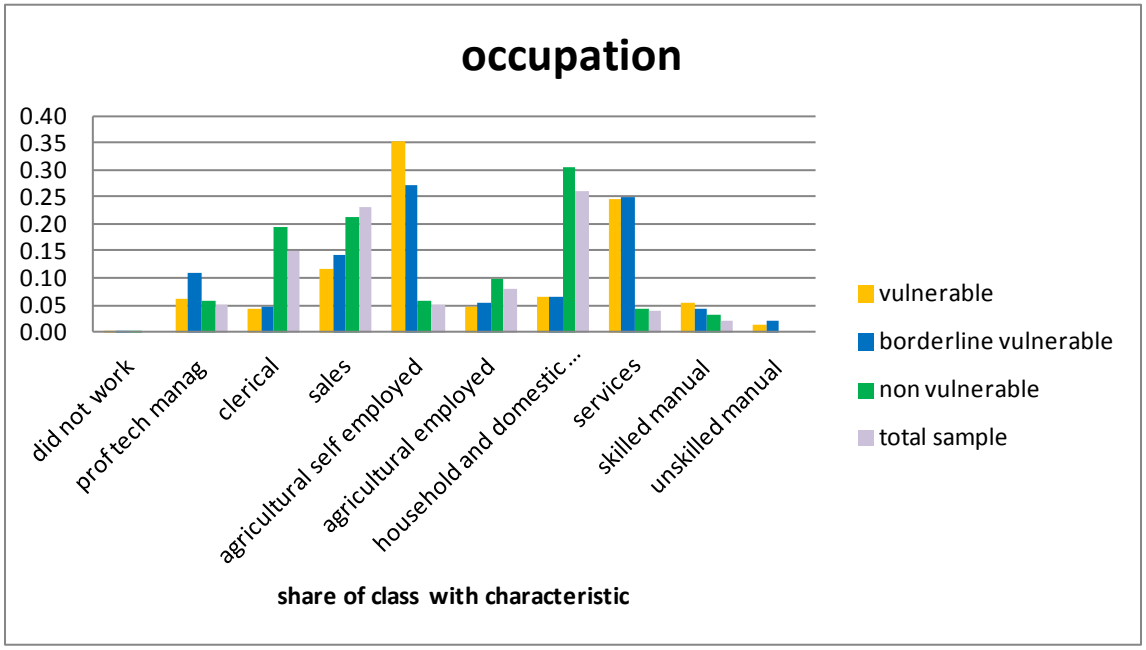

Figure A 26 Occupation of respondent, urban West Africa

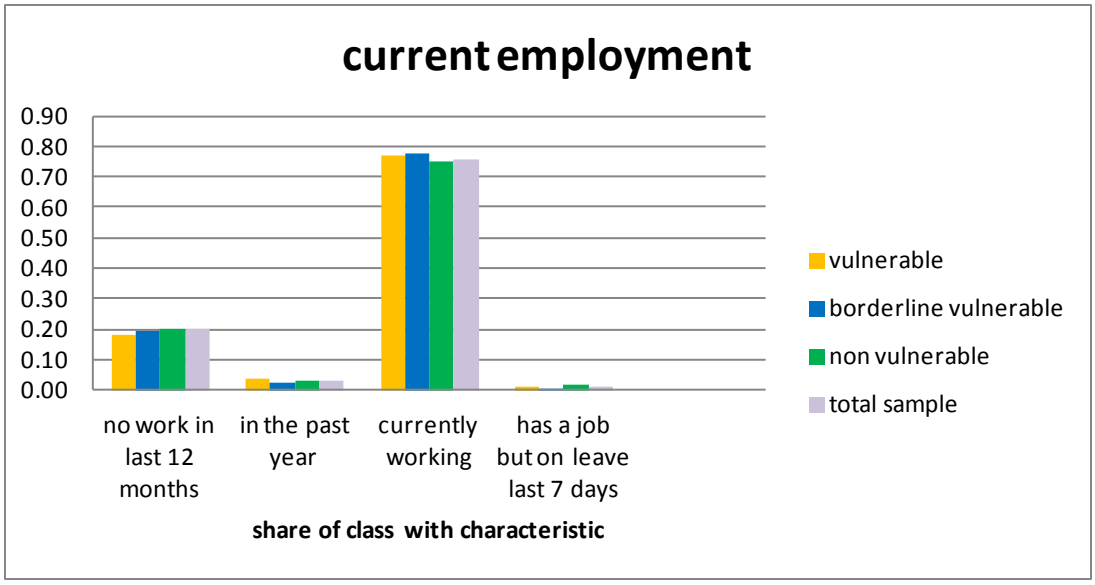

Figure A 27 Employment status of respondent, urban West Africa

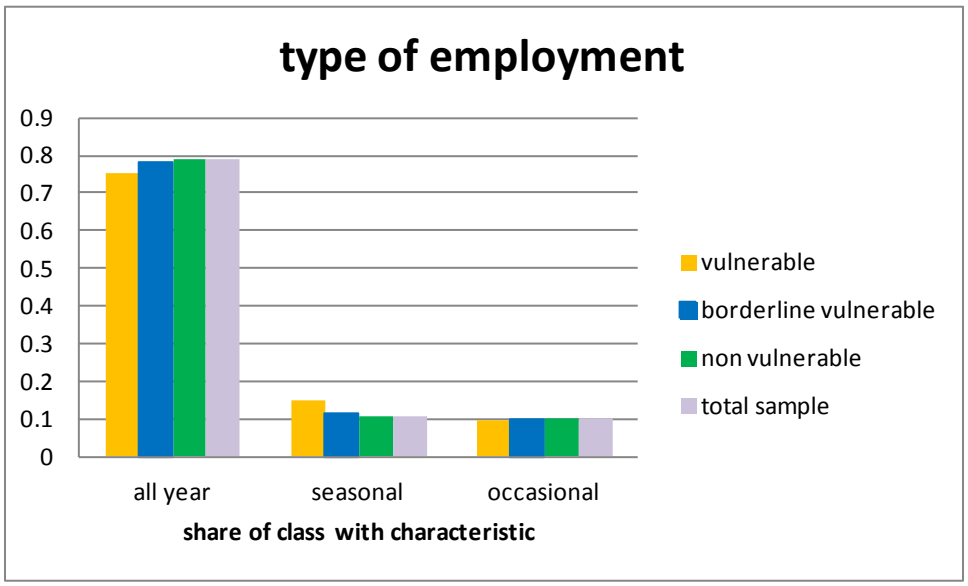

Figure A 28 Type of employment of respondent, urban West Africa

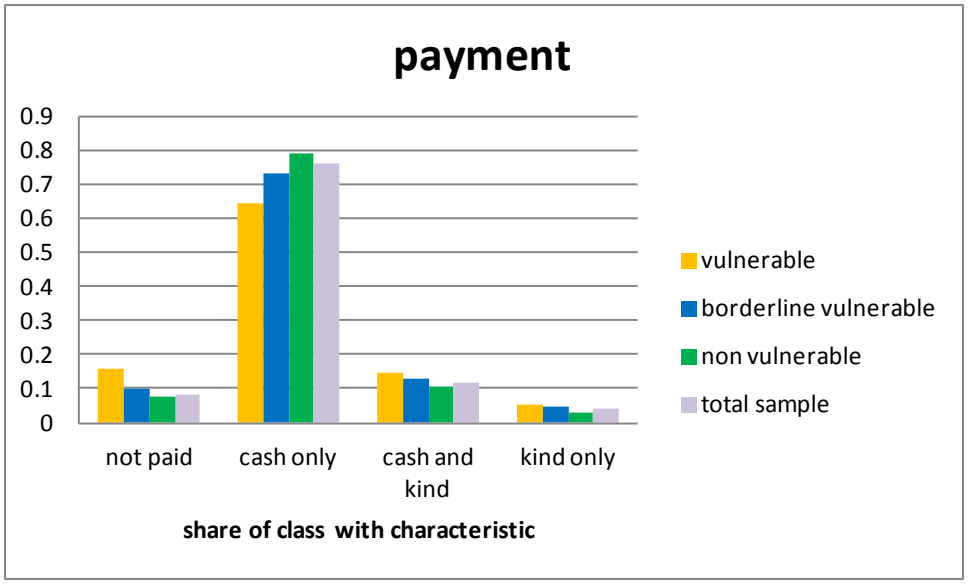

Figure A 29 Type of payment of respondent, urban West Africa

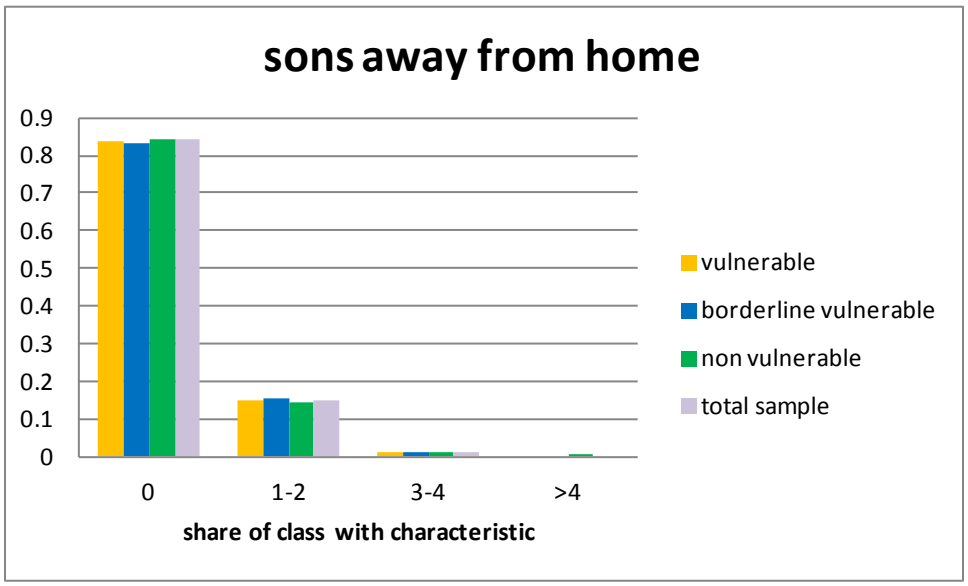

Figure A 30 Sons away from home, urban West Africa

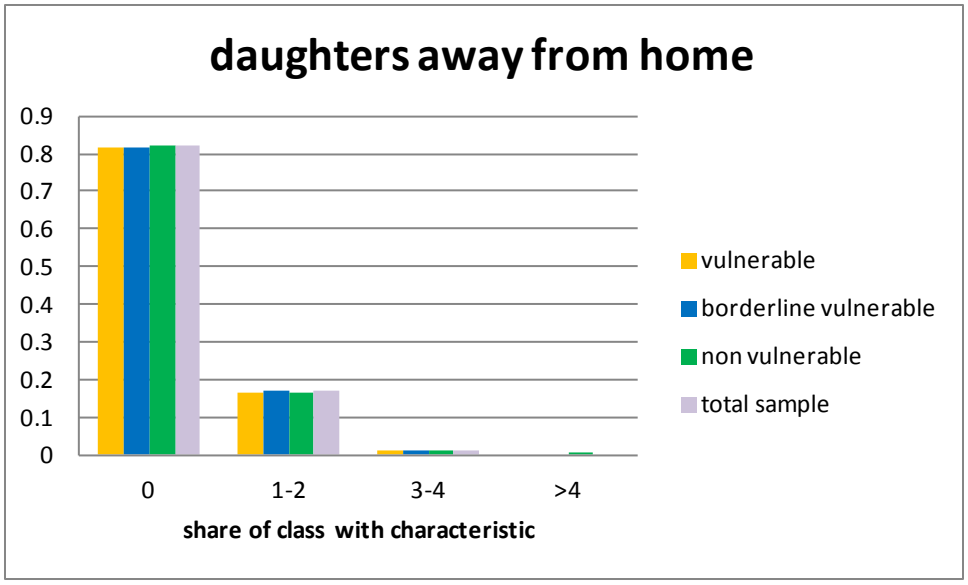

Figure A 31 Daughters away from home, urban West Africa

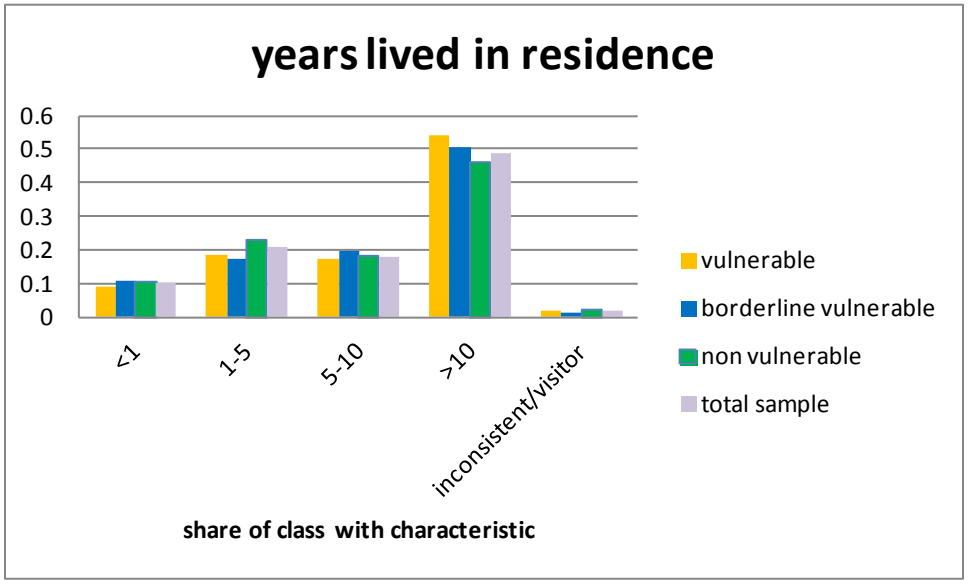

Figure A 32 Years lived in current residence, urban West Africa

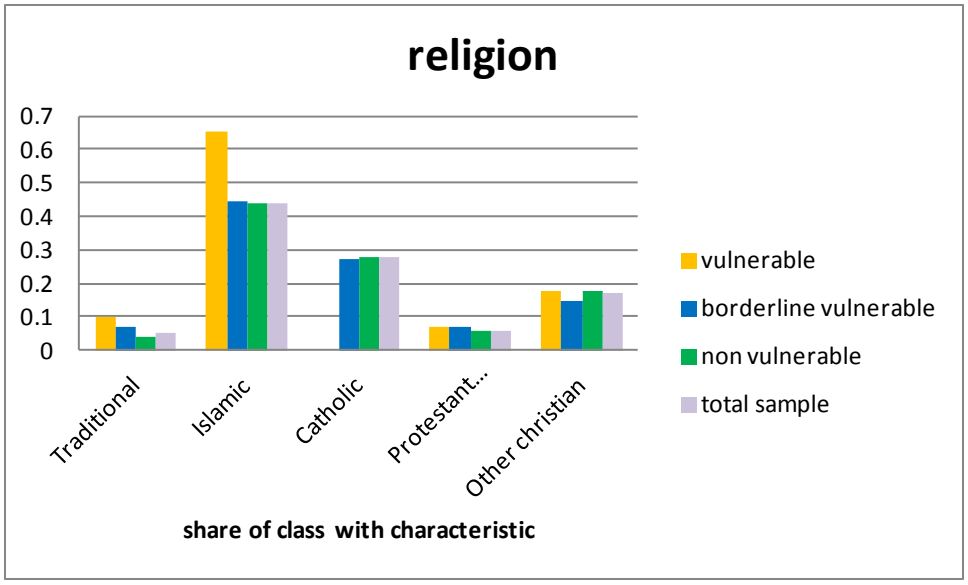

Figure A 33 Religion of respondent, urban West Africa

Urban West Africa: Afrobarometer data

Figure A 34 to Figure A 40 present the relative frequencies of different characteristics over the four vulnerability classes defined for the West Africa study area, for urban households for the Afrobarometer data.

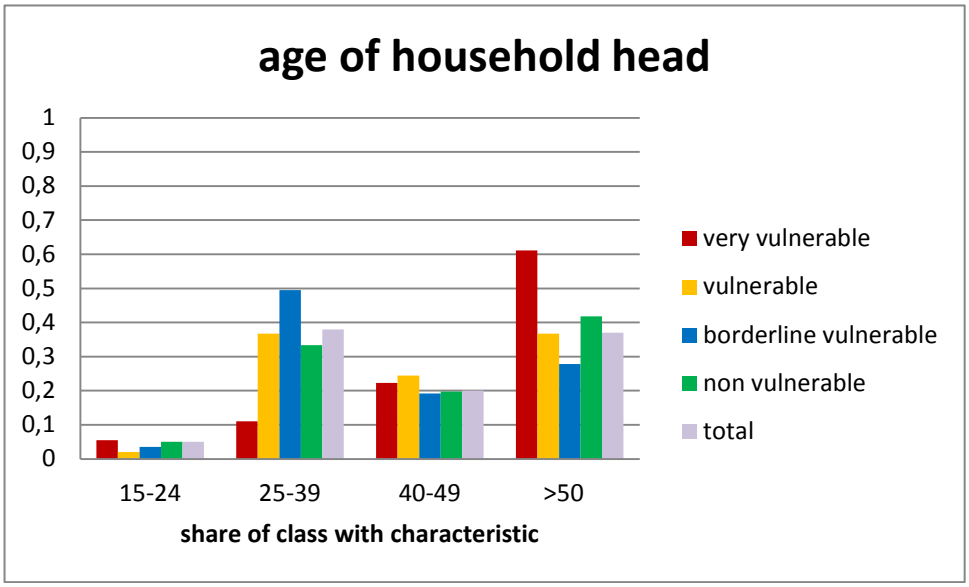

Figure A 34 Age of head of household, urban West Africa

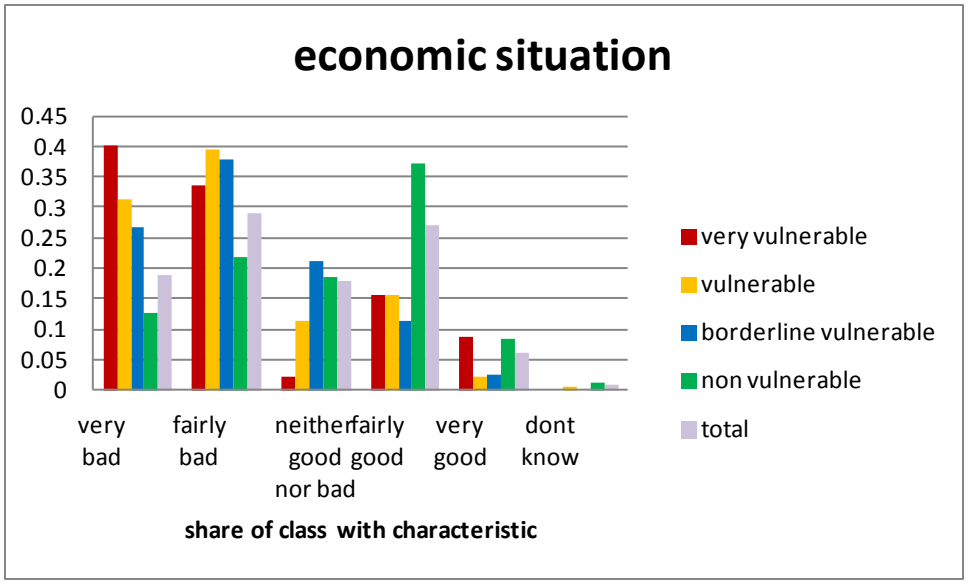

Figure A 35 Report on economic situation, urban West Africa

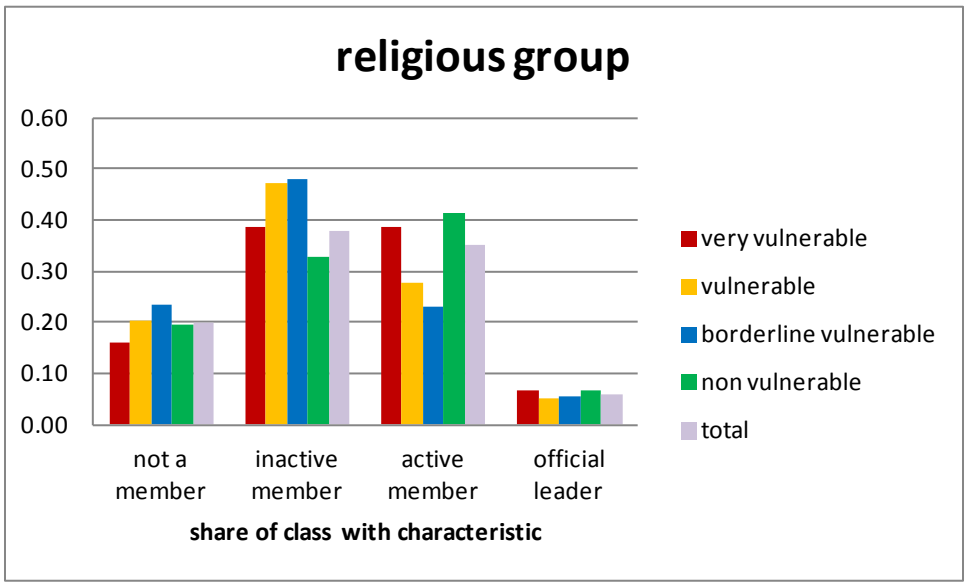

Figure A 36 Membership of religious group, urban West Africa

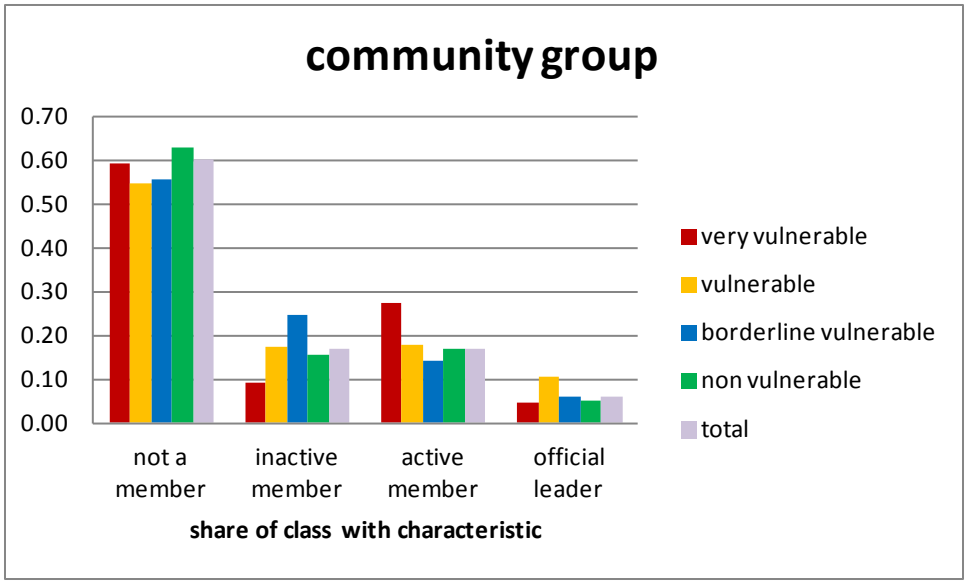

Figure A 37 Membership of community group, urban West Africa

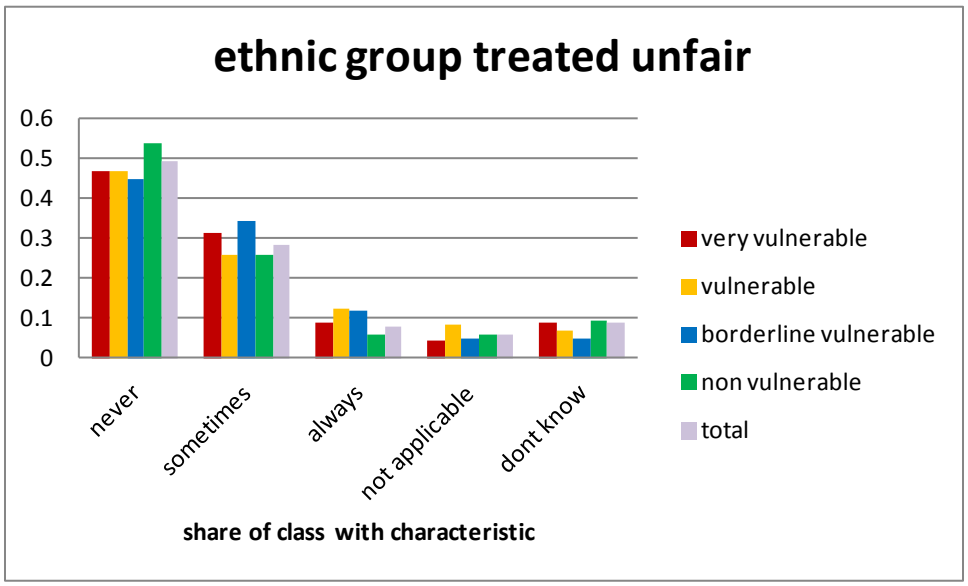

Figure A 38 Report on unfair treatment of respondent's ethnic group, urban West Africa

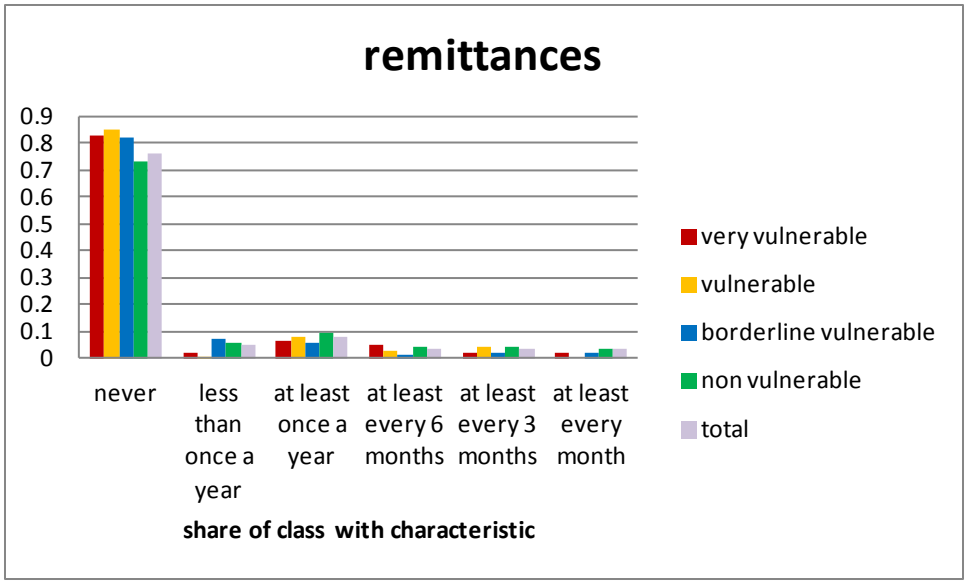

Figure A 39 Frequency of remittances, urban West Africa

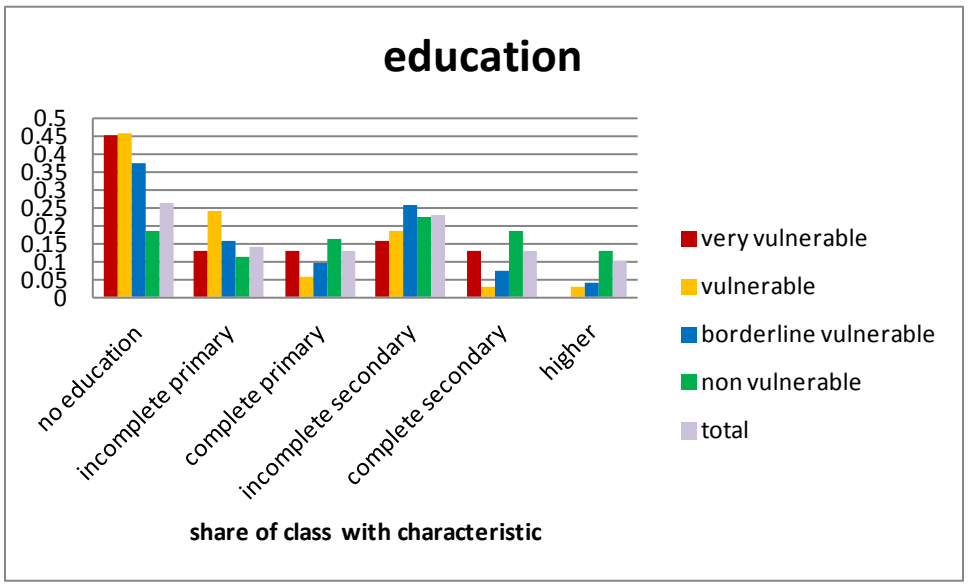

Figure A 40 Educational attainment of respondent, urban West Africa

Rural East Africa: DHS data

Figure A 41 to Figure A 53 present the relative frequencies of different characteristics over the four vulnerability classes defined for the East Africa study area, for rural households.

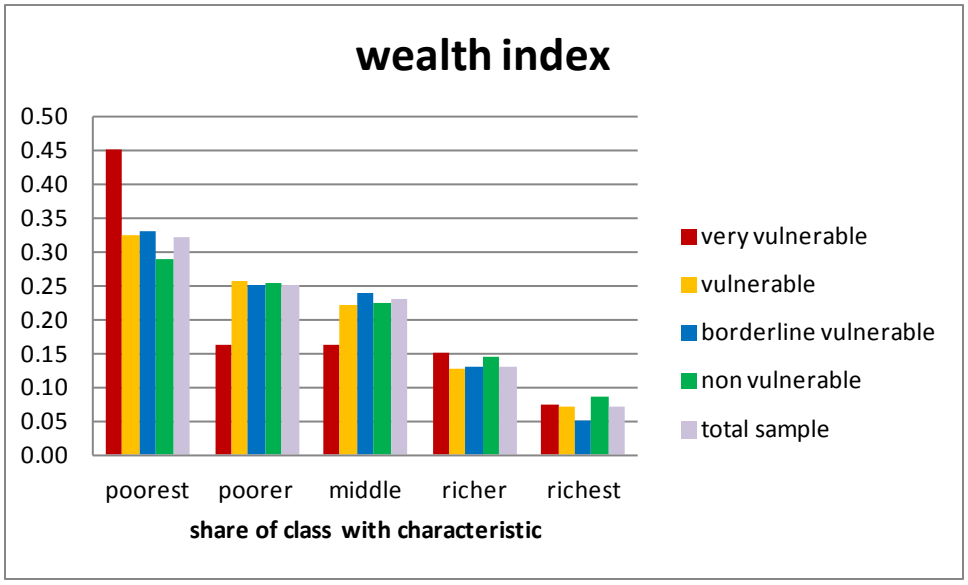

Figure A 41 Wealth index, rural East Africa

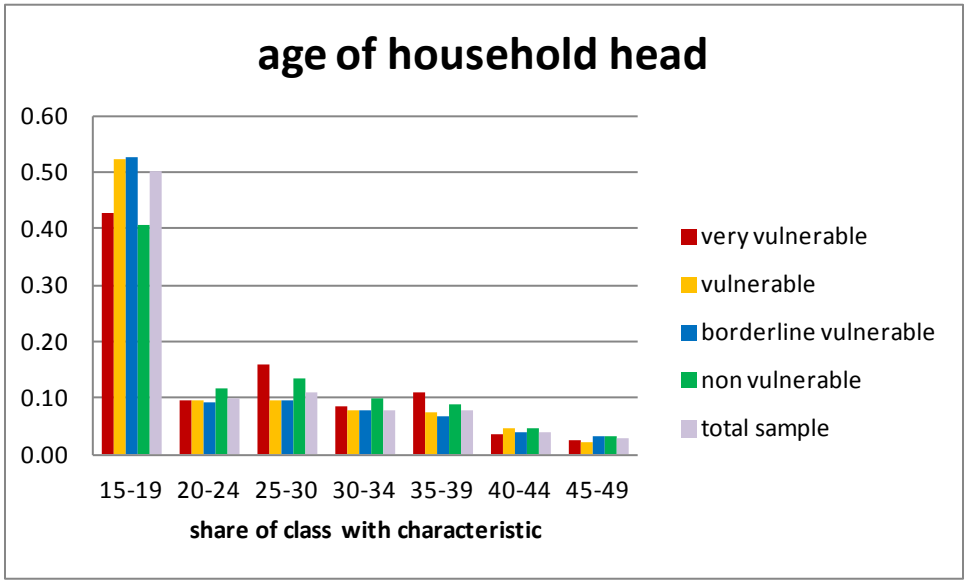

Figure A 42 Age of household head, rural East Africa

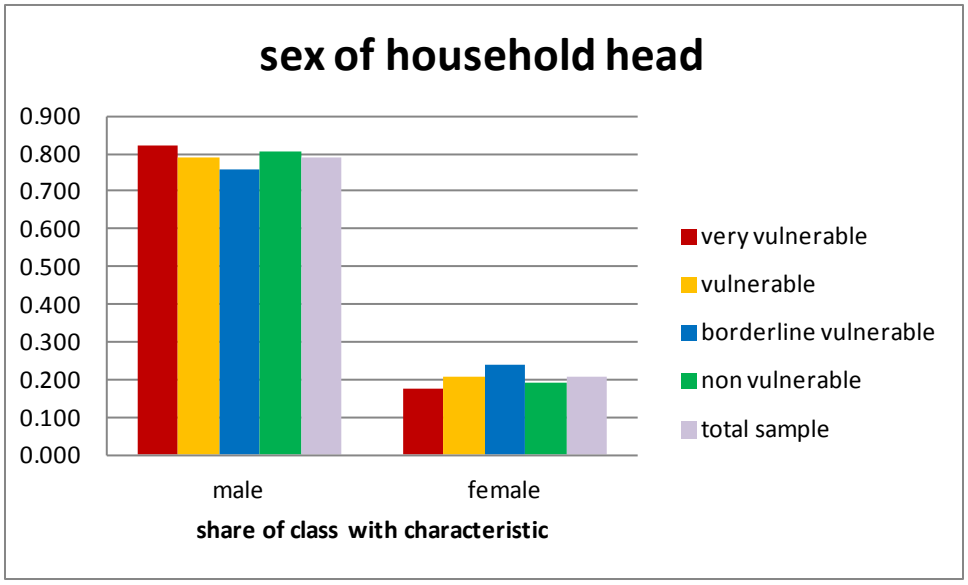

Figure A 43 Sex of household head, rural East Africa

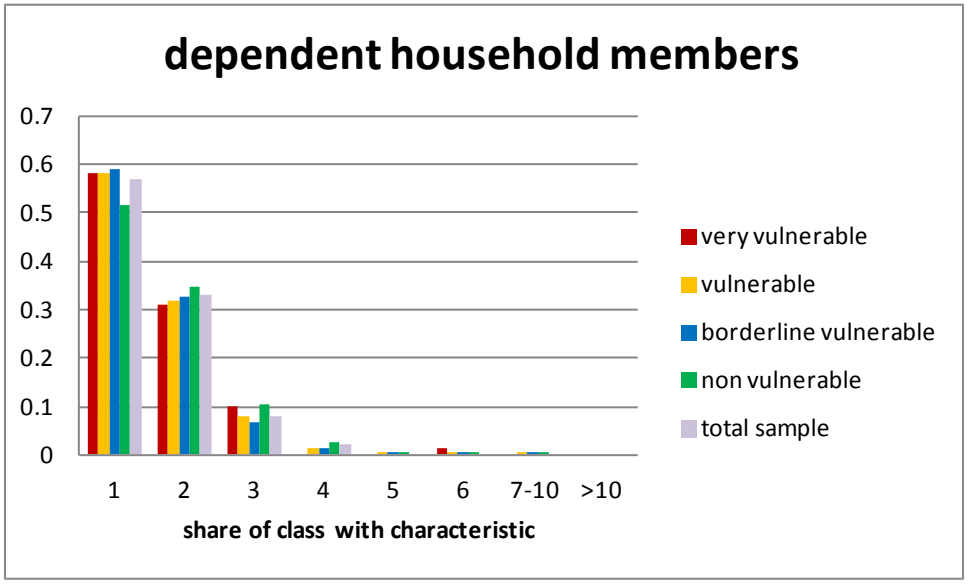

Figure A 44 Number of dependent household members, rural East Africa

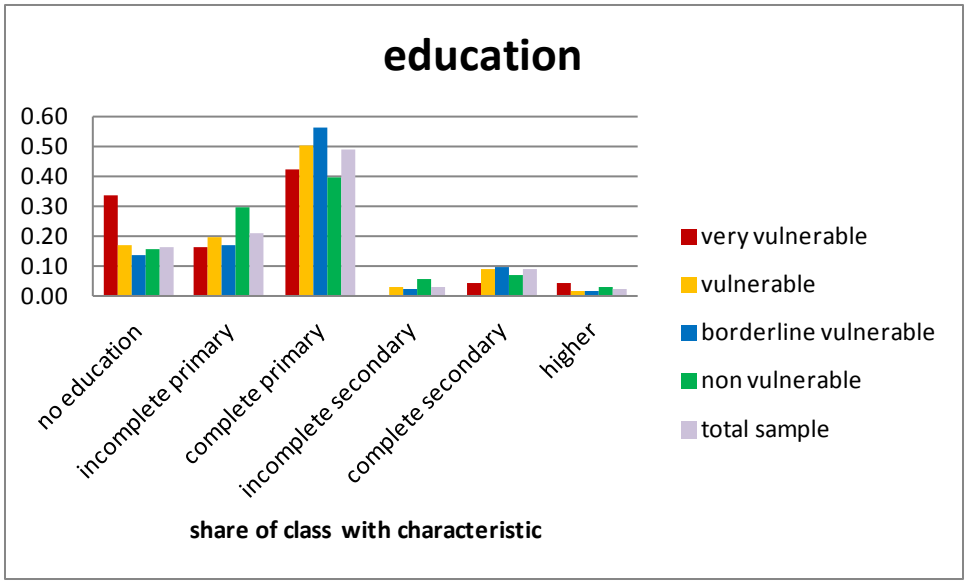

Figure A 45 Educational attainment of respondent, rural East Africa

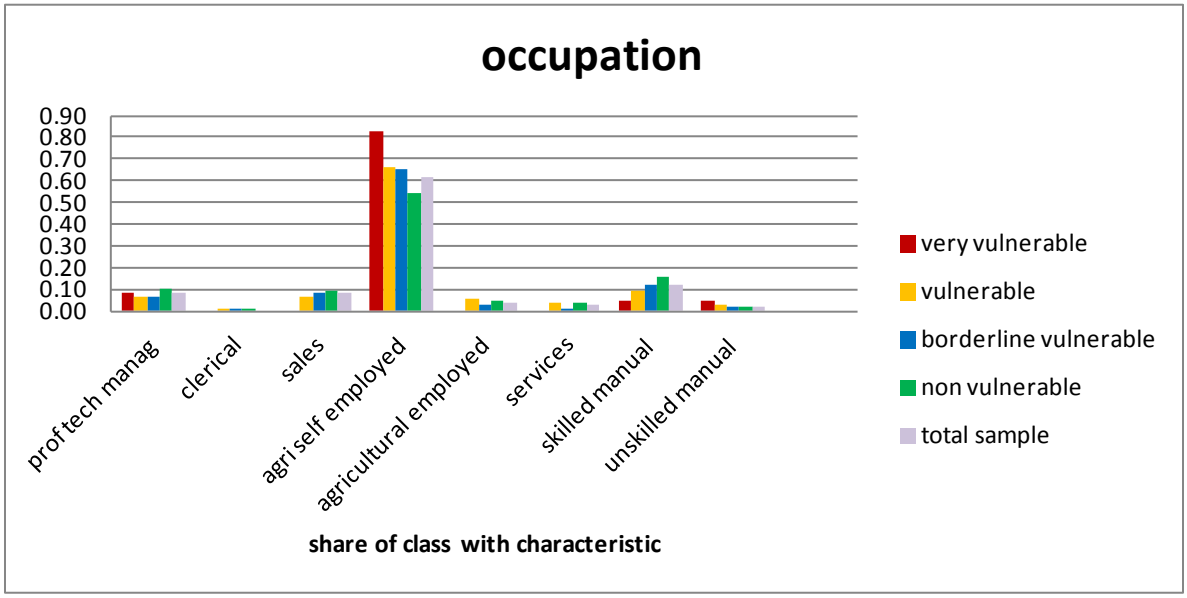

Figure A 46 Occupation of respondent, rural East Africa

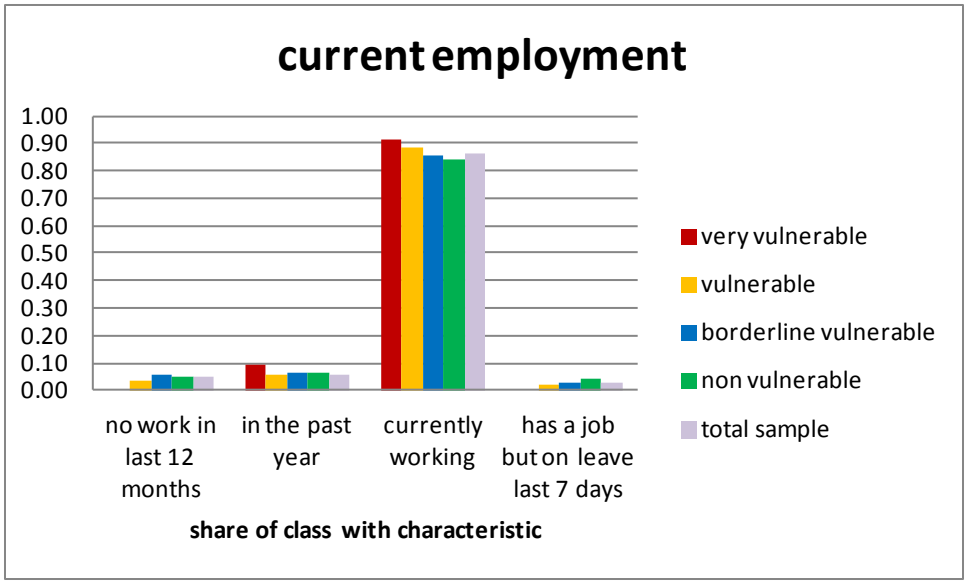

Figure A 47 Employment status of respondent, rural East Africa

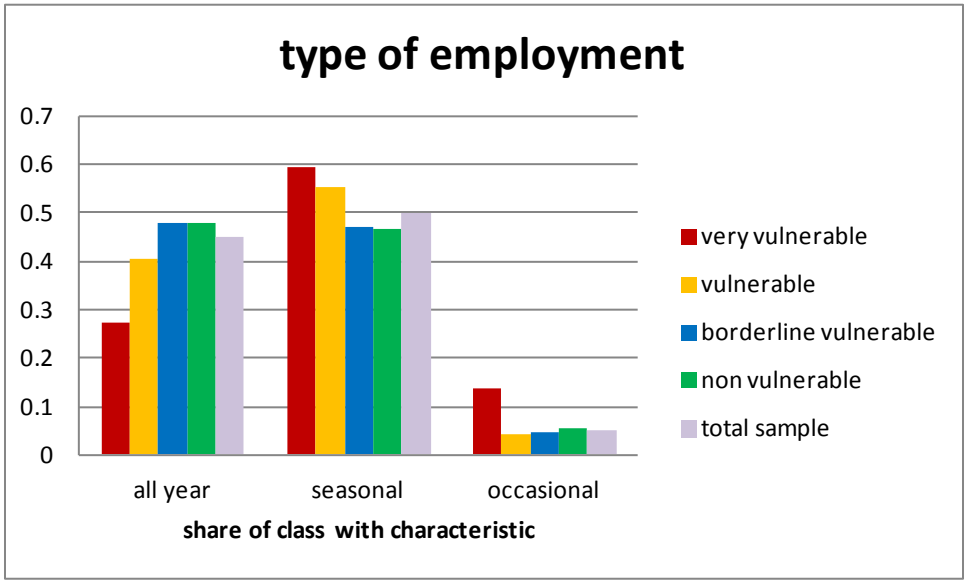

Figure A 48 Employment type of respondent, rural East Africa

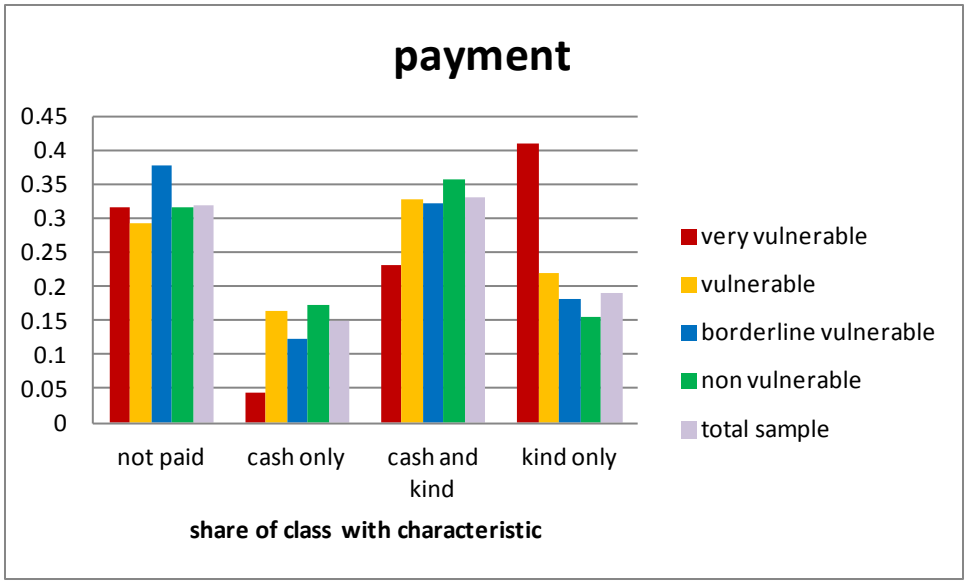

Figure A 49 Type of payment to respondent, East Africa

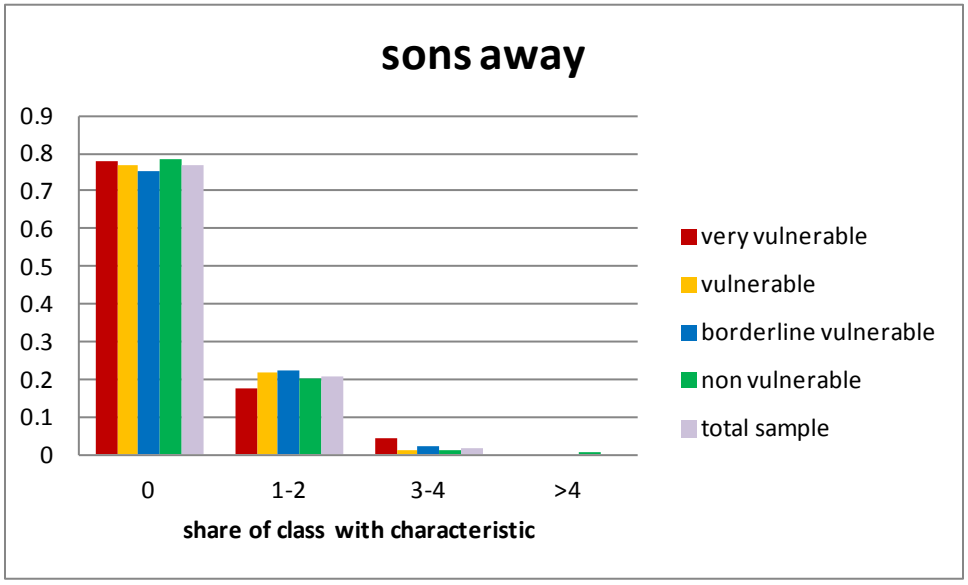

Figure A 50 Sons away from home, rural East Africa

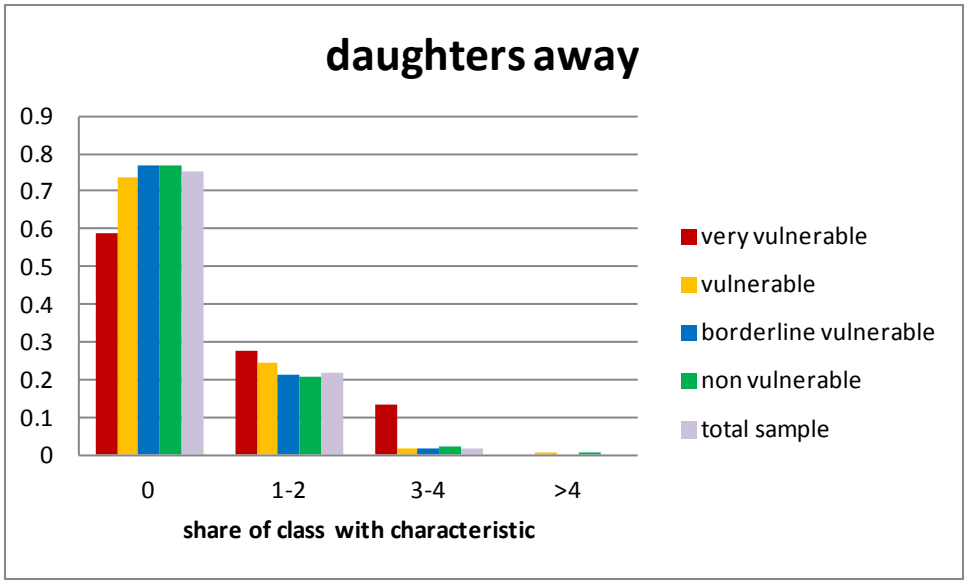

Figure A 51 Daughters away from home, rural East Africa

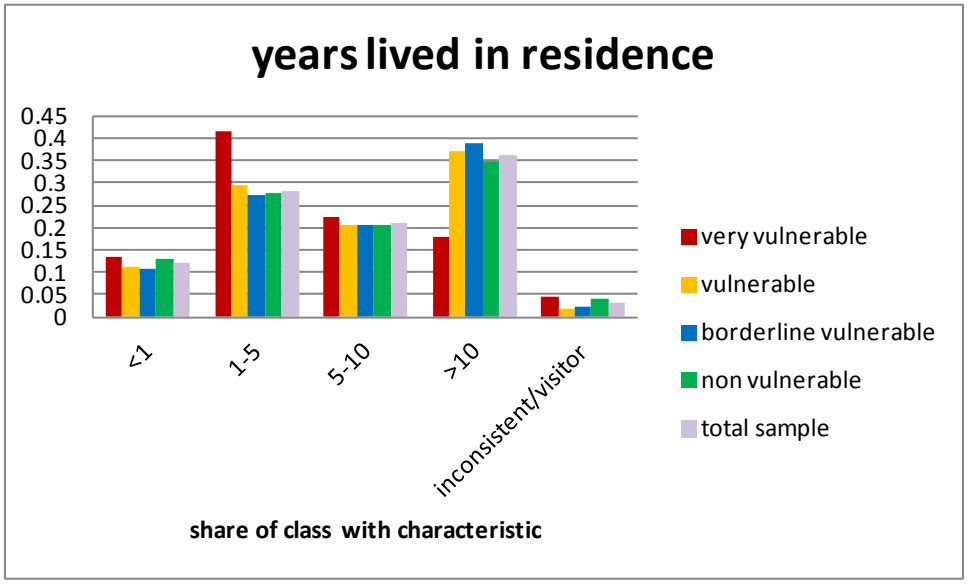

Figure A 52 Years lived in current residence, rural East Africa

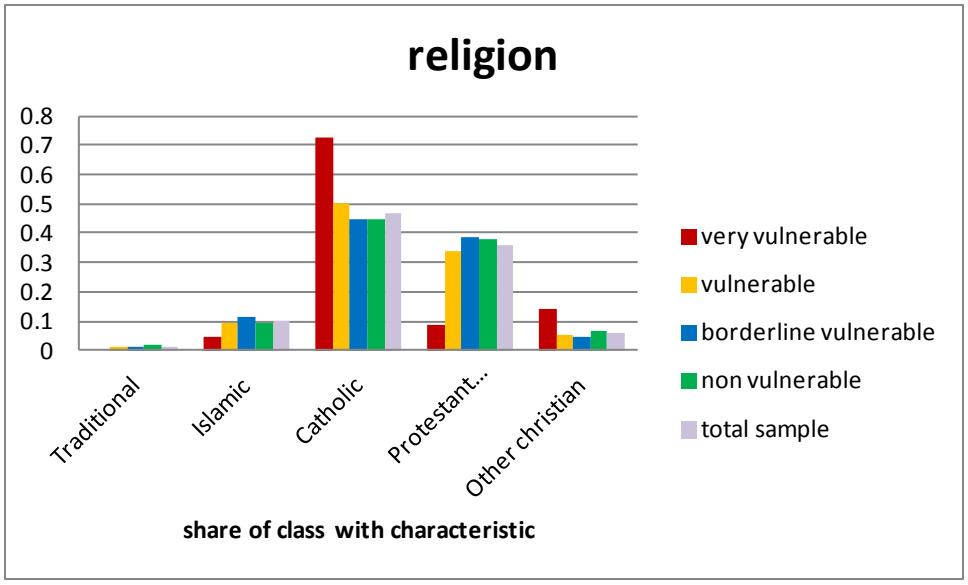

Figure A 53 Religion of respondent, rural East Africa

Rural East Africa: Afrobarometer data

Figure A 54 to Figure A 60 present the relative frequencies of different characteristics over the four vulnerability classes defined for the East Africa study area, for rural households for the Afrobarometer data.

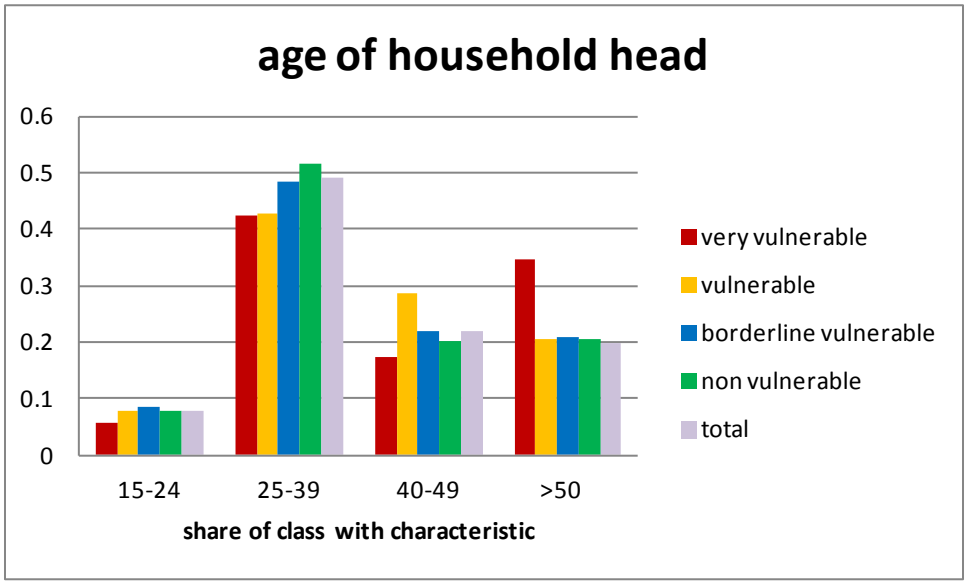

Figure A 54 Age of household head, rural East Africa

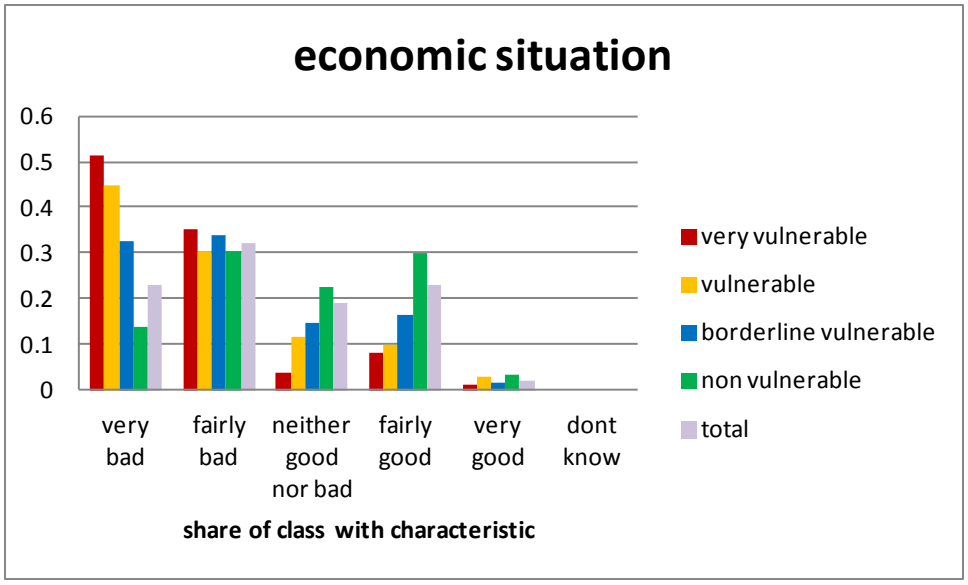

Figure A 55 Report of economic situation, rural East Africa

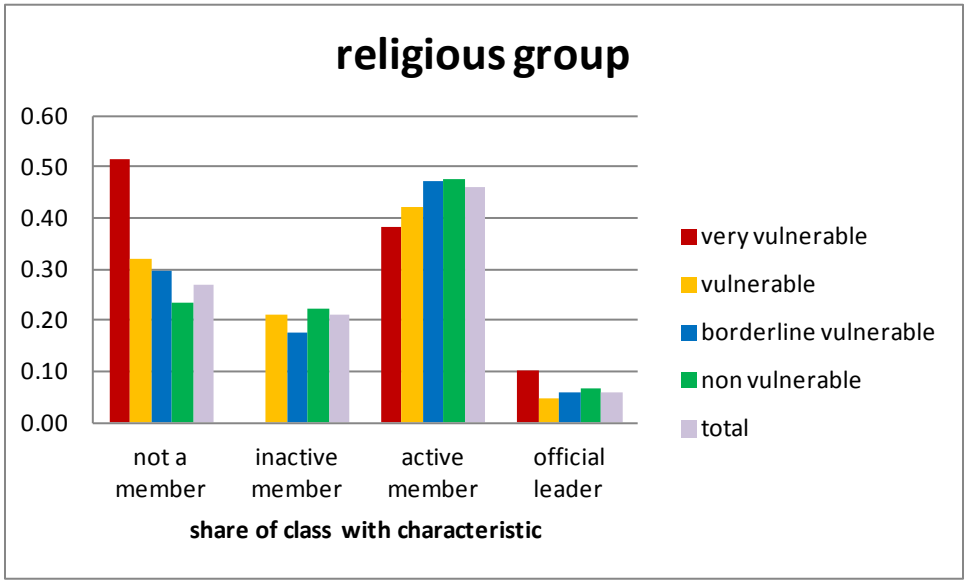

Figure A 56 Member of religious group, rural East Africa

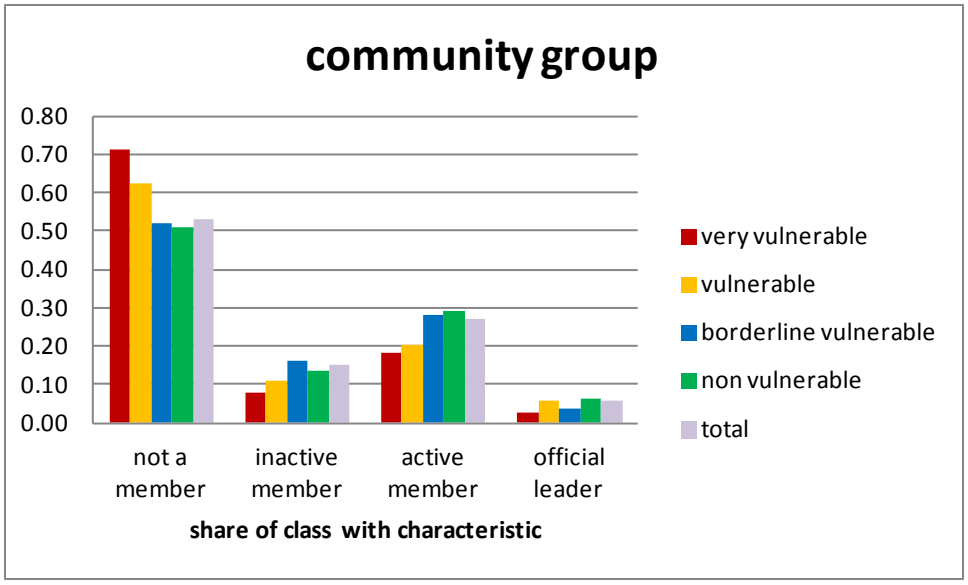

Figure A 57 member of community group, rural East Africa

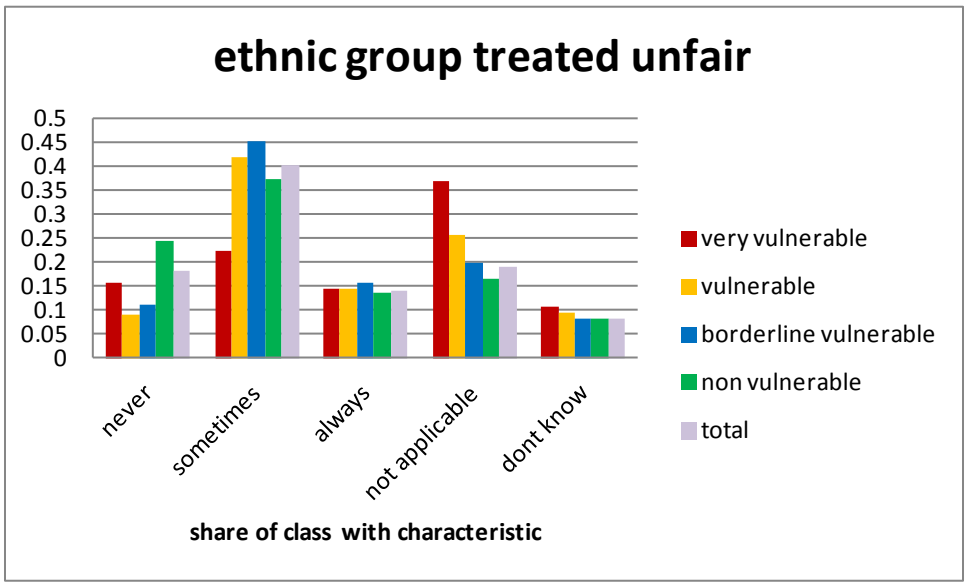

Figure A 58 Report on unfair treatment of respondent's ethnic group, rural East Africa

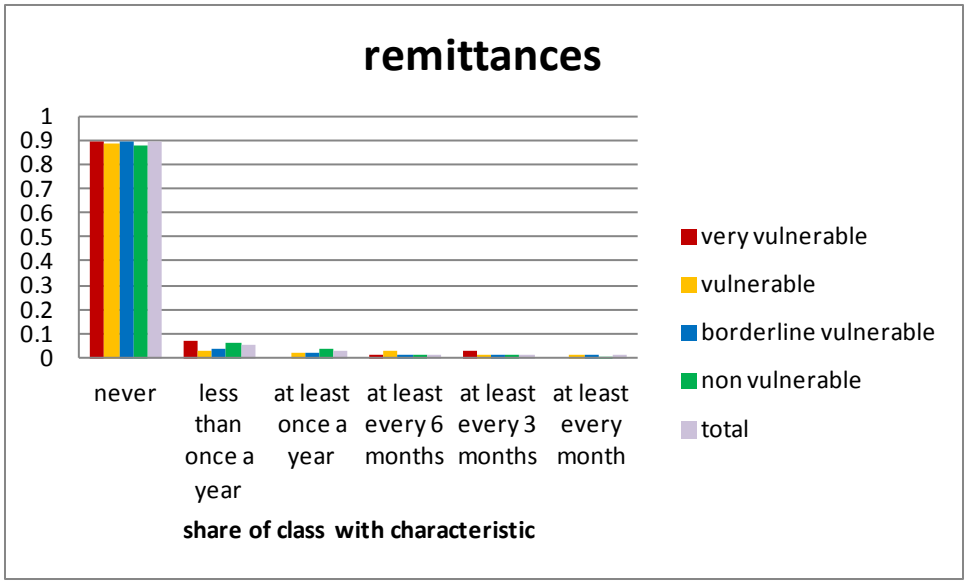

Figure A 59 Frequency of remittances, rural East Africa

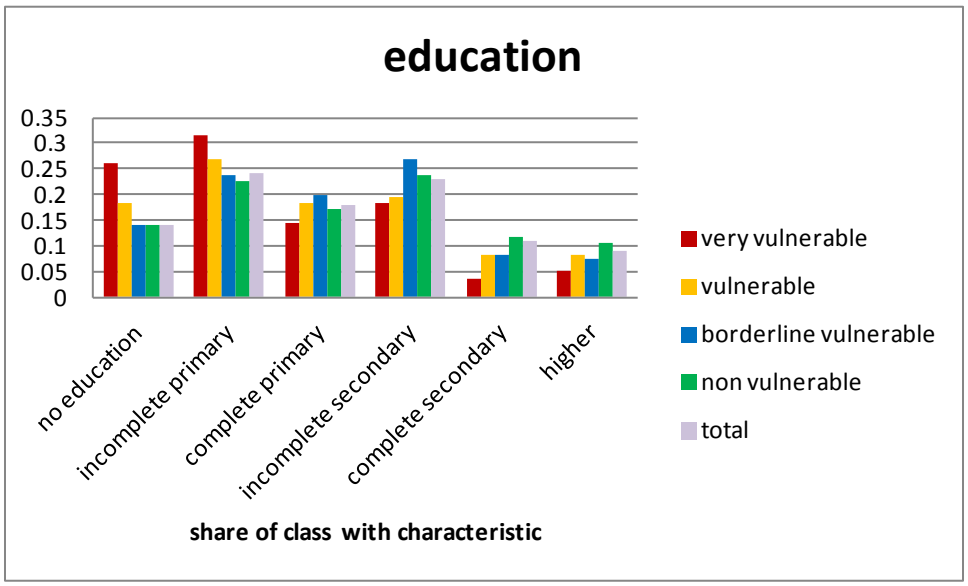

Figure A 60 Educational attainment of respondent, rural East Africa

Urban East Africa: DHS data

Figure A 61 to Figure A 72Figure A 53 present the relative frequencies of different characteristics for three of the four vulnerability classes defined for the East Africa study area, for urban households. Very vulnerable households represent a too small part of the population to be included.

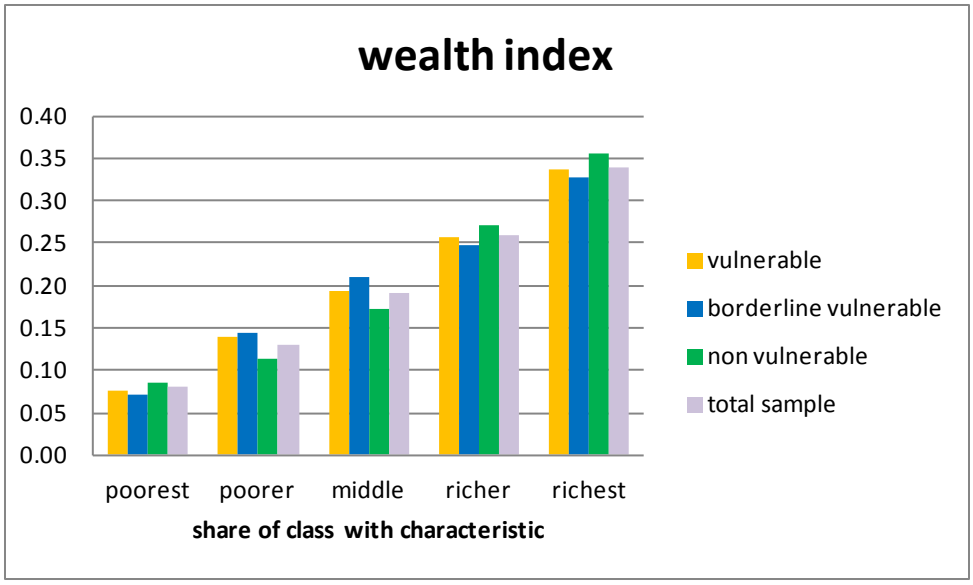

Figure A 61 Wealth index, urban East Africa

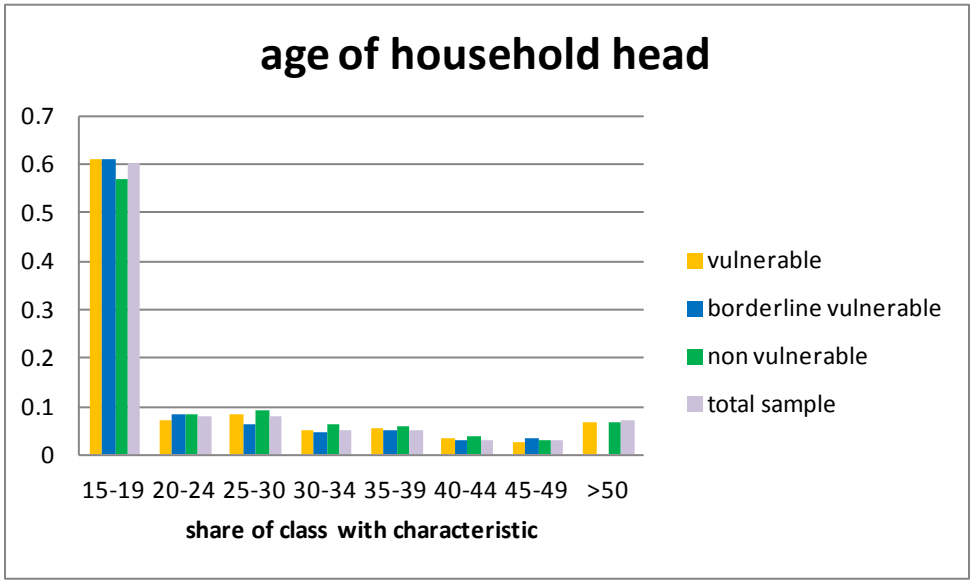

Figure A 62 Age of household head, urban East Africa

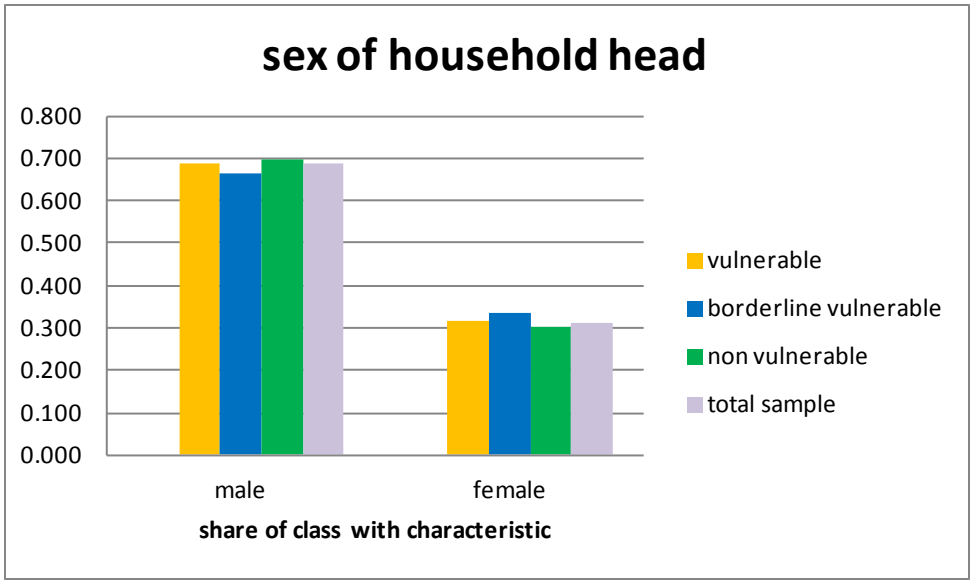

Figure A 63 Sex of household head, urban East Africa

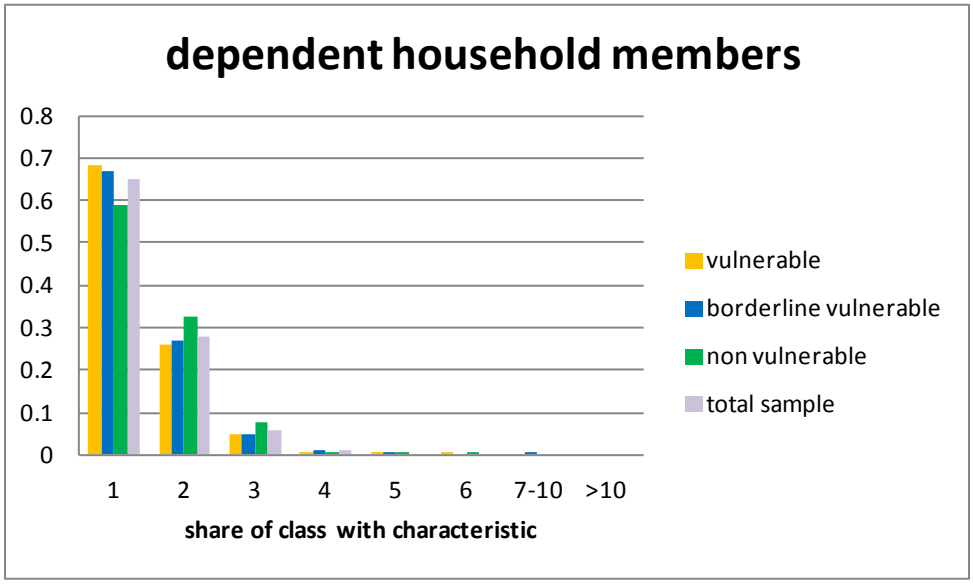

Figure A 64 Number of dependent household members, urban East Africa

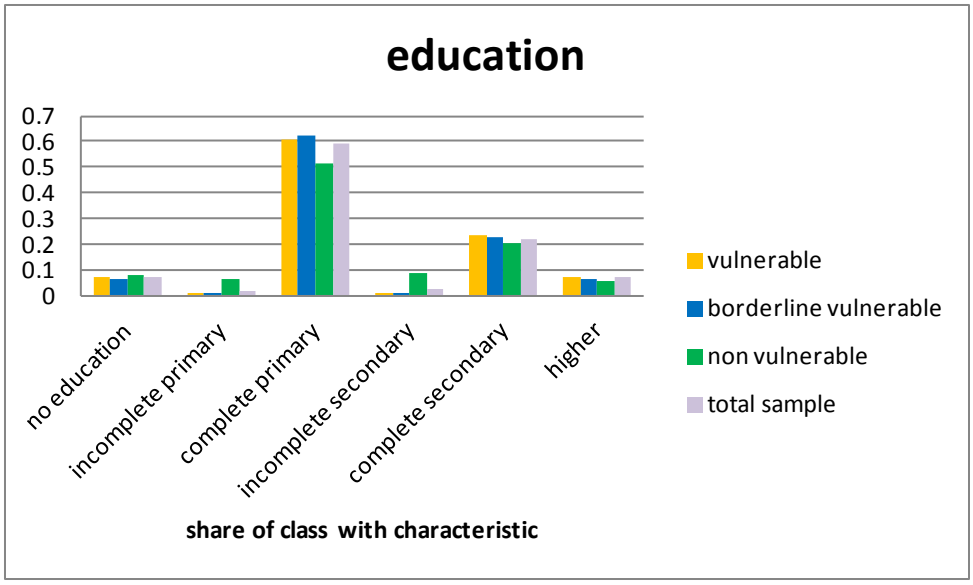

Figure A 65 Educational attainment of respondent, urban East Africa

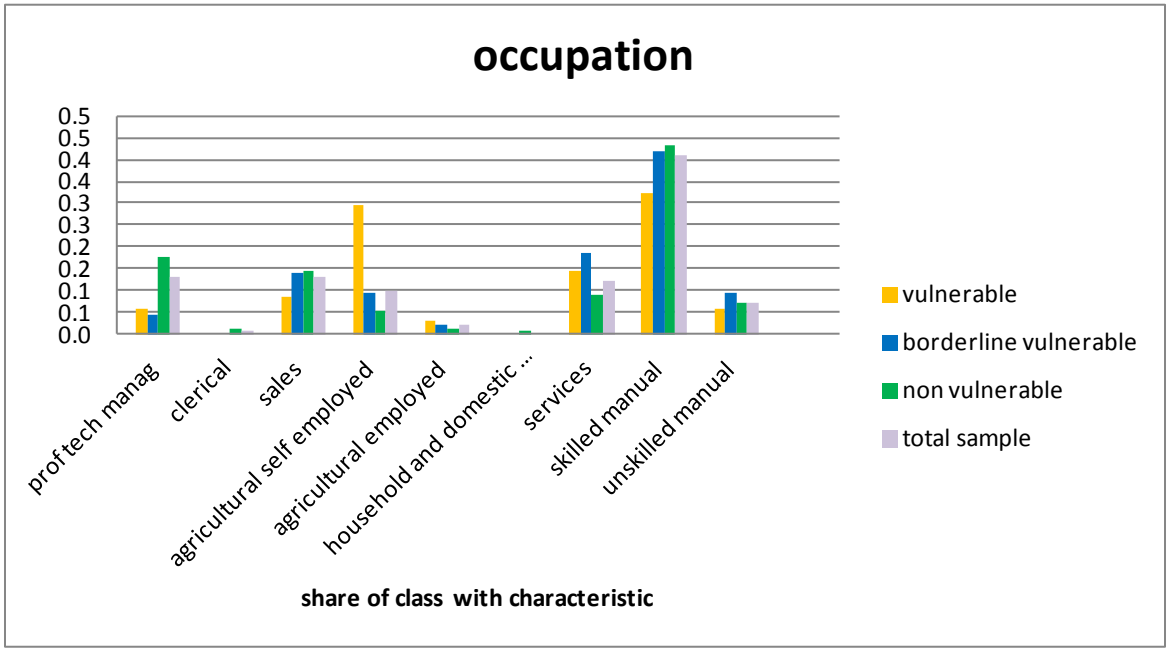

Figure A 66 Occupation of respondent, urban East Africa

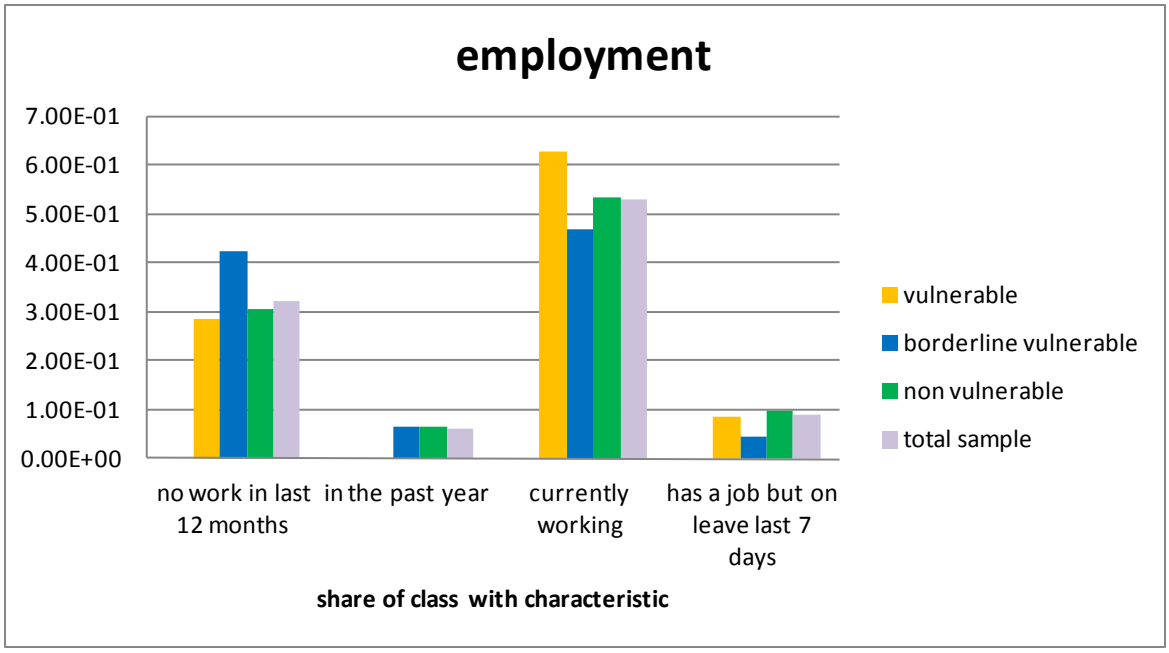

Figure A 67 Employment status of respondent, urban East Africa

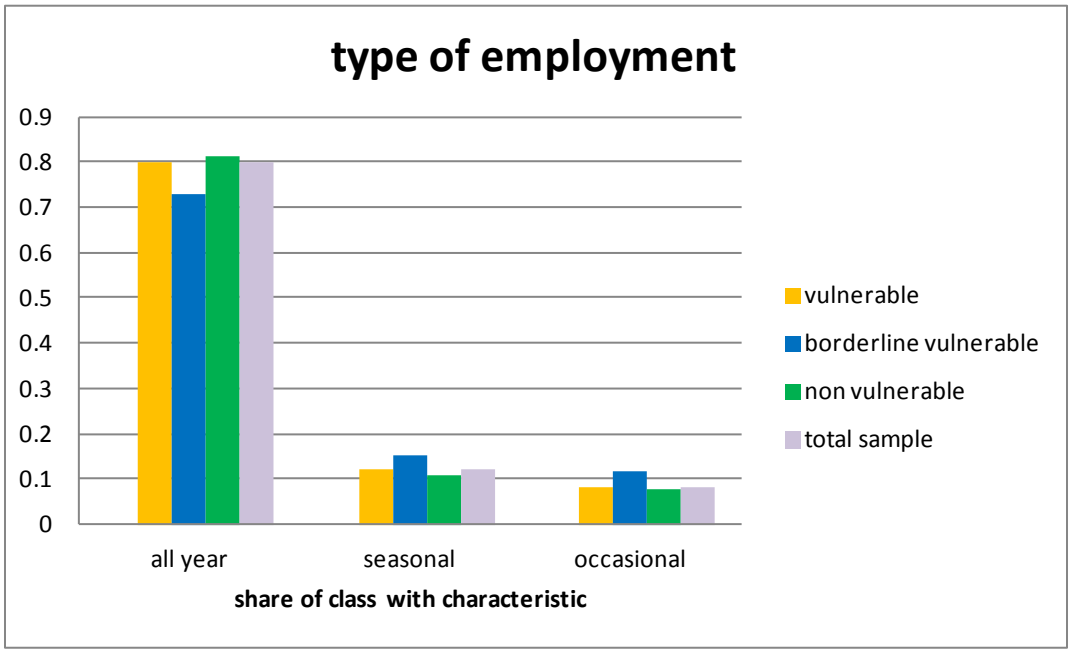

Figure A 68 Type of employment of respondent, urban East Africa

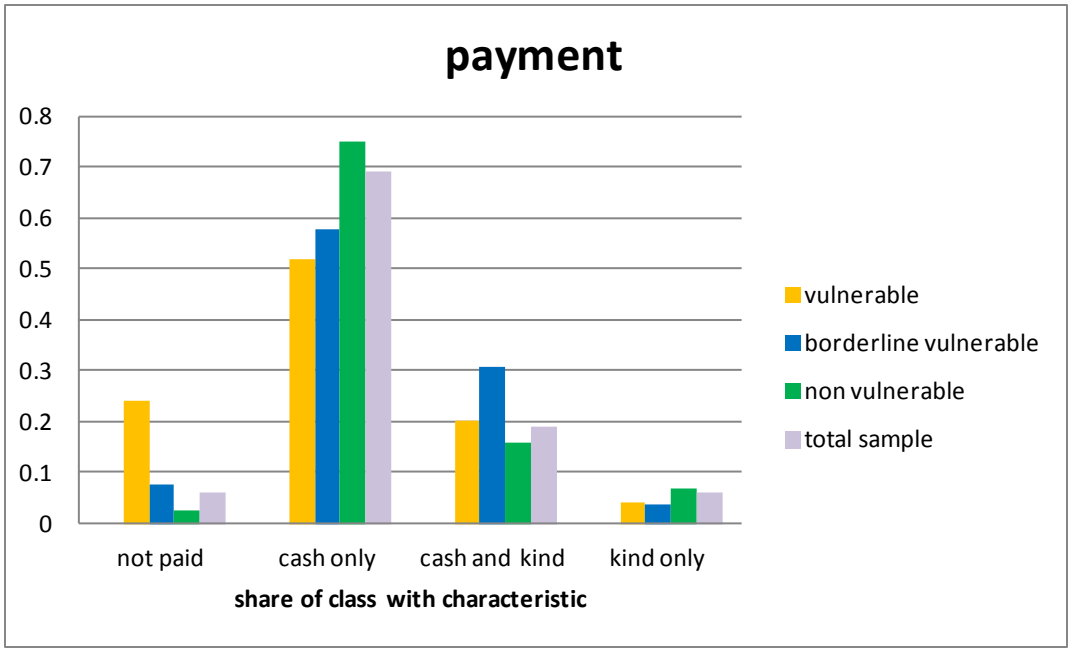

Figure A 69 Type of payment of respondent, urban East Africa

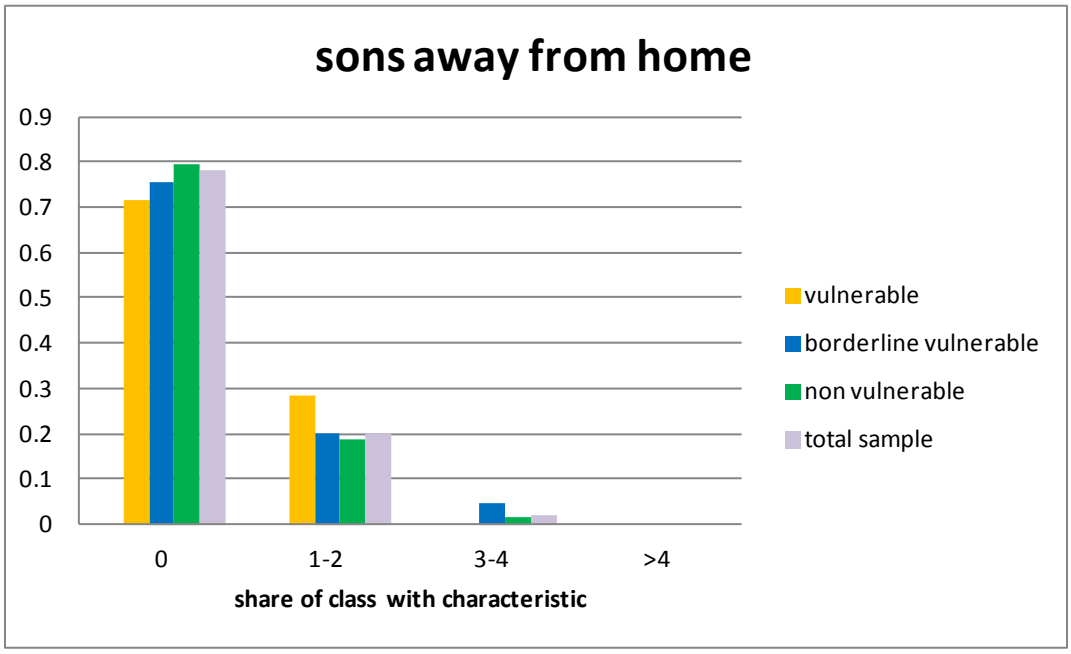

Figure A 70 Sons away from home, urban East Africa

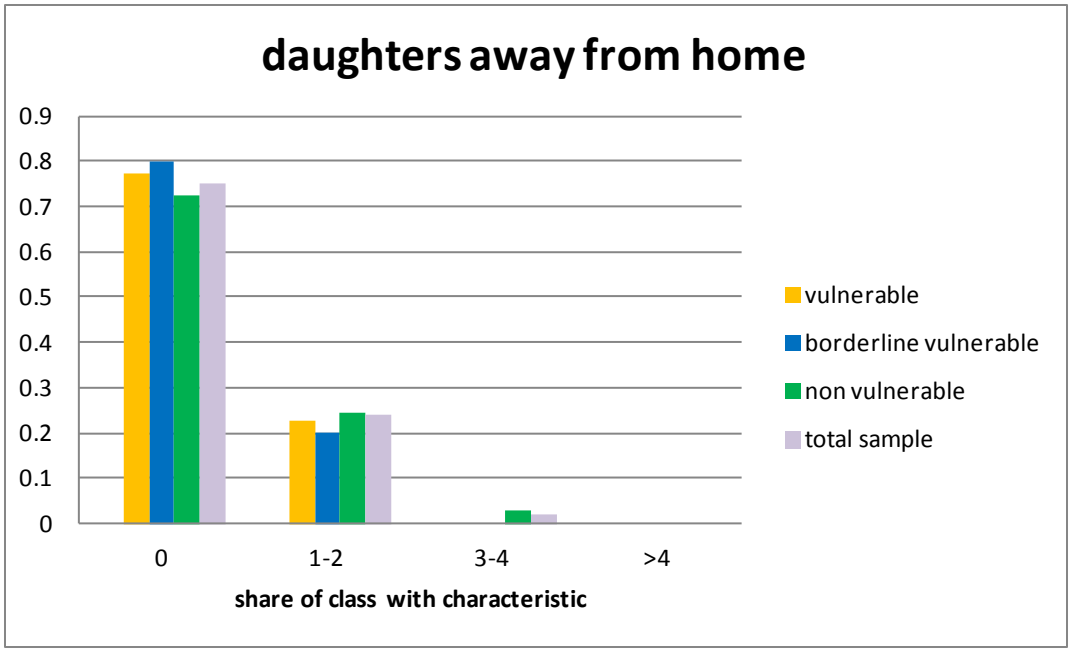

Figure A 71 Daughters away from home, urban East Africa

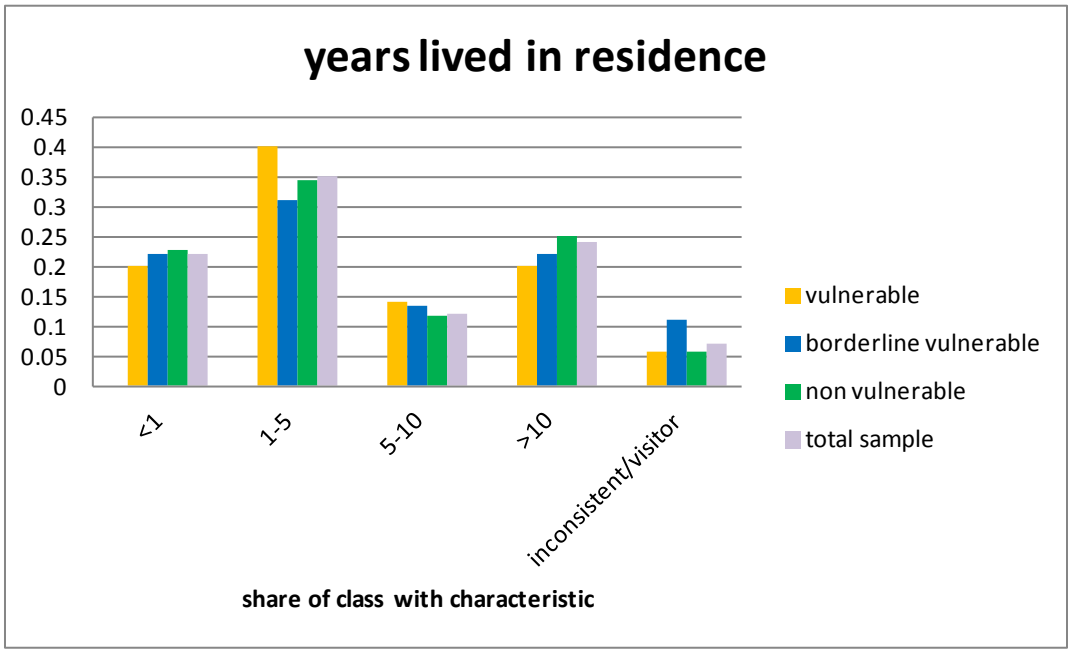

Figure A 72 Years lived in residence, urban East Africa

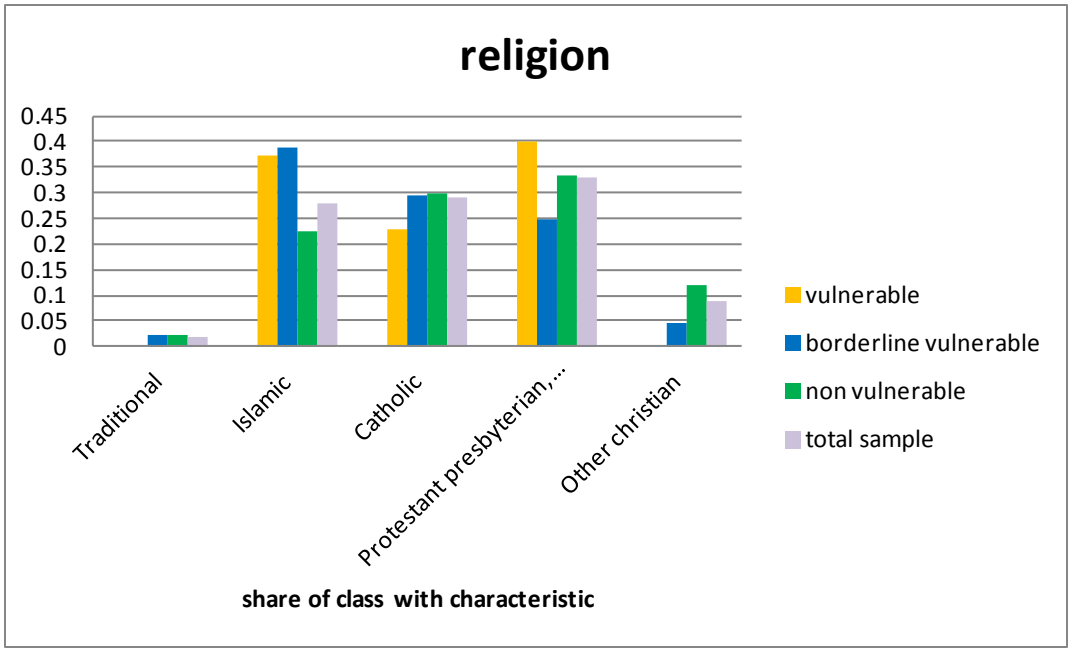

Figure A 73 Religion of respondent, urban East Africa

Urban East Africa: Afrobarometer

Figure A 74 to Figure A 80 present the relative frequencies of different characteristics over the four vulnerability classes defined for the East Africa study area, for urban households for the Afrobarometer data.

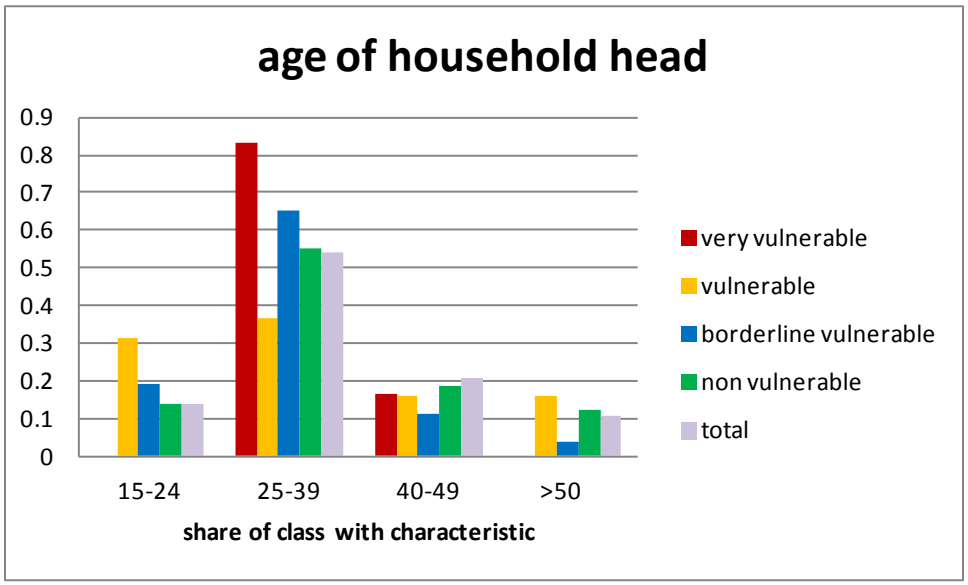

Figure A 74 Age of household head, urban East Africa

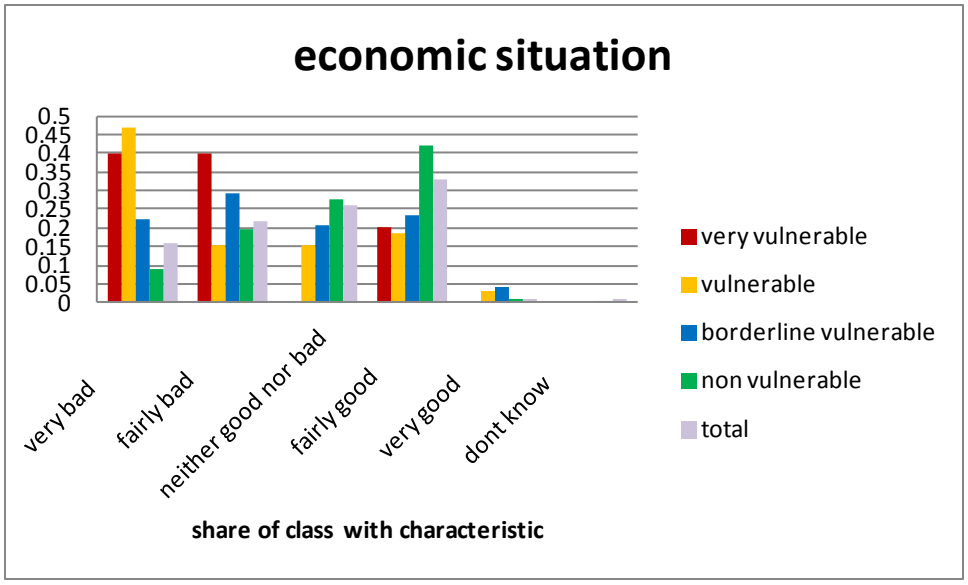

Figure A 75 Report on economic situation, urban East Africa

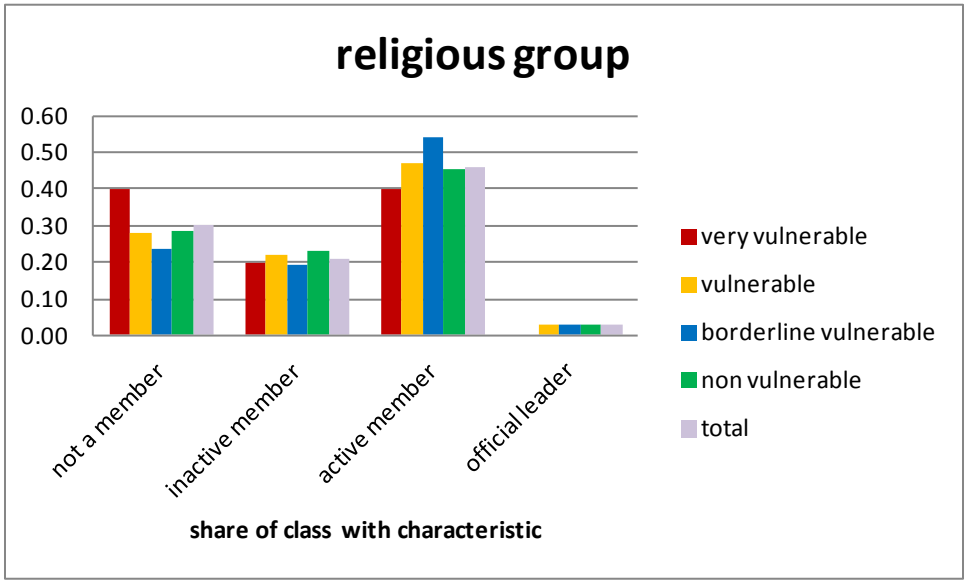

Figure A 76 Member of religious group, urban East Africa

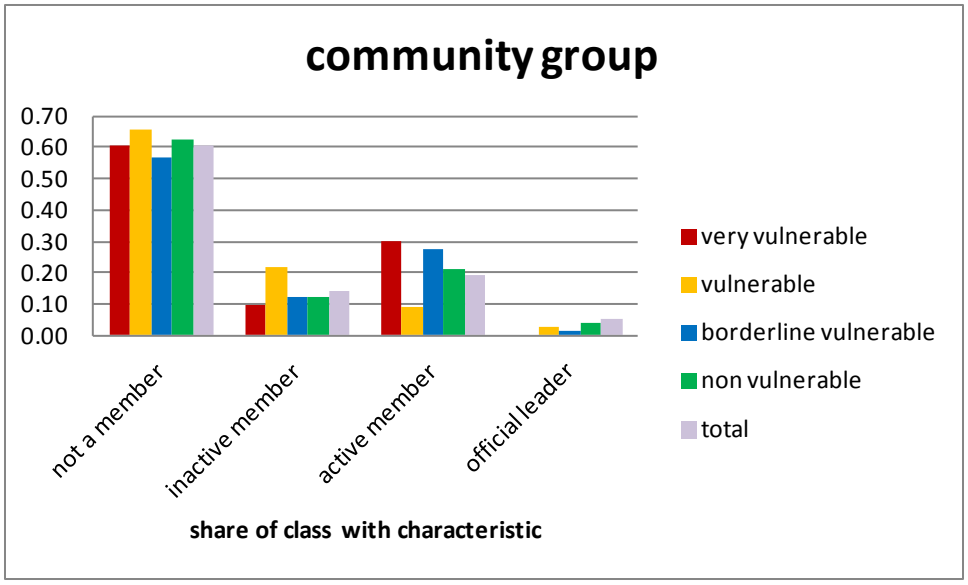

Figure A 77 Member of community group, urban East Africa

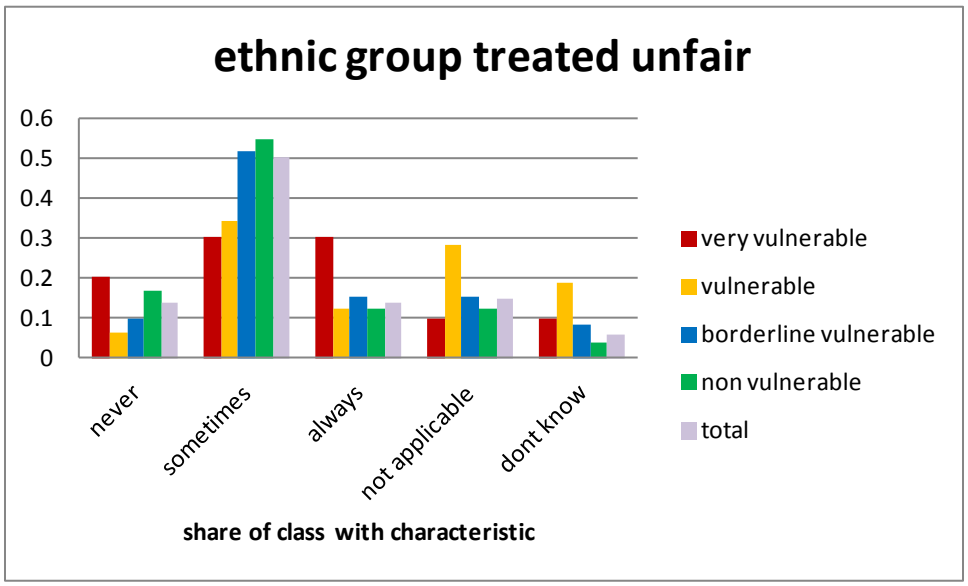

Figure A 78 Report on unfair treatment of respondent's ethnic group, urban East Africa

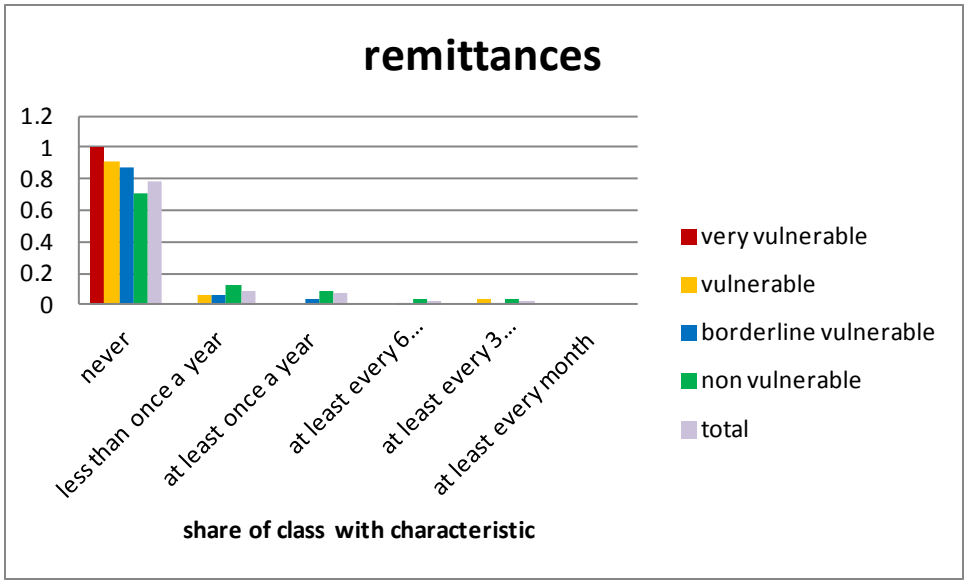

Figure A 79 Frequency of remittances, urban East Africa

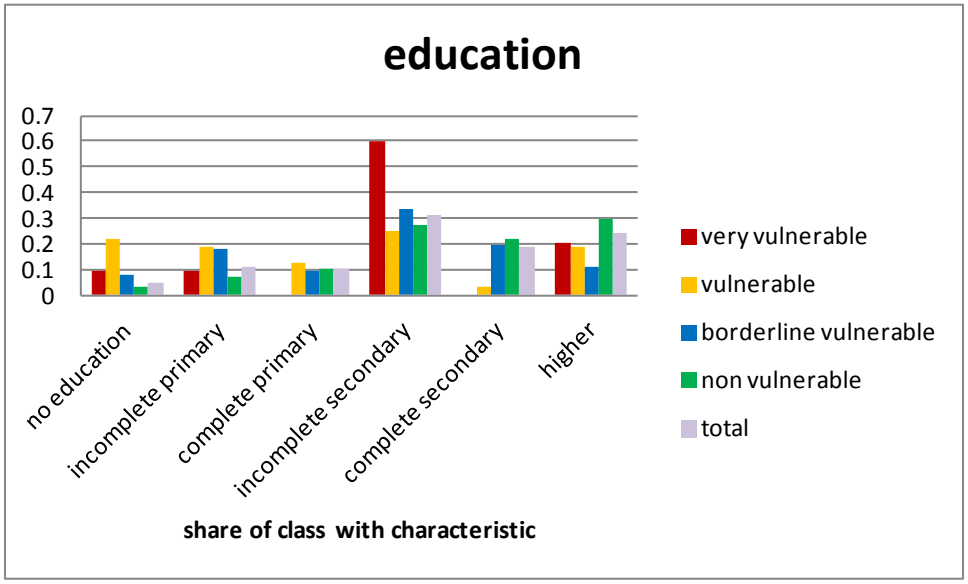

Figure A 80 Educational attainment of respondent, urban East Africa

B.2. Profiles of groups

Rural West Africa

This section presents the profiles for the very vulnerable and vulnerable rural population in West Africa. The codes used in the table are explained in Table B 6 and Table B 7.

Table B 1 Profiles of very vulnerable rural populations in West Africa

Age of hh head	education	occupation	payment for work	farming system	freq in % of group
3	1	5	1	3	9.52
2	1	5	1	3	9.52
4	1	5	1	3	7.14
3	1	7	2	3	7.14
6	1	5	2	3	7.14
6	1	5	1	3	7.14
6	1	5	1	4	7.14
4	1	5	1	4	7.14
5	1	5	1	3	7.14
5	1	5	2	3	7.14
5	1	5	1	4	2.38
5	1	5	3	3	2.38
6	1	5	3	2	2.38
4	1	8	2	6	2.38
3	1	5	3	3	2.38
2	1	5	1	4	2.38
2	1	5	2	4	2.38
2	1	7	1	3	2.38
3	1	5	2	3	2.38
1	1	5	4	3	2.38

Table B 2 Profiles of vulnerable rural populations in West Africa

Age of hh head	education	occupation	payment for work	farming system	freq in % of group
3	1	5	1	3	7.28
4	1	5	1	3	7.07
2	1	5	1	3	6.07
5	1	5	1	3	5.97
2	1	5	1	4	4.08
3	1	5	1	4	3.94
4	1	5	1	4	3.66
6	1	5	1	3	3.41
5	1	5	1	4	2.66
3	1	5	2	3	2.52
5	1	5	4	3	2.41
3	1	5	4	3	2.17
2	1	5	4	3	2.10
3	1	5	3	2	1.74
4	1	5	4	3	1.74
4	1	5	2	3	1.42
2	1	5	2	3	1.28
4	1	5	3	3	1.28
1	1	5	1	3	1.21
6	1	5	1	4	1.21
5	1	5	3	2	1.14
6	1	5	4	3	1.10
3	1	5	3	3	1.10
7	1	5	1	3	0.99
5	1	5	2	3	0.92
2	1	5	3	3	0.92

2	1	5	3	2	0.82
7	1	5	4	3	0.75
4	1	5	3	2	0.75
7	1	5	1	4	0.67
1	1	5	4	3	0.60
2	1	5	4	4	0.57
2	1	5	2	2	0.57
6	1	5	2	3	0.50
5	1	5	2	2	0.50
3	1	5	2	6	0.50
1	1	5	1	4	0.50
6	1	5	3	3	0.46
5	1	5	3	3	0.43
6	1	5	3	2	0.43
3	1	5	2	2	0.43
1	1	5	3	3	0.36
5	1	5	4	4	0.36
4	1	5	4	2	0.36
4	2	5	1	3	0.32
6	1	5	2	2	0.28
4	1	5	4	4	0.28
4	1	5	2	2	0.28
1	1	5	4	4	0.28
2	1	4	2	3	0.28
1	1	5	2	3	0.21
4	1	5	3	6	0.21
2	2	5	2	3	0.21
2	1	8	3	2	0.21
7	1	5	3	3	0.21
6	1	5	4	4	0.21
4	1	5	2	4	0.21

3	1	8	2	2	0.21
3	1	5	1	2	0.21
3	1	4	1	4	0.21
5	1	8	2	6	0.18
7	1	5	3	2	0.18
2	1	5	1	2	0.18
2	1	5	2	4	0.18
4	1	4	2	3	0.18
2	1	4	1	4	0.18
2	1	4	1	3	0.18
3	1	7	2	3	0.18
3	1	5	4	4	0.18
4	1	8	2	5	0.18
4	1	8	2	6	0.18
2	2	5	1	3	0.18
3	1	5	2	4	0.18
3	1	8	2	6	0.18
3	2	5	1	3	0.18
3	2	5	1	4	0.18
3	2	5	2	2	0.18
3	2	5	2	3	0.18
3	1	5	2	5	0.14
3	1	8	3	2	0.14
3	1	0	2	2	0.14
3	1	8	1	3	0.14
3	2	5	3	2	0.14
3	1	5	4	2	0.14
3	2	5	4	3	0.14
1	1	5	3	2	0.14
2	1	3	1	4	0.14
2	2	5	4	3	0.14

2	1	8	2	6	0.14
2	1	8	2	2	0.14
2	1	5	3	4	0.14
2	1	7	4	3	0.14
3	4	5	2	3	0.14
5	2	5	4	3	0.14
5	1	8	3	2	0.14
6	1	5	3	6	0.14
4	1	8	1	3	0.14
4	1	8	2	2	0.14
7	1	5	2	3	0.14
6	2	5	1	4	0.14
6	2	5	1	3	0.14
4	2	5	3	2	0.14
4	3	5	1	3	0.14
5	1	5	2	6	0.14
5	1	7	1	3	0.14
6	1	7	1	3	0.11
6	1	7	2	3	0.11
4	1	8	3	2	0.11
4	1	8	3	3	0.11
6	1	5	2	6	0.11
6	1	5	2	4	0.11
4	4	8	2	3	0.11
5	1	5	3	4	0.11
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6	1	9	2	6	0.11
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2	4	2	2	5	0.11
2	4	5	1	3	0.11
2	3	6	3	3	0.11

2	2	7	1	3	0.11
2	2	8	2	2	0.11
6	2	5	3	2	0.11
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6	2	5	2	2	0.11
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5	1	7	3	3	0.11
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3	1	8	2	3	0.11
3	1	8	4	2	0.11
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3	1	4	4	3	0.11
3	3	5	2	3	0.11
3	1	4	2	3	0.11
3	3	5	1	4	0.11
4	1	7	1	3	0.11

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6	1	4	1	3	0.04
6	1	5	3	4	0.04
6	1	7	1	4	0.04
5	4	0	2	6	0.04
5	4	8	3	2	0.04
5	2	9	2	2	0.04
5	3	5	1	3	0.04
5	3	5	2	4	0.04
5	4	7	3	2	0.04
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5	1	5	4	2	0.04
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4	1	7	4	3	0.04
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4	1	9	2	2	0.04
4	1	7	2	2	0.04

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4	4	8	2	2	0.04
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2	3	5	2	3	0.04
2	3	5	2	4	0.04
2	3	5	4	3	0.04
2	3	4	1	3	0.04
2	3	3	1	4	0.04
2	2	8	2	5	0.04
2	2	8	4	2	0.04
2	2	9	3	3	0.04
2	2	0	2	5	0.04
2	3	7	2	3	0.04
2	4	1	3	2	0.04
3	1	3	2	3	0.04
3	1	4	1	2	0.04
3	1	4	2	2	0.04
3	1	4	2	4	0.04
3	1	3	1	4	0.04
3	1	3	1	3	0.04
2	4	7	1	3	0.04
2	4	9	2	1	0.04
3	1	2	2	2	0.04
3	1	2	3	3	0.04

Table B 3 Profiles of vulnerable rural populations in Benin, Ghana and Burkina Faso

age of hh	education	occupation	payment for	farming	economic	unfair treatment of	times remittances	freq. In % of

head			work	system	situation	ethnic group	received	group
2	1	5	1	3	4	1	1	10.61
2	1	5	1	3	2	1	1	10.61
2	1	5	1	4	1	1	1	8.52
2	1	5	4	3	2	1	1	6.92
2	1	5	1	4	2	1	1	6.92
2	1	5	1	4	2	2	2	5.32
2	1	5	1	3	2	2	2	4.79
2	1	5	1	4	4	1	1	4.26
2	1	5	1	3	4	2	1	3.73
2	1	5	1	3	5	1	1	3.73
2	1	5	1	3	2	2	3	3.73
2	1	5	4	3	4	1	1	2.13
2	1	5	3	3	4	1	1	2.13
2	1	5	2	3	2	1	1	2.13
2	1	5	3	3	4	2	1	1.60
2	4	2	2	5	4	2	1	1.06
2	1	4	1	4	2	2	2	1.06
2	1	5	4	4	4	1	1	1.06
2	1	5	4	4	1	1	1	1.06
2	1	5	3	4	4	1	1	1.06
6	1	5	1	3	2	1	1	1.06
4	3	5	1	3	2	1	1	1.06
4	4	8	2	3	3	1	1	1.06
2	1	5	3	3	2	1	1	1.06
2	1	5	2	4	2	2	2	1.06
2	4	1	3	2	4	2	1	0.53
2	3	3	1	4	4	1	1	0.53
2	1	8	2	4	2	2	2	0.53
2	1	7	2	3	4	1	1	0.53
2	1	7	1	3	4	2	1	0.53

4	2	5	1	3	4	2	1	0.53
4	2	5	2	6	2	1	1	0.53
6	1	5	4	3	2	1	1	0.53
4	2	5	3	2	2	1	1	0.53
2	1	6	4	3	2	1	1	0.53
2	1	6	1	4	5	1	1	0.53
2	1	5	4	3	2	2	2	0.53
2	1	4	2	3	4	2	1	0.53
2	1	4	2	3	2	1	1	0.53
2	1	4	1	3	2	1	1	0.53
2	1	3	1	4	5	1	1	0.53
2	1	4	4	3	2	1	1	0.53
2	1	5	1	4	5	1	1	0.53
2	1	5	3	4	1	1	1	0.53
2	1	5	3	3	5	1	1	0.53
2	1	5	2	3	4	2	1	0.53
2	1	5	2	3	4	1	1	0.53
2	1	5	2	3	2	2	3	0.53

Urban West Africa

This section presents the profiles for the vulnerable urban population in West Africa. The codes used in the table are explained in Table B 6 and Table B 7.

Table B 4 Profiles of vulnerable urban populations in West Africa

wealth quintile	education	occupation	payment for work	years in residence	freq. in % of group
3	1	5	2	4	6.20
3	1	5	1	4	2.73
4	1	5	1	4	2.73

3	1	5	4	4	2.33
4	1	5	3	4	1.93
1	1	5	2	4	1.93
3	1	8	2	4	1.53
5	1	5	2	4	1.53
5	1	5	1	4	1.53
1	1	5	3	4	1.53
1	1	5	4	4	1.53
2	1	5	2	4	1.53
5	1	8	2	4	1.13
2	1	5	3	2	1.13
2	1	4	2	4	1.13
2	1	8	2	4	1.13
2	2	8	2	2	1.13
1	1	4	2	4	1.13
1	2	8	2	2	1.13
2	2	8	3	4	1.13
3	1	5	3	4	1.13
3	2	4	2	4	1.13
1	2	3	3	4	0.80
4	5	9	2	4	0.80
2	1	8	2	2	0.80
3	2	5	2	3	0.80
3	2	6	2	2	0.80
2	1	7	2	1	0.80
5	2	7	1	4	0.80
3	4	5	2	3	0.80
1	4	2	2	4	0.80
2	1	6	2	4	0.80
3	1	5	2	2	0.80
3	1	5	1	3	0.80

3	1	8	2	2	0.80
3	1	5	1	2	0.80
2	3	5	3	2	0.80
3	1	8	2	3	0.80
4	2	8	2	4	0.80
1	1	8	3	4	0.80
1	2	3	1	4	0.80
1	1	8	2	2	0.80
1	1	3	1	4	0.80
4	1	5	2	3	0.80
4	1	7	2	4	0.80
1	1	5	2	2	0.80
4	4	4	2	4	0.80
3	1	5	4	3	0.80
5	1	4	1	4	0.80
5	1	5	1	3	0.80
1	2	8	2	4	0.80
3	4	9	2	4	0.40
4	2	9	2	2	0.40
1	4	2	2	5	0.40
5	1	8	3	1	0.40
5	1	9	2	4	0.40
5	1	8	2	3	0.40
5	1	8	2	1	0.40
5	1	6	1	4	0.40
5	1	5	2	3	0.40
5	1	5	3	4	0.40
5	2	5	3	1	0.40
5	2	8	2	1	0.40
5	4	2	1	4	0.40
5	5	2	2	2	0.40

5	4	8	2	2	0.40
5	4	7	1	4	0.40
5	4	4	2	2	0.40
5	4	6	1	4	0.40
5	1	4	2	4	0.40
4	4	8	2	3	0.40
2	1	8	2	3	0.40
2	1	8	2	5	0.40
2	1	7	2	4	0.40
2	1	6	4	4	0.40
2	1	5	4	4	0.40
2	1	5	3	1	0.40
2	1	5	3	3	0.40
2	1	8	3	2	0.40
2	1	8	3	4	0.40
2	2	4	2	1	0.40
2	3	3	2	2	0.40
2	3	4	2	3	0.40
2	2	0	2	4	0.40
2	2	8	2	4	0.40
2	2	8	2	3	0.40
2	2	7	2	2	0.40
2	2	7	2	4	0.40
2	1	5	1	3	0.40
2	1	4	2	3	0.40
2	1	4	2	2	0.40
1	1	8	2	3	0.40
1	2	2	2	3	0.40
1	1	8	2	1	0.40
1	1	5	3	2	0.40
1	1	5	2	3	0.40

1	1	2	3	2	0.40
1	1	5	2	1	0.40
1	2	5	2	4	0.40
1	2	6	2	4	0.40
1	3	2	2	1	0.40
2	1	3	2	4	0.40
2	1	4	2	1	0.40
2	1	3	2	2	0.40
2	1	2	3	4	0.40
1	4	2	4	4	0.40
1	3	5	3	4	0.40
1	3	6	2	3	0.40
2	3	5	3	4	0.40
3	1	2	2	2	0.40
4	1	4	2	2	0.40
4	1	5	3	3	0.40
3	6	0	2	4	0.40
3	5	7	2	4	0.40
3	4	8	2	4	0.40
3	4	2	2	4	0.40
3	4	8	2	3	0.40
4	1	7	2	3	0.40
4	1	8	2	3	0.40
4	1	8	2	4	0.40
4	3	4	2	4	0.40
4	4	8	2	2	0.40
4	2	0	2	4	0.40
4	2	7	2	4	0.40
4	2	6	2	3	0.40
4	1	9	2	2	0.40
4	2	1	2	4	0.40

3	3	5	2	4	0.40
3	2	0	2	1	0.40
3	2	8	4	3	0.40
3	1	6	4	4	0.40
3	1	7	2	3	0.40
3	1	6	2	4	0.40
3	1	5	4	2	0.40
3	1	5	3	3	0.40
3	1	2	2	4	0.40
3	1	5	3	2	0.40
3	1	8	2	1	0.40
3	1	8	3	4	0.40
3	2	3	1	4	0.40
3	2	7	2	4	0.40
3	2	8	2	2	0.40
3	2	7	2	2	0.40
3	2	6	2	4	0.40
3	2	5	2	2	0.40
3	2	5	1	4	0.40
3	2	5	1	5	0.40

Table B 5 Profiles of vulnerable urban populations in Benin, Ghana and Burkina Faso

wealth quintile	education	occupation	payment for work	years in residence	economic situation	unfair treatment of ethnic group	times remittances received	freq. in % of group
3	1	5	2	4	5	2	3	14.29
1	1	5	2	4	2	1	1	7.14
3	4	9	2	4	4	1	1	7.14
3	1	5	3	4	1	1	1	7.14
4	1	7	2	3	5	1	4	7.14
3	1	5	2	4	1	1	1	7.14

2	1	4	2	3	4	1	1	7.14
2	1	5	2	4	4	1	1	7.14
5	4	7	1	4	1	3	1	7.14
5	2	8	2	1	2	2	1	7.14
5	1	5	3	4	1	1	1	7.14
1	1	5	4	4	4	1	1	7.14
2	1	4	2	1	4	1	1	7.14

Coding for West Africa

Table B 6 Coding for West Africa

	Wealth quintile	Age of household head	Education	Occupation	Payment for work	Years lived in place of residence
1	poorest	15-19	no education	did not work	not paid	< 1
2	poorer	20-24	incomplete primary	prof tech man	cash only	1-5
3	middle	25-29	complete primary	clerical	cash and kind	5-10
4	richer	30-34	incomplete secondary	sales	kind only	visitor
5	richest	35-39	complete secondary	agri self employed		don't know
6		40-44	higher	agri employed		
7		45-50		household/dom services		
8		>50		Services		
9				skilled manual		
10				unskilled manual		
11				don't know		

Table B 7 Coding for West Africa

	Farming system	Economic situation	unfair treatment of ethnic group	times remittances received
1	tree crops	Very bad	Never	Never
2	root crops	Fairly bad	sometimes	Less than once a year
3	cereal-root crops mixed	Neither good nor bad	always	At least once a year
4	agro-pastoral millet	Fairly good		At least every 6 months
5	sparse (arid)	Very good		At least every 3 months
6	coastal fishing			At least every month
7				
8				
9				
10				
11				

Rural East Africa

This section presents the profiles for the very vulnerable and vulnerable rural population in East Africa. The codes used in the table are explained in Table B 11 and Table B 12.

Table B 8 Profiles of very vulnerable rural populations in East Africa

wealth quintile	education	occupation	duration of employment	daughters away	years in residence	LGP	land use	farming system	freq in % of group
4	2	4	3	3	2	5	5	5	8.40
1	1	1	1	2	4	3	5	7	4.58
1	1	4	2	1	3	3	3	5	4.58
1	1	4	2	1	1	3	3	5	4.58
1	1	4	2	1	2	4	7	5	4.58
1	1	4	2	1	2	3	5	5	4.58
1	2	9	3	1	2	4	3	5	4.58
2	1	4	2	1	2	4	7	5	4.58
1	1	4	2	1	4	3	3	5	4.58
1	3	4	2	2	1	4	0	5	4.58
1	1	4	2	2	4	3	7	5	4.58
1	1	4	2	1	3	4	3	5	4.58
2	1	4	2	1	2	4	0	5	4.58
2	1	4	2	2	1	5	5	5	4.58
2	2	1	1	2	3	5	5	5	4.58
1	2	4	1	1	2	5	5	5	4.58
1	2	4	2	1	3	5	5	5	4.58
1	2	4	1	1	4	5	7	2	4.58
1	1	8	2	3	5	3	5	5	4.58
3	1	4	1	1	2	5	5	5	4.58
3	2	4	1	2	3	5	6	2	4.58

Table B 9 Profiles of vulnerable rural populations in East Africa

education	occupation	duration of employment	LGP	land use	farming system	freq in % of group

2	4	3	4	7	5	6.94
2	4	3	5	5	5	4.27
1	4	3	4	7	5	3.85
1	4	3	5	5	5	3.40
2	4	3	5	5	2	2.67
2	4	3	5	0	2	2.50
2	4	3	4	5	5	2.22
1	4	3	3	5	7	2.08
2	4	3	4	3	5	2.08
1	4	3	5	0	2	1.91
2	4	3	4	0	5	1.63
2	4	3	5	0	5	1.49
4	4	3	5	0	2	1.32
1	4	3	5	0	5	1.32
2	4	3	5	6	2	1.18
1	4	3	4	5	5	1.18
1	4	3	5	5	2	1.04
2	4	3	5	7	2	1.04
1	4	3	3	7	5	1.04
1	4	3	3	7	7	1.04
2	5	3	5	5	2	0.90
2	3	3	5	0	2	0.90
2	1	3	5	0	2	0.90
2	4	2	4	7	5	0.90
2	8	3	4	7	5	0.90
2	1	3	5	5	2	0.73
2	4	2	4	3	5	0.73
2	8	3	5	0	2	0.73
1	4	3	4	0	5	0.73
3	4	3	4	7	5	0.73
2	4	3	5	1	2	0.73

2	4	3	5	6	5	0.73
2	3	3	5	5	5	0.59
2	4	1	5	5	2	0.59
2	8	3	4	6	5	0.59
4	4	3	5	5	2	0.59
4	8	3	5	5	2	0.59
1	4	3	3	5	5	0.59
1	4	3	5	7	2	0.59
1	4	3	4	3	5	0.59
3	4	3	5	5	5	0.45
2	8	3	4	3	5	0.45
3	1	3	4	5	5	0.45
3	4	3	5	5	2	0.45
3	3	3	5	0	2	0.45
3	4	3	4	3	5	0.45
3	4	3	4	0	5	0.45
2	8	3	5	5	2	0.45
3	4	3	5	0	5	0.45
4	3	3	5	7	2	0.45
6	3	3	5	5	5	0.45
1	5	3	5	7	2	0.45
1	5	3	4	3	5	0.45
1	4	3	5	6	2	0.45
1	5	3	5	0	2	0.45
1	8	3	4	7	5	0.45
2	4	3	3	7	5	0.45
2	3	3	5	0	5	0.45
2	4	2	5	5	2	0.45
2	4	3	3	5	7	0.45
1	4	3	3	3	5	0.45
2	7	3	4	7	5	0.45

2	7	3	5	0	2	0.45
2	1	3	4	5	5	0.31
2	1	3	4	6	5	0.31
1	1	3	4	7	5	0.31
2	1	3	4	3	5	0.31
1	9	3	4	5	5	0.31
1	9	3	4	3	5	0.31
2	1	3	5	5	5	0.31
2	1	4	5	6	2	0.31
2	3	3	3	5	5	0.31
2	3	3	4	7	5	0.31
2	3	3	4	0	5	0.31
2	3	1	5	0	2	0.31
1	4	2	5	5	5	0.31
1	4	2	3	5	5	0.31
1	4	3	5	1	5	0.31
1	4	1	5	1	2	0.31
1	8	3	3	5	7	0.31
1	8	3	3	7	5	0.31
2	7	4	5	6	5	0.31
4	4	2	5	5	2	0.31
2	4	3	5	3	5	0.31
3	4	3	5	1	5	0.31
3	5	3	5	5	2	0.31
3	4	3	5	0	2	0.31
2	4	4	5	5	2	0.31
2	4	3	5	1	5	0.31
3	7	3	5	5	2	0.31
3	8	3	4	3	5	0.31
2	4	3	5	1	5	0.31
2	4	3	4	6	5	0.31

4	1	3	5	5	5	0.31
3	8	3	5	0	2	0.31
2	8	3	5	6	5	0.31
2	8	3	5	6	2	0.31
2	8	3	5	5	5	0.31
2	8	2	5	5	2	0.31
2	7	3	5	6	2	0.31
2	7	3	5	5	2	0.31
2	5	3	5	0	5	0.31
2	8	4	5	0	2	0.31
2	5	3	5	0	2	0.31
2	0	2	5	5	5	0.31
2	9	3	5	6	2	0.31
2	9	3	5	1	5	0.31
6	1	3	5	5	5	0.31
2	4	2	5	5	5	0.31
1	1	3	4	5	5	0.31
2	4	1	5	1	2	0.31
4	8	3	4	6	5	0.31
4	4	3	5	0	5	0.31
4	4	3	5	1	2	0.31
4	4	3	5	6	5	0.31
4	4	3	5	1	5	0.31
1	4	2	4	7	5	0.31
2	4	3	3	3	5	0.31
4	7	3	5	0	5	0.31
2	4	1	5	0	5	0.31
2	4	1	5	0	2	0.31
3	1	3	4	7	5	0.14
2	9	3	4	7	5	0.14
2	9	3	4	3	5	0.14

2	9	2	5	7	2	0.14
3	1	3	5	5	2	0.14
3	3	3	5	6	5	0.14
3	4	3	4	5	5	0.14
3	5	3	4	3	5	0.14
3	4	3	5	1	2	0.14
3	4	3	5	6	5	0.14
3	4	3	5	1	2	0.14
2	8	4	5	5	5	0.14
2	8	3	5	1	2	0.14
2	8	3	5	0	5	0.14
2	5	3	5	1	2	0.14
2	5	3	5	7	2	0.14
2	5	3	4	7	5	0.14
2	5	3	4	3	5	0.14
2	7	1	5	7	2	0.14
2	7	3	4	5	5	0.14
2	7	3	5	5	5	0.14
2	8	3	5	7	2	0.14
2	8	3	4	0	5	0.14
2	8	2	5	0	2	0.14
2	8	1	5	5	2	0.14
3	5	3	5	5	5	0.14
3	7	3	4	7	5	0.14
3	8	3	5	7	2	0.14
4	9	3	5	5	5	0.14
4	8	3	5	0	2	0.14
4	8	3	5	5	5	0.14
4	7	3	5	1	2	0.14
6	3	3	4	5	5	0.14
6	8	3	5	5	2	0.14

4	5	3	5	5	5	0.14
4	4	4	5	0	5	0.14
4	4	3	5	5	5	0.14
4	1	3	5	5	2	0.14
3	0	1	5	0	2	0.14
3	9	3	5	0	2	0.14
3	9	3	4	7	5	0.14
4	1	3	5	6	5	0.14
4	2	3	4	5	5	0.14
4	2	3	5	5	2	0.14
4	4	3	4	7	5	0.14
4	4	3	3	3	5	0.14
4	3	3	5	0	5	0.14
4	3	3	5	0	2	0.14
2	5	2	5	6	5	0.14
2	4	4	5	1	5	0.14
2	4	4	5	1	5	0.14
1	4	1	5	5	5	0.14
1	4	1	3	5	5	0.14
1	3	3	5	7	2	0.14
1	3	3	5	5	5	0.14
1	4	2	3	5	7	0.14
1	4	2	3	7	5	0.14
1	4	2	4	3	5	0.14
1	4	3	5	6	5	0.14
1	4	3	3	0	7	0.14
1	4	2	5	0	2	0.14
1	4	2	5	5	2	0.14
1	3	3	4	7	5	0.14
1	1	3	5	7	2	0.14
1	1	3	4	6	5	0.14

1	1	3	4	3	5	0.14
1	4	4	5	0	2	0.14
1	5	1	5	0	2	0.14
1	5	3	3	5	7	0.14
2	3	3	5	2	2	0.14
2	3	3	4	6	5	0.14
2	3	1	5	5	2	0.14
2	1	3	4	0	5	0.14
2	3	3	5	5	2	0.14
2	3	3	5	1	2	0.14
2	3	3	5	1	5	0.14
2	4	3	3	5	5	0.14
2	4	2	5	0	2	0.14
2	4	2	4	6	5	0.14
2	4	1	3	5	5	0.14
2	1	3	4	7	5	0.14
2	1	3	3	7	7	0.14
2	1	3	3	5	7	0.14
1	5	3	5	0	5	0.14
1	5	3	5	5	2	0.14
1	5	3	4	7	5	0.14
1	5	3	3	7	5	0.14
1	5	3	5	1	2	0.14
1	7	3	3	5	7	0.14
1	7	3	5	0	5	0.14
1	9	3	5	5	2	0.14
1	9	3	4	7	5	0.14
1	9	3	3	0	7	0.14

Urban East Africa

This section presents the profiles for the urban vulnerable population in East Africa. The codes used in the table are explained in Table B 11 and Table B 12.

Table B 10 Profiles of vulnerable urban populations in East Africa

age of hh head	occupation	payment for work	sons away	years in residence	freq in % of group
5	4	1	2	1	8.29
3	4	1	1	2	8.29
3	8	2	1	2	8.29
1	8	2	1	4	4.17
7	5	2	2	2	4.17
6	4	3	2	2	4.17
6	4	2	2	2	4.17
6	1	2	2	4	4.17
5	8	3	2	2	4.17
5	8	1	1	2	4.17
5	7	3	1	2	4.17
3	4	2	1	1	4.17
2	9	3	1	3	4.17
2	8	2	1	3	4.17
2	7	2	1	2	4.17
3	4	2	1	4	4.17
3	7	2	1	2	4.17
5	7	2	1	5	4.17
4	8	2	1	3	4.17
4	7	4	2	4	4.17
3	8	1	1	5	4.17

Coding for East Africa

Table B 11 Coding for East Africa

	Wealth quintile	Age of household head	Education	Occupation	Duration of employment	Payment for work
1	poorest	15-19	no education	did not work	all year	not paid
2	poorer	20-24	incomplete primary	prof tech man	seasonal	cash only
3	middle	25-29	complete primary	clerical	occasional	cash and kind
4	richer	30-34	incomplete secondary	sales		kind only
5	richest	35-39	complete secondary	agri self employed		
6		40-44	higher	agri employed		
7		45-50		household/dom services		
8		>50		services		
9				skilled manual		
10				unskilled manual		
11				don't know		

Table B 12 Coding for East Africa

	Sons away from home	Daughters away from home	Years lived in place of residence	LGP	Land use	Farming system
1	none	none	< 1	0-60	>75% Cultivated land	irrigated
2	1-2	1-2	1-5	60-120	>75% Forest land	highland perennial
3	3-4	3-4	5-10	120-180	>75% Grass and woodland	root crop
4	>4	>4	visitor	180-270	>75% Barren land	cereal-root crop mixed
5			don't know	270-365	50-75% Cultivated land	maize mixed
6					50-75% Forest land	agro-pastoral millet
7					50-75% Grass and woodland	pastoral
8					50-75% Barren land	arid
9					>50% Built-up land	
10					Land cover associations	
11					water	

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