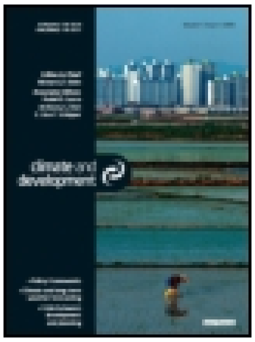

Climate and Development

ISSN: 1756-5529 (Print) 1756-5537 (Online) Journal homepage: https://www.tandfonline.com/loi/tcld20

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CLIMATE AND DEVELOPMENT
https://doi.org/10.1080/17565529.2019.1580555

Gender differentiated vulnerability to climate change in Eastern Uganda

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ABSTRACT

Climate change literature is rife with the assertion that women are more vulnerable to climate change, which state is expected to reflect on female-headed households. However, this assertion has however not been empirically proven aside from the general poverty-gender linkages. This study used primary data collected in 2016 from 735 randomly selected households from four districts in Eastern Uganda to construct a gender vulnerability index to compare and explain the drivers of vulnerability between male and female-headed households. The results show that female-headed households were more vulnerable (GVI-IPCC = −0.134) than male-headed households (GVI-IPCC = −0.176). The results further show that disparity in adaptive capacity mediates vulnerability between male and female-headed households. This underscores the importance of proactive interventions rather than protectionist approaches to reducing vulnerability. The study has extended the analytical utility of the livelihood vulnerability index to create a gender vulnerability index for comparing contextual groups of households in Eastern Uganda.

ARTICLE HISTORY
Received 7 September 2017
Accepted 28 January 2019

KEYWORDS
Gender; climate change; adaptive capacity; vulnerability

1. Introduction

Africa is more vulnerable to climate change to climate change due to high levels of poverty and over-reliance on rain-fed agriculture (Challinor, Wheeler, Garforth, Craufurd, & Kassam, 2007; IPCC, 2001, 2007). But there are differences in vulnerability to climate change across countries (Mc Carthy et al., 2001; Dixon, Smith, & Guill, 2003) which trickle down to the subnational and local levels (e.g. Deressa, Hassan, & Ringler, 2008; Eriksen, Brown, & Kelly, 2005; O'Brien & Leichenko, 2000). At the local level, climate-related stress accentuates the plight of some social groups e.g. women whose exposure to climate change is high due to their limited mobility even in the event of climatic extremes. Women are also highly sensitive to climate shocks since it affects their core responsibilities in the household including food, water and energy security (Glazebrook, 2011; Jost et al., 2016). Moreover, their adaptive capacity is viewed as unfavourable due to a lack of access to key resources (Enarson & Morrow, 1998; Terry, 2009) and low decision making power (Lambrou & Piana, 2006).

Against such a background, women are assumed to be more vulnerable to climate change which following Chant (1999), will reflect on female-headed households. Empirically though, this generalization has not been sufficiently proven and may probably not hold universally as gender norms vary from place to place, yet it promotes the view that climate vulnerability is gender-linked. Arora-Jonsson (2011) contests the link between gender and vulnerability. In particular, Enarson (2006) also argues that rather than vulnerability being linked to gender, resource entitlements determine the level of people's vulnerability. This suggests that it is conceivable to find little difference in vulnerability between men and women with similar resource entitlements and brings to doubt and brings to doubt a view that adaptation assistance should target women who are most vulnerable.

Identifying the most vulnerable is a daunting task but important in designing adaptation policy actions (Vincent & Cull, 2010). Vulnerability assessments are important in identifying the most vulnerable and indeed many assessments have been done. Vulnerability assessments often use regional and national level datasets. Such assessments have low local usefulness since the actual responsibility of adaptation lies at the household level (Notenbaert, Karanja, Herrero, Felisberto, & Moyo, 2013). Vulnerability assessments need to be cognizant of the fact that regional and national data seldom reflects the way individual/household characteristics like ownership and access to resources mediate vulnerability creating vulnerability differentials between and within social groups even over a small area (Cutter, Boruff, & Shirley, 2003; Cutter, Mitchell, & Scott, 2000; Deressa et al., 2008). The study aims at determining whether household vulnerability to climate change in Eastern Uganda bifurcates along the gender of the household head and the main drivers of the difference in vulnerability between the two gender-disaggregated household categories.

2. Gender and vulnerability

Considering vulnerability to climate change as a state of well-being that varies among individuals based on their resource endowments and placement within the social hierarchy (Adger & Kelly, 1999) directly connects vulnerability to gender. But research on the exact nature of relationship between gender and vulnerability has been inconclusive. For instance,

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Neumayer and Plumper (2007) argue that not all women are vulnerable, as they are not homogenous with respect to access to requisite resources for adaptation.

The ambiguity of gender exacerbates the problem even further (c.f. West & Zimmerman, 1987). Gender refers to norms, behaviours and roles that a given culture associates with a person's biological sex. But gender remains a difficult concept to translate at the local level. Locally though gender has been used as a synonym for sex, i.e. all females are women. In reality, not all females are ascribed the same roles and responsibilities within a given society. For instance, a female in a male-headed household vis-*à*-vis one in a female-headed one is ascribed different roles by society and behave differently. Such minor details may be lost if interventions target women as locally interpreted. This creates a challenge for even well-intentioned interventions targeting the most vulnerable.

3. Study area and methods

The study used baseline cross-sectional data collected by the Regional Capacity Building for Sustainable Natural Resource Management and Agricultural Productivity under Climate Change project (CAPSNAC) in Eastern Uganda. The region is distinguished as one of the most climate-sensitive areas of Uganda. The area extends from the wetter Mt Elgon districts of Bududa and Manafwa to the drought-prone low-lying areas of Iganga and Namutumba (Figure 1).

Eastern Uganda is one of the most highly populated and agriculturally productive areas of Uganda. Annual precipitation varies from 1200 in the lowlands to 1500 mm in the highlands. The majority of local people are poor subsistence farmers who depend on rain-fed agriculture which is complemented by dependence on natural resources which in some cases contribute up to 28% of the total income of some households (Angelsen et al., 2014). The area has also been one of the most hit areas by climate change evens most notably Bududa landslides between 1997 and 2010.

A cross-sectional household survey of 803 farmers was conducted during the first cropping of 2016. The household survey covered eight sub-counties in four districts. The sample households were randomly selected from village household lists provided by local leaders. The minimum sample size using a 95% confidence interval and a 5% margin of error was 648 households. After data cleaning to remove cases with nonresponses, 735 observations were usable for analysis.

Farmers were asked about their perceptions on long-term (5–30 years) temperature and precipitation patterns in the area. Almost all the respondents (99.7%) perceived noticeable changes in the weather patterns over that period. The majority (62%) had noticed that the onset of rains was much later, yet it also ceased earlier than normal (56.6%).

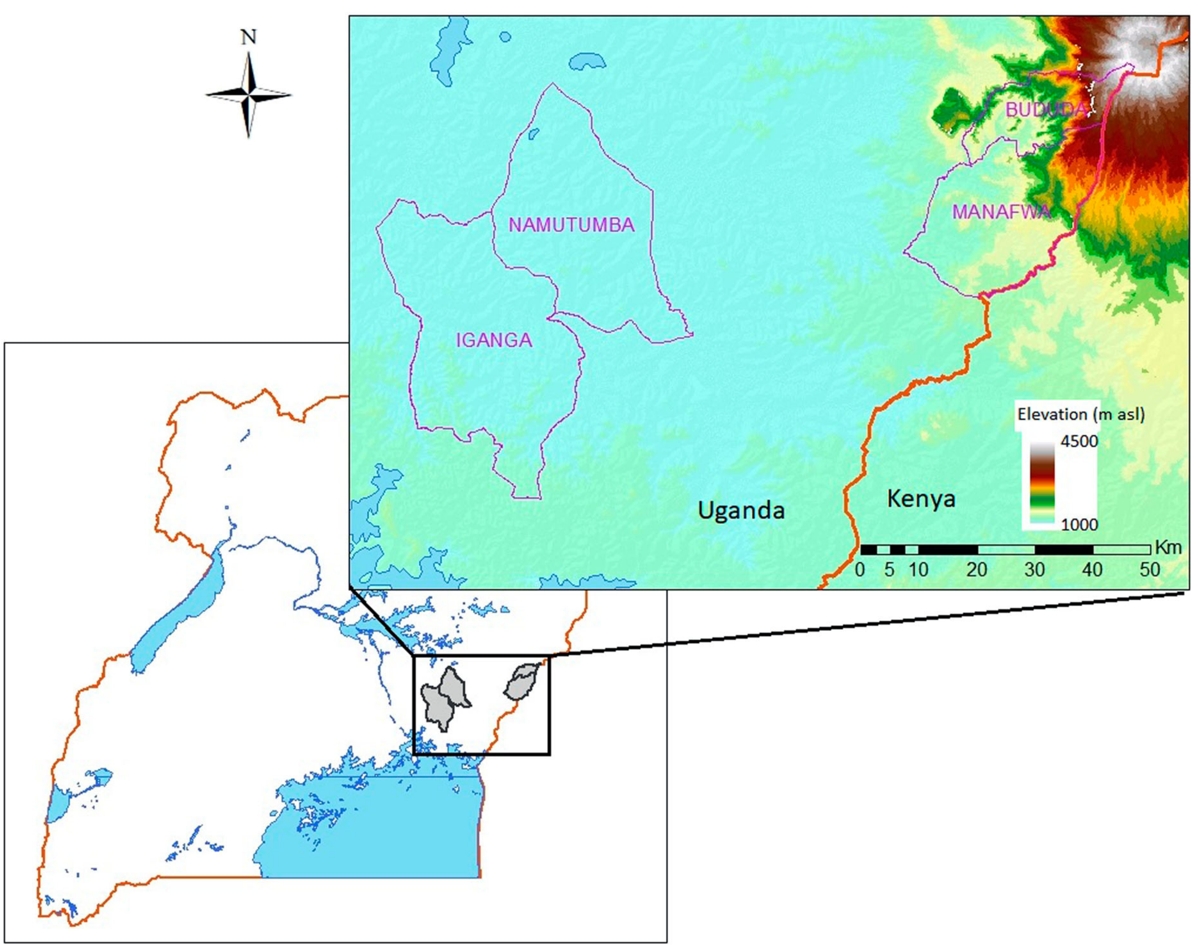

Figure 1. Map of Uganda showing the location of the four study districts in Eastern Uganda.

On the whole, the amount of precipitation is mainly thought to have increased (47%) although its distribution is more variable. Such observed changed in local weather are thought to lead to vulnerabilities of livelihoods especially when farmers cannot make quick adjustments. The vulnerability of livelihood is however not expected to be uniform across all households.

4. A gender vulnerability index

Vulnerability is a multi-dimensional concept of many latent variables that cannot be directly determined from household surveys. According to IPCC (2001), vulnerability is a function of exposure, sensitivity and adaptive capacity. Each of the three dimensions of vulnerability can, however, be expressed by use of vulnerability indicators to create an index of vulnerability (Adger, Brooks, Bentham, Agnew, & Eriksen, 2004). Vulnerability indices are valuable in identifying the most vulnerable people at a local scale (Hinkel, 2011). As such, calculation of vulnerability indices is now common practice (e.g. Hahn, Riederer, & Foster, 2009).

Vulnerability indices integrate several multidimensional issues using indicators as proxies (Hahn et al., 2009). The theoretical relationship between the indicators and vulnerability should be verifiable, usually based on understanding of relationships (Nardo et al., 2005; Wiréhn, Danielsson, & Neset, 2015) in an inductive or deductive manner (Adger et al., 2004; Hinkel, 2011) and literature review (Brooks, Adger, & Kelly, 2005). This study considers climate change to be a combination of climate variability and extremes (Mc Carthy et al., 2001) and like most vulnerability indices, uses the IPCC definition of vulnerability.

Adaptive capacity here means all forms of endowments available to the household to cope with or recover from actual or expected changes in the environment (Ebi, Kovats, & Menne, 2006), and sensitivity expresses the potential for disturbance a system may face in the event of climate change. This study departs from similar studies in the way exposure is constructed. While most vulnerability indices express exposure quantitatively using actual weather/climate data on climatic variables (e.g. Hahn et al., 2009; Opiyo, Wasonga, & Nyangito, 2014; Wiréhn et al., 2015), our study uses actual impact of climate change to show differences in exposure among households. This approach is premised on the fact that households that reported the greatest impacts are the most exposed (Pandey & Jha, 2012). The vulnerability index mirrors the sustainable livelihood framework approach used by Hahn et al. (2009) to compare livelihood vulnerability of two villages in Mozambique. A similar approach has been used elsewhere, e.g. Shah, Dulal, Johnson, and Baptiste (2013), Pandey and Jha (2012) and Zarafshani et al. (2012). The indicator method used is based on inductive arguments to construct mathematically combine indicators into a composite index (Adger et al., 2004).

Vulnerability indices encounter a challenge of choosing indicator weights especially in the absence of a justifiable reason to attach weights to the different indicators. Several methods exist for weighting indicators, for instance, equal weighting (e.g. Eakin & Bojorquez-Tapia, 2008), expert opinion (e.g. Ravindranath et al., 2011; Vincent, 2004) and PCA (e.g. Deressa et al., 2008; Gbetibouo, Ringler, & Hassan, 2010). Principal component analysis (PCA) was not used to construct the index due to low correlation among the indicators a prerequisite for PCA (Nardo et al., 2005). This study follows Sullivan, Meigh, and Fediw (2002) by attaching equal weights to each of the indicators in the resulting index. There is a minimum danger of double counting usually associated with equal weighting (Nardo et al., 2005) because of the low correlation among indicator variables used for constructing the index.

5. Vulnerability indicator variables

Indicators are classified according to how they conceptually link to vulnerability. Thus, adaptive capacity indicators measure access to such factors as technology (access to weather information, extension services, irrigation, farm equipment) and social networks (participation in local social groups) asset and income diversity and human resources (Eakin & Bojorquez-Tapia, 2008). Individual-specific variables like education and age are taken for the household head who takes most of the production decisions in the household. All indicators of adaptive capacity are hypothesized to have an opposite relationship with vulnerability. Sensitivity indicators describe elements of a household that make it very susceptible to climate variability for instance dependence on seasonal crops while exposure indicators variables show the actual outcome of climate change on households for instance if the household was forced into a temporary migration due to a climate-related event.

Adaptive capacity indicator variables

Human resource capacity

A large number of healthy productive adults in a household is a measure of labour capacity to engage several livelihood activities and manpower in case the household were to engage in labour-intensive adaptation strategies like irrigation. Therefore, larger households are considered to have higher adaptive capacity to climate variability. The practice of hiring labour was also captured, pooling labour represents additional human resources to the household. Households that hired labour were assumed to have increased the workforce available to engage in agricultural production.

Higher education is linked to higher prospects for off-farm employment (Holand, Lujala, & Rød, 2011). Literacy rate proxies skills and knowledge available to the household (Smith & Lenhart, 1996). Subsequently, low education may constrain the ability to understand climate advisory information (Zarafshani et al., 2012). For this study, education was measured by the number of years spent in school by the head of the household. A higher number of years spent in school would imply a higher adaptive capacity for the reasons given.

Technology resources

Access to agricultural technology and agricultural extension services increases adaptive capacity of households (Pretty, Toulmin, & Williams, 2011). Irrigation and use of improved varieties reduce vulnerability to climate uncertainty (Opiyo et al., 2014; O'Brien et al., 2004; Wreford, Moran, & Adger, 2010). Access to animal traction or tractors increases productivity and reduces reaction time whenever there is variability in onset of rains. Also, access to weather and climate projection information facilitates decision making on adaptation (Bryan et al., 2013; Gbetibouo, 2009). Due to the low availability of weather projection information in rural areas, another index of information capacity was included in the analysis. Information capacity index was proxied by the diversity of information, communication, and technology (ICT) gadgets available to a household. These included television, radio and telephone. These ICT resources have been found to increase access to climate information (Churi, Mlozi, Tumbo, & Casmir, 2012).

Diversity of income and assets

A household's asset base reduces its vulnerability. Resources may have to be appropriated for a household to cope with climate change. These resources come from either recurrent cashflows saved up income or from the liquidation of assets. A household with a richer portfolio of assets and income sources has more options for raising the resources needed to initiate adaptation interventions. Data on actual household income was not available, this study, therefore, uses the number of income sources to show the vitality of the household and it is premised that a number of income sources is indicative of livelihood diversification which is a well-known ex-ante risk management strategy (Heltberg, Siegel, & Jorgensen, 2009). The diversity of cash income which is a sign of vitality (Eakin, 2005) was also captured. It is hypothesized that a household with more diversified incomes has a better capacity to adapt to climate. Possession of livestock assets and an index of livestock diversity are included due to the role livestock plays in increasing resilience of vulnerable people by diversifying risk (Freeman, Kaitibie, Moyo, & Perry, 2008). The amount of farmland owned is used due to the prominence of land to rural livelihoods as the most important production asset (Demetriades & Esplen, 2008).

Social networks

Participation in social networks (Yohe & Tol, 2002) and access to credit (Caretta, 2014) increase adaptive capacity. Social networks of whatever nature can be conduits of information on best farming practices. They are also a good source of soft financial assistance in times of hardship (Gabrielsson, Brogaard, & Jerneck, 2013), just like remittances from family members and assistance from government and NGOs. Therefore, membership to social groups and reported receipt of assistance from government, NGOs or kinsmen were used as an indicator of adaptive capacity.

Sensitivity indicators

Farm-level sensitivity was proxied by indicators that show potential for livelihood distortion in the event of a climate-related shock. A household that often-stored part of the previous season's production had less sensitivity to crop failure during a particular growing season. The proportion of households that did not store food and the number of months in a year that a household experienced food shortage was collected as indicators of sensitivity. Crop diversity index was calculated bearing in mind that crops have different growth requirements and any climatic shock will not affect crops similarly. Therefore, households with a wider portfolio of crops can secure some of their crop income and consumption even in the event of a climatic shock. Land and land use characteristics like the status of soil fertility and the proportion of households practising agroforestry were also used to proxy sensitivity. Households practising agroforestry have been found to be more food secure, have better incomes and generally less sensitive to climate change than non-practising households (Thorlakson & Neufeldt, 2012). The quality of land is a sensitivity indicator because crops grown on fertile land will have more vigour even under harsh conditions. Salary and remittance income are particularly emphasized because they are less sensitive to local environmental conditions.

Exposure indicators

Usually, exposure is proxied by the frequency and intensity of contact with the sources of stress, preferably using actual climatic data (Etwire, Al-Hassan, Kuwornu, & Osei-Owusu, 2013; Hahn et al., 2009). Use of actual climatic data is less useful for detecting intra community differences in climate change vulnerability because all households would have the same values for exposure. According to Hahn et al. (2009), whereas natural disasters exposure factors like heavy rainfall and floods occur at a regional rather than household level, their effects can be felt individually. For this study, exposure was indicated by the actual impacts of climate change to the household by identifying those households that suffered the most impact such as death to persons or livestock, damage to farm structures, and those that were forced into temporary migration. One caveat for this approach is that exposure is underestimated in the model as only those households that reported extreme cases of impact like death, destruction of property and temporary migration are shown to be exposed to climate change.

6. Construction of the gender vulnerability index

The gender vulnerability index is a second generation assessment that incorporates adaptive capacity with sensitivity and exposure to determine vulnerability (Füssel & Klein, 2006). Second generation assessments assume that vulnerability precedes any exposure to a stimulus (Kelly & Adger, 2000). Here it is postulated that variations in the socio-economic characteristics between households headed by different gender mediate vulnerability (c.f. Deressa, Hassan, & Ringler, 2011). This approach has been used before by Adger and Kelly (1999) to assess vulnerability between social groups in Vietnam.

Exposure, sensitivity and adaptive capacity are each constructed from n sub-components (Table 1). The sub-components were first standardized following UNDP (2013) method for calculating component indices into the Human Development Index i.e. the ratio of the difference between actual subcomponent for the household category and sample minimum, and the range of sample maximum and minimum values for each sub-component.

$$Index_{sg^i} = \frac{S_g - S_{min}}{S_{max} - S_{min}}$$

where S_g is the original sub-component for each household category, and S_{min} and S_{max} are the minimum and maximum values, respectively, for each sub-component determined using combined data for both household categories.

An illustrative example of how the index is calculated is given by Hahn et al. (2009).

Diversity indices for crops, livelihood strategies, livestock assets, crop and livestock contributing to cash income and technology options were calculated following Shah et al. (2013). However, for ease of interpretation, the resulting index was subtracted from unity such that a household with more crop choices had a higher diversity index.

The standardized sub-components were then averaged using the equation below

$$M_g = \frac{\sum_{i=1}^{n} Index_{sg^i}}{n}$$

where M_g = one of the eight major components for gender g_i [Human resource capacity (HRC), Livelihood Strategies (LS), Social Networks (SN), Land/use characteristic (LC), Food security (FS), Technology (T), Off-farm Income (OFI) or Climate change impact (CI)], $Index_{sg^i}$ represents the sub-components, indexed by i, that make up each major component, and n is the number of sub-components in each component.

The indices for exposure, sensitivity and adaptive capacity were calculated differently each as an index containing several subcomponents (Figure 2).

The indexes for exposure (*Exp*), Adaptive capacity (*Ad.Cap*) and sensitivity (*Sen*) have been calculated as follows

$$Exp = \frac{w_{CI} CI_i}{w_{CI}}$$

Where: W_{CI} the weight for climate change impact calculated from the number of indicators under the sub-component.

The index for adaptive capacity (*Ad.Cap*) has been calculated as follows

$$Ad.Cap = \frac{w_{HRC} HRC_i + w_{LS} LS_i + w_{SN} SN_i + w_T T_i}{w_{HRC} + w_{LS} + w_{SN} + w_T}$$

Table 1. Sub-component values and maximum and minimum values for female and male-headed households in Eastern Uganda.

		Major component values	
Major component	Sub component	Female-headed (n = 154)	Male headed (n = 581)
Human resource capacity	Households that hire farm labour	24.7	38.6**
	Years spent in school by household head	4.90	5.75
	Mean age of household head	44.8	45.7
	Mean household size	6.7	7.5*
Natural disaster	Per cent reporting death of persons and livestock	11.7	14.8
	Per cent who temporarily migrated	1.9	1.9
	Per cent reporting diseases to persons and livestock	15.6	19.3
	Per cent reporting destruction of property	14.3	14.1
	Severity of exposure	0.24	0.26
Technology	Accessing extension services	7.1	8.8
	ICT diversity index [1-1/(#ICT + 1)]	0.40	0.52**
	Per cent using inorganic fertilizers	24	37.7**
	Per cent using irrigation	1.3	6.2*
	Per cent using improved cultivars	46.8	58.3*
	Percent receiving 2–3 month weather projections	60.4	74.2**
	Per cent using animal traction	21.4	27.5
Land characteristics	Perceive their land as not fertile	34.4	25.6*
	Per cent without access to wetland	87.7	84.5
	Per cent with steep land	33.8	40.4
	Per cent not practising agroforestry	68	49.2**
Livelihood strategy	Diversity of income sources 1-[1/(#income sources + 1)]	0.60	0.69**
	Diversity index for crop cash income 1-[1/(#cash crops + 1)]	0.42	0.47*
	Diversity index for livestock assets 1-[1/(#livestock + 1)]	0.48	0.57**
	Diversity of livestock cash income 1-1/(#livestock cash sources + 1)	0.40	0.50**
	Mean size of farmland (acres)	2.1	3*
Social networks	Per cent with membership to a social group	39	52.5**
Food security	Index of dependence on seasonal crops 1-[1/(#seasonal crops + 1)	0.31	0.34
	Per cent who do not store part of previous season's harvest	87	85.9
	Number of months with food shortage	4.35	4.20
Off-farm income	Per cent without salary income	94.8	91.4
	Per cent without remittance income	65.6	65.7

Asterisks indicate sub-components where there was significant difference between the household categories at 95% (*) and 99% (**) level of significance.

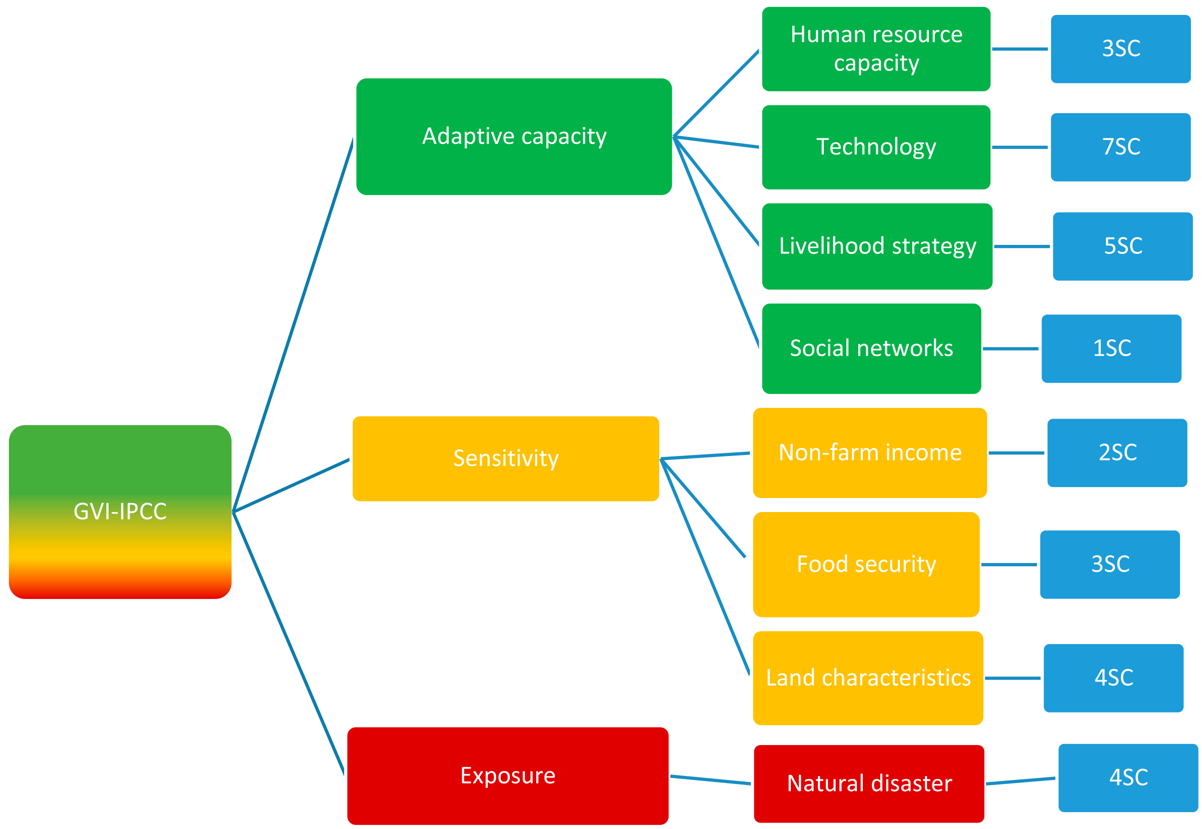

Figure 2. Categorization of major components into contributing factors from the IPCC definition for calculating GVI-IPCC.

Where: W_{HRC}, W_{LS}, W_{SN}, and W_T is the weight of human resource capacity, livelihood strategy, social networks and technology calculated from the number of indicators under the sub-components.

The index for sensitivity (Sen) has been calculated as follows

$$Sen = \frac{w_{LC}LC_i + w_{OFI}OFI_i + w_F FS_i}{w_{LC} + w_{OFI} + w_{FS}}$$

W_{LC}, W_{OFI}, and W_{FS} is the weight for land characteristics, off-farm income and food security calculated from the number of indicators under the sub-components

This approach ensures that all sub-components contribute equally to the overall GVI (e.g. Cutter et al., 2000) because there was no justifiable way to assign different weights on the sub-components.

Further, a GVI-IPCC index that uses the IPCC framework approach to combine the three contributing factors to vulnerability into an overall index for each gender differentiated household category is constructed. The model specification for GVI-IPCC index is as shown in equation below

$$GVI - IPCC = (Exp_{g_i} - Ad.Cap_{g_i}) * Sen_{g_i}$$

Where GVI – IPCC is the Gender Vulnerability Index for gender differentiated household category g_i expressed using the IPCC framework, Exp_{g_i} is the calculated exposure score (equivalent to the Natural Disaster component), $Ad.Cap_{g_i}$ is the calculated adaptive capacity score (weighted average of the human resource characteristics, livelihood strategy, social networks and technology components), and Sen_{g_i} is the calculated sensitivity score (weighted average of the Food security, Land/use characteristics and Off-farm income sub-components).

The overall vulnerability index for each gender differentiated household category was then calculated following equation (1).

A student t-test and Pearson chi-square at 5% level of significance were used to compare numerical and categorical sub-components for the two household categories respectively.

7. Results

Table 1 shows the GVI subcomponent values for female and male-headed households together with the minimum and maximum values for the whole sample. The major component values and the composite GVI for male and female-headed households are presented in Table 2.

Gender differentiated adaptive capacity to climate change

Male-headed households generally performed better across all the indicators of adaptive capacity and thus have a better adaptive capacity to climate change. Male-headed households showed more adaptive capacity in the human resource capacity major component. There were significant differences in two of the four sub-components of human resource capacity. A chi-square test showed that hiring additional labour was significantly ($\chi2 = 13.248$, $p = 0.001$) associated with the gender of the household head being male. Male-headed households also had significantly more household members ($t = 2.5$, $p = 0.013$).

Table 2. GVI-IPCC contributing factors calculations for Male and female-headed households in Eastern Uganda.

IPCC contributing factor	Major component	Major component values: Female-headed (n = 154)	Major component values: Male-headed (n = 581)	Number of sub-components	Contributing factor values: Female-headed	Contributing factor values: Male-headed	GVI-IPCC index: Female-headed	GVI-IPCC index: Male-headed
Exposure	Natural Disaster	0.136	0.152	5	0.136	0.152	−0.134	−0.176
Adaptive capacity	Social networks	0.39	0.53	1	0.346	0.447		
	Livelihood strategy	0.448	0.535	5				
	Technology	0.306	0.402	7				
	Human resource capacity	0.300	0.362	4				
Sensitivity	Non-farm income	0.802	0.786	2	0.638	0.597		
	Food security	0.534	0.538	3				
	Land characteristics	0.560	0.499	3				

Across the use of technology major component, a significantly higher proportion of male-headed households were found to apply inorganic fertilizers ($\chi2 = 10.364$, $p = 0.001$), use irrigation ($\chi2 = 6.004$, $p = 0.014$), improved cultivars ($\chi2 = 6.58$, $p = 0.010$) had better access to seasonal weather forecasts ($\chi2 = 11.316$, $p = 0.001$) and had a higher ICT diversity index ($t = 4.676$, $p = 0.000$). The overall index on the technology component was higher for male-headed households implying more adaptive capacity in terms of technology use.

The vulnerability spider diagram (Figure 3) reveals which aspect of the households' characteristics contributes most to vulnerability. The diagram shows that differentials in vulnerability between genders are caused more by disproportionate adaptive capacity than either sensitivity or exposure.

Male-headed households also performed better on the livelihood strategy major component by, having a more diversified livelihood portfolio in terms of income sources ($t = 5.19$, $p = 0.000$), a higher diversity of livestock assets ($t = 3.33$, $p = 0.001$) and were able to sell more kinds of livestock ($t = 3.579$, $p = 0.000$). Male-headed households also owned almost one acre more of agricultural land ($t = 3.858$, $p = 0.000$). Male-headed households showed better performance in the social networks. Male-headed households were more likely to have at least one member belonging to a local social group ($\chi2 = 8.92$, $p = 0.003$). These included savings, marketing, and local self-help groups. More male-headed households also reported accessing adaptation assistance from Non-Governmental Organizations ($\chi2 = 13.248$, $p = 0.000$) and government agencies ($\chi2 = 17.79$, $p = 0.000$) after a climate change related catastrophe.

Gender differentiated sensitivity to climate change

There is little difference between male and female-headed households across most of the sensitivity indicators considered in the analysis. However, more female-headed households perceived their land as having low fertility ($\chi2 = 4.698$, $p = 0.03$), and did not practice agroforestry ($\chi2 = 16.624$, $p = 0.000$).

Gender differentiated exposure

Numerical values of exposure suggest that male-headed households suffered more due to climate change (Table 1) and can thus be considered more exposed, but statistical analyses showed that the differences between the two categories of households were not statistically significant in any of the indicators of exposure used in this study.

GVI-IPCC: male versus female-headed households

Overall GVI-IPCC index reveals that female-headed households were more vulnerable to climate change (Figure 4). The difference in adaptive capacity contributes most to the disparity

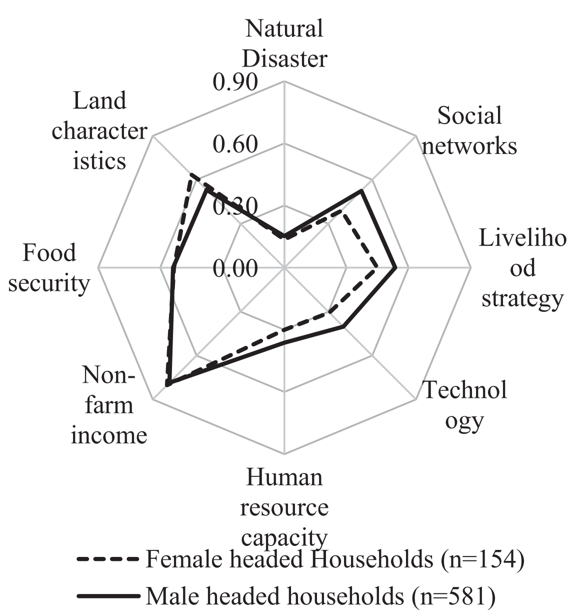

Figure 3. Vulnerability spider diagram of major components to the gender vulnerability index for male and female-headed households in Eastern Uganda.

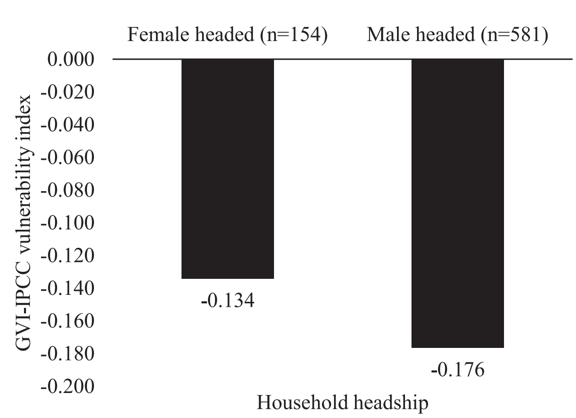

Figure 4. GVI-IPCC vulnerability index for male and female-headed households in Eastern Uganda.

in vulnerability whereas there is a general congruence in exposure and sensitivity between male and female-headed households

8. Discussion

The preceding results corroborate the assertion that female-headed households are more vulnerable than male-headed households albeit only slightly. According to Moser (1998), the disparity in vulnerability could be explained by the fact that women tend to possess fewer assets and opportunities compared to men, which reflect on the households they head. This study investigated whether the observation that women are more vulnerable to climate change can be extended to imply that there will be differences in vulnerability between male and female-headed households. Shah et al. (2013), also found little difference in vulnerability between male and female-headed households. This highlights the danger that may result from making conclusions about vulnerability of female-headed households based on perceived vulnerability of women. The study makes a distinction between women and female-headed households since household level data was collected. As a point of departure, this study recognizes that not all women in the community belong to female-headed households. Like Doss (2015) observed, female versus male-headed households' comparisons ignore the status of females in male-headed households and in particular oversimplifies the nature of households with couples (which are mostly male-headed). Moreover, conclusions about vulnerability of female-headed households cannot be made from vulnerability of individual women due to the mediating effect of the household where there is collective action of all members.

This study promotes the need to make household level assessments of vulnerability using household headship as categorizing variable. Female-headed households are an identifiable group that is increasing (Chant, 2004) due to economic migration of spouses and other factors. Whether the incidence of a female-headed household is as a result of an absentee husband for extended periods of the year, widowhood or escaping from domestic violence (Nalule, 2015), the result is usually the same for such households. They are usually more resource constrained than their male counterparts (Barros, Fox, & Mendonca, 1997; Chant, 2004; McLanahan, 1983) which probably explains the results as further illustrated below.

Whereas a labor market exists in the area, gender stereotypes may constrain female-headed households to hire labor (Larson, Savastano, Murray, & Palacios-López, 2016). In a recent study by the World Bank comparing productivity between male and female managed plots, women farmers' inability to mobilize extra labor was highlighted (O'Sullivan, Rao, Banerjee, Gulati, & Vinez, 2014). The disparity on hiring farm labor has been reported as a major driver of the gender gap in agricultural productivity (c.f. Ali, Bowen, Deininger, & Duponchel, 2015). Our results corroborate this constraint. Consequently, female-headed households may not be able to accomplish all the necessary farm operations in time to cope with an increasingly shorter rainy season.

Moreover, female-headed households were also found to have fewer household members. Being a patriarchal setting, cultural norms dictate that a household is considered female-headed only in the absence of an adult male, this means female-headed households invariably have fewer adult members (Doss, 2015). This disadvantages female-headed households as they miss out on getting adult male earnings but also end up having a higher dependence ratio (Chant, 2004).

Female-headed households showed less robust livelihoods which increases their vulnerability to climate change. Female-headed households (which were predominately of widowed women) owned less land probably because the majority of women get access to land and other property through their marital attachments (Doss et al., 2012). When a woman is not married, the mode of access to land through marriage is not an option. Widowed women could also have been affected by a cultural practice of sharing property between the adult children and the husband's family at the demise of the husband.

The larger portfolio of livestock by male-headed households in Eastern Uganda could be due to the nature of livestock raring especially in Bududa and Manafwa districts. Being hilly areas, the predominant system of livestock farming is zero grazing which would add more labor constraints to a female-headed household whose head is already responsible for securing food for the household. In the male-headed households with spouses, these chores can be divided among the adult members. This discourages women from holding large livestock like cattle. The low livestock endowment of female-headed households makes them unable to use livestock as a means of securing current consumption by selling livestock and using the proceeds to purchase consumption items. Male-headed households have higher crop diversity probably because in addition to the usual food crops, most male-headed households grew coffee which in Bududa and Manafwa is an important income generating crop and status symbol for every man. This corroborates what is often reported that men are more engaged in income-generating production (e.g. Glazebrook, 2011).

Female-headed households performed poorer in the social networks. Most often, lone mothers lack the spare time to engage in social networking because of the heavy burden of securing the household's food needs. Participating in social groups is important in building adaptive capacity to climate change (Adger, 2003; Vincent, 2007). These local networks are handy where state-led actions are not forthcoming (Adger et al., 2003). According to (Chant, 2004) the fear to be burdened with the expectation to reciprocate could constrain lone mothers and their households from joining social groups.

The low sensitivity of female-headed households in the food security sub-component could well be explained by the nature of women as being more conscientious and virtuous (Sundblad et al., 2007) with regards to ensuring food security of their households than men. Female-headed households were found to be less food insecure since a larger proportion of female-headed households reportedly stored part of the previous season's harvest. This makes female-headed households' food security status less vulnerable to short term variations in climate.

9. Conclusion

This paper shows that the livelihood vulnerability index by Hahn et al. (2009) can be modified and used to compare vulnerability at lower levels, e.g. household level. Based on the livelihood vulnerability concept, this study has constructed a gender vulnerability index to compare households using the gender of the household head to disaggregate data to reveal the most vulnerable and easily identifiable groups of households. This assessment could aid in optimizing resource allocation for climate change adaptation at the local level.

The study confirms that indeed vulnerability bifurcates along the gender of the household head, and results corroborate the general view that female-headed households are more vulnerable to climate change. The study showed that disparity in adaptive capacity was a bigger cause of vulnerability differences between female and male-headed households, than either sensitivity or exposure. However, the difference in vulnerability to climate change between male and female-headed households based on the calculated index was less prominent than suggested by the available literature which overemphasizes the vulnerability of women to climate change. The difference in vulnerability between gender differentiated households was small probably due to the low intensity of climate change stress experienced in the area. The most reported observed climate change stress in the area was a change in timing and length of the rain season (Balikoowa et al., 2018) a mild climate stress compared to the 'laboratory of extreme events and climate variability' within which most researchers conduct vulnerability research (Grothmann & Patt, 2005, p. 201). It is concluded that gender may not the best dimension along which differences in vulnerability to some climate change manifestations can be assessed, and that gender-differentiated vulnerabilities may not be expressed for all climate change manifestations. The unintended consequence of overemphasizing gender in climate change debates is that it misinforms the direction of adaptation planning, as resources are allocated based on wrong assumptions about vulnerability outcomes. If indeed there are intra-community differences in vulnerability to climate change, they are best captured by other disaggregating factors than gender. The study showed that reducing vulnerability among the ever-expanding category of female-headed households requires that more effort is put in proactive adaptation, thus increasing their adaptive capacity other than protectionist interventions. However, the study exposes one disadvantage of using household headship to generalize on the vulnerability of women as it masks the synergies that exist in mixed gender households and blurs over the role women play in reducing vulnerability in mixed gender households. More disaggregation of household headship is recommended to assess the vulnerability of only male and only female-headed households in comparison to mixed gender households as a first step in understanding whether vulnerability to climate change is linked to women. Further intersectional studies are needed to more accurately capture how gender interacts with other household variables like age, ethnicity and religion and how their interactions cause different vulnerability outcomes.

Disclosure statement

No potential conflict of interest was reported by the authors.

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