Original Research Article

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Gender analysis of vulnerability of rural smallholder farming households to climate change and variability in Zimbabwe's four major tobacco growing provinces

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Gender based vulnerability analysis of rural smallholder farming households to climate change variability in four major tobacco growing provinces of Zimbabwe

Abstract

Aims: The study investigated the extent to which there was a difference in the vulnerability of male and female smallholder tobacco farmers to climate change (CC); and assessed farmers' exposure, sensitivity, and adaptive capacity to climate change and variability using an index-based approach.

Study design (Place and Duration of Study): Tobacco Sales Floor (TSF), Boka Tobacco Floors (BTF), and Premier Tobacco Auction Floor (PTAF), and the data was collected between March and July 2024 in Harare.

Methodology: We collected primary data from tobacco growing provinces of Manicaland (MN, 115 respondents), Mashonaland Central (MC,195), Mashonaland East (ME, 195), and Mashonaland West (MW, 195) were selected at random distributed by gender as 36% being women and 64% being male. Both Livelihood Vulnerability Index (LVI) and the Livelihood Vulnerability Index and Intergovernmental Panel on Climate Change (LVI-IPCC) we employed to achieve their study.

Conclusion: The optimal value of the LVI is between 0 (least vulnerable) and 1 (most vulnerable), while the IPCC index varies between minus one (-1) (least vulnerable) to positive one (+1) (most vulnerable). Overall LVI shows that female headed households (FHH) were more vulnerable to climate change (CC) with an index of 0.528 when compared to male headed households (MHH). Looking at the seven sub-components, FHH's vulnerability was high socio-demographic profile [0.489 (FHH) versus 0.473 (MHH)]; food [0.515 (FHH) versus 0.502 (MHH)]; social networks [0.661 (FHH) versus 0.622 (MHH); health [0.686 (FHH) versus 0.616 (MHH) and water [0.415 (FHH) versus 0.212 (MHH). On the other hand, MHH were more vulnerable to CC in the category of livelihood strategies [0.448 (MHH) versus 0.413 (FHH)]; and natural disasters and climate variability [0.526 MHH) versus 0.516 (FHH)]. According to the overall calculated LVI_{IPCC}, households headed by women were more vulnerable to climatic variability and change (LVI_{IPCC} = -0.005) than households headed by men (LVI_{IPCC} = 0.007). In terms of sub-components, households headed by women ($CFI_{Exposure}$=0.526) were more vulnerable with regards to exposure when compared to male-headed households ($CFI_{Exposure}$= 0.516). Compared to male-headed families ($CFI_{Sensitivity}$ = 0.458), female-headed households ($CFI_{Sensitivity}$ = 0.527) were more sensitive to climate change and variability. When it comes to adaptable capacities, FHH ($CFI_{adaptive\ capacity}$ =0.510) were more vulnerable than male-headed households MHH ($CFI_{adaptive\ capacity}$=0.525). When reading the adaptive CFI, the implication is that the higher the index is, the higher the level of adaptive capacity of a given household the lower their vulnerability to climate change.

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1 INTRODUCTION

Climate change (CC) which is define by the Intergovernmental Panel on Climate Change (IPCC) (2014) as any long-term shift in the climate that results from natural variability as well as human activity is having severe negative consequences especially to rural agriculture societies and economies. Stated differently, vulnerability is a manifestation of a system's sensitivity, adaptive capacity, and the nature, extent, and degree of its exposure to climate change and variability (Daudu, et al, 2021). According to accepted wisdom, vulnerability arises from the interplay of the system's sensitivity and adaptive ability with biophysical drivers, such as climate exposure (Shah, et al, 2013). Analysis of climate change vulnerability can be done at the national, regional, and household levels (Acheampong et al., 2014; Opiyo, 2014; and Manaye, 2024). The research goal, the data at hand, and the study's methodology all influence the choice of vulnerability analysis scale. Due to increased drought and flooding, climate change is already negatively impacting agricultural production. Over the past century, yields have already decreased by between 1% and 2%, and it is predicted that this trend will worsen (Wiebe et al. 2015). Apart from their exposure to climate extremes and gradual changes in climate conditions, rural households are more vulnerable due to a confluence of social, economic, and environmental factors (Nelson, 2011; Goodrich et al, 2017; and Lente, et al, 2024). Rural communities are particularly vulnerable due to remotiness constraints such as inaccessibility, fragility, and marginality.

Due to their high reliance on climate-sensitive natural resources and the fact that they lack resources, indigenous rural communities in Zimbabwe face particular environmental, social, and economic challenges from climate change. Majority of Zimbabweans are already vulnerable to a variety of difficulties, such as hunger, disease outbreak susceptibility, natural disasters, and loss of livelihood (Chatsiwa, 2024). The effects of climate change and associated hazards on the livelihoods of marginalised communities and the unique challenges faced by tobacco rural farmers have received little attention up to this point in Zimbabwe's four tobacco growing provinces of Manicaland (MN), Mashonaland Central (MC), Mashonaland East (ME) and Mashonaland West (MW)[1]. Despite the fact that farmers, both male and female, in the same geographic area are subject to the same climate stresses, the impact of these conditions differs depending on the degree of exposure, sensitivity and adaptive ability of the two genders (Daudu, et al, 2021).

A number of studies that have been done in Zimbabwe and other countries on climate change have placed a greater emphasis on gender perception, adaptation, and mitigation than they have on the gender component of vulnerability to changing climatic conditions. In the context of Zimbabwe, Mwadzingeni et al (2021) investigated the impact of climate change on three irrigated areas located in Midlands provinces using the livelihood vulnerability index (LVI). Other scholars who did research on Zimbabwe looked at various dimensions of climate change including farmers perceptions (Moyo, et al, 2012); shock-response strategies used by farmers to deal with climate shocks (Nkonya et al, 2023); sources of vulnerability to a variable and changing climate among smallholder households (Rurinda et al, 2014); climate change and future crop suitability (Hunter, et al, 2020); climate change impacts, vulnerability and adaptation (Brown, et al, 2012); climate-resilient agricultural system (ICRISAT, 2021) and assessment of the economic impacts of climate change on agriculture (Nhemachena, 2007). All these studies did not include gender lenses in their analysis.

This study's two specific objectives are to: (i) ascertain whether there is a difference in the vulnerability of male and female smallholder tobacco farmers to climate change; and (ii) assess farmers' exposure, sensitivity, and adaptive capacity to climate variability and change using an index-based approach. The study hypothesises that the degrees of vulnerability in households headed by men and women differ significantly.

[1] Zimbabwe has 10 provinces and with regards to tobacco farming the following four are the major producers: Mashonaland West (34.4% by volume (kilograms)), and 35.8% by value (US$)); Mashonaland Central (34.9% by volume and 36.3% by value); Mashonaland East (13.4% by volume and 12.2% by value); and Manicaland (16.5% by volume and 15.3% by value). These four provinces produce 99.7% of total tobacco by volume and 99.6% by value[1] (TIMB, 2021).

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2 METHODOLOGY

2.1 description of study area with map of study area needed
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The research uses four methods to evaluate how vulnerable livelihoods are to climate change. First, when choosing indicators, the study took into account the indigenous knowledge of the community. Local views, experiences, and observations of climate change and associated risks shape communities' adaptation strategies (Manandhar, et al, 2011). In the tobacco growing provinces of Zimbabwe, which are vulnerable to climate change, incorporating local and indigenous knowledge can provide advice for more efficient planning, management, and decision-making. Second, the research also investigates the impact of gender and ethnicity on livelihood vulnerability to climate change and associated hazards. Third, an evaluation of the livelihood vulnerability index (LVI) was conducted using primary empirical data. Very few studies on the vulnerability of climate change have gathered primary empirical data. Conversely, the majority were constructed using secondary data sourced from multiple sources (Shah, et al, 2013; and Preston, et al, 2011). In order to offer guidance for local planning related to climate change adaptation and mitigation, this study evaluates the LVI based on field observations. Finally, by highlighting critical points of intersection where vulnerability, gender, and cultural converge, this research aids in the creation of suitable climate change adaptation plans for global international research and development (R&D) projects.

2.1 Data collection

The livelihood vulnerability approaches, namely LVI and LVI-IPCC, of a rural tobacco farming communities were evaluated through the utilisation of primary data gathered from the household survey. By collecting primary data, one can avoid relying on climate models and secondary data, which are unable to adequately represent the effects at the local community level (Sujakhu, et al, 2019). Primary data in the form of cross-sectional data from household survey of tobacco farmers selling their product at three Tobacco Industry and Marketing Board (TIMB) 2023 licenced companies namely Tobacco Sales Floor (TSF), Boka Tobacco Floors (BTF), and Premier Tobacco Auction Floor (PTAF), between March and July 2024 was conducted for the study. The capital city, Harare, is home to these three companies. Since these three companies typically offer somewhat higher prices than any of the decentralised contract auction floors in the small towns of Bindura (MC), Karoi (MW), Mvurwi (MC), Marondera (ME), and Rusape (MN), the majority of tobacco farmers prefer to sell to one of these three companies at their respective branches in Harare. Each year and mostly between March and July, almost all the country's 167,000 smallholder tobacco farmers from the four tobacco-growing provinces in the country travel to Harare.

To collect primary data, the author developed, pre-tested, and shared a questionnaire with tobacco farming households. Following consultation with Government provincial agricultural officers and an initial development of the questionnaire guided by the literature, each province's unique local reality was taken into account during modification. Interviews with thirty randomly selected tobacco farmers from each of the three auction floors in Harare (TSF, BTF, and PTAF) were conducted to pre-test or pilot the questionnaire. The actual vulnerability of the province's tobacco farmers to climate change was then taken into account during finalization of the questionnaire. Because of this, the final questionnaire had the limitations and ambiguities of the original questionnaire fixed or corrected prior to the actual data collection. The questionnaire contained thirty-one significant variables that were used to calculate the LVI and other variables to meet the other objectives. Every interview lasted an hour on average.

A total of 700 smallholder tobacco-farming households distributed by provinces [115 (MN), 195 (MC), 195 (ME), and 195 (MW)] were selected at random. In the end, 700 persons responded to the survey; however, 33 were excluded for not providing enough information. Although it would have been ideal if 50% of the sample consisted of women, most tobacco-producing households are led by men by nature. 240 women, or 36% of the total, ultimately took part in the survey. Furthermore, thirty-six in-depth interviews with key informants, two legislators, two head of farmer unions, two village chiefs, two local agricultural extension agents, and one local climate change (CC) expert, were conducted in each of the three tobacco auction floors using the checklist of questions. Of these, nine were from the

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four provinces. Through these interviews, the study was able to gain a comprehensive understanding of the socioeconomic and cultural context as well as observe the effects of climate-related events in the study area.

Three separate FGDs were held: (i) one with an equal number of men and women, (ii) one exclusively for women, and (iii) one for men only. The study conducted twelve FGDs in total. Discussions with different groups made it possible to have a multifaceted understanding of livelihoods and vulnerabilities related to climate change. In addition, these focus group discussions (FGDs) offered a historical account of past disaster events and their impact on communities. This information was helpful for the study's sociological analysis and helped to clarify the discussion's conclusions and points of contention. Finally, data on temperature and rainfall were acquired from Zimbabwe's Meteorological Services Department (MSD). The reference period of the meteorological data was between 1980 and 2024. Information on Zimbabwe and Africa, as well as global climate variability and change, was gathered from a variety of sources, including journals, textbooks, and project reports.

2.2 Measuring vulnerability to climate change and variability

Two indices were estimated in order to assess the type and degree of susceptibility of farming households headed by men and women to climatic variability and change: the LVI, which is based on a balanced weighted average and the LVI_{IPCC} which is based on the IPCC vulnerability framework. Although LVI-IPCC identifies the studied community's adaptive capacity, sensitivity, or exposure information that may be helpful in developing plans for reducing livelihood vulnerability to changing climate and related hazards, LVI identifies the important component(s) and nested sub-components, which are the most significant drivers of vulnerability in the studied community (Sujakhu, et al, 2019). Moreover, livelihood elements that can capitalise on current adaptive ability and sensitivity should be taken into account for community-level planning related to adaptation and mitigation. As such, it has been found to be helpful to calculate both indexes simultaneously. Furthermore, vulnerability is evaluated using particular indicators that are considered to be appropriate for the communities under study. These indications draw attention to the susceptibility of an individual, a group, or a system to particular risks (Tubiello and Rosenzweig, 2008).

2.2 IPCC Framework for calculating LVI

According to the IPCC Third Assessment Report (2007) climate change vulnerability depends on exposure, sensitivity, and adaptive capability ((Paavola, 2008 and Macchi, 2011). Vulnerability is a negative function of the system's ability to adapt and a positive function of the system's exposure and sensitivity (Barros, et al, 1997 and Ford and Smit, 2004). Exposure is the type and extent to which a system is subjected to a notable shift in the climate, while sensitivity refers to the degree to which a system is impacted by climate-related stimuli, either negatively or positively. Adaptive capacity is the ability of a system to adapt to climate fluctuation and extremes in order to either mitigate potential harm or deal with its aftermath (Paavola, 2008).

2.3 Assessing vulnerability to climate change: livelihood vulnerability index (LVI)

The livelihood vulnerability index (LVI), which was developed by Hahn et al. (2009) and used by many scholars including Etwire et al. (2013), Jamshidi et al (2019), Daudu et al (2021), Phuong et al (2023), and Maru et al (2021) among others, was computed using the balance weighted approach to model the vulnerability to climate change of smallholder maize farming households. The Livelihood Vulnerability Index (LVI) framework is especially pertinent to comprehending climate change (CC) vulnerability, as it offers a structured approach to examining the essential elements of livelihoods as well as the external circumstances affecting them. Using the IPCC definition of vulnerability to climatic impacts, the LVI was calculated for each of the households that were chosen for the study. It utilises seven primary components: health, social networks, livelihood strategies, access to food, water, and natural hazards, as well as climate change and sociodemographic profile. It is necessary to

standardise each component as an index using equation (1) because each component is composed of multiple indicators or sub-components, each of which is measured on a different scale.

$$Index_{shi} = \frac{Sh - S\min}{S\max - S\min} \quad (1)$$

where S_h represents the household indicator's observed sub-component and S_{min} and S_{max} stand for the minimum and maximum values, respectively.

Equation (2) is used to average the sub-component indicators once they have been standardised in order to determine the index of each major component:

$$M_h = \frac{\sum_{i=1}^{n} index_{shi}}{n} \quad (2)$$

where $index_{shi}$ is the sub-components, indexed by I, that make up each major component, and *n* is the number of sub-components in each major component. For household *h*, the seven major components are [Socio-Demographic Profile (SDP), Livelihood Strategies (LS), Social Network (SN), Health (H), Food (F), Water (W), or Natural Hazard, or Climate Variability (NDCV)]. M_h is one of these seven major components

The household-level LVI is obtained by averaging the values for each of the seven major components for a household using an equation (3).

$$LVI_h = \frac{w_{SDP}SDP_h + w_{LS}LS_h + w_H H_h + w_{SN}SN_h + w_F F_h + w_h W_h + w_{NDC}NDC_h}{w_{SDN} + w_{LS} + w_H + w_{SN} + w_F + w_W + w_{NDC}} \quad (3)$$

Each major component's weight, or W_{Mi}, is determined by counting the number of sub-components that comprise it. This is done to make sure that every sub-component contributes the same amount to the total LVI. The vulnerability score (LVI) ranges from 0 (low vulnerability) to 0.6 (very vulnerable).

2.4 IPCC Framework for Calculating LVI

The seven main components were grouped under exposure, adaptive capacity, and sensitivity in the alternative method of calculating LVI, which integrated the IPCC vulnerability definition. Similar to the LVI, each major component was made up of a number of smaller components or indicators. Similarly, the LVI–IPCC was computed using equations (1) through (3). This method computed three weighted averages of the major sub-components in accordance with the three contributing factors described using equation (4), as opposed to using a single weighted average as in the LVI approach.

$$CF_h = \frac{\sum_{i=1}^{n} wM_i M_{hi}}{\sum_{i=1}^{n} wM_i} \quad (4)$$

where *i* is the index of the major components for the household; w_{Mi} is the weight of each major component; *n* is the number of major components in each contributing factor; and where CF_h is a household's exposure, sensitivity, or capacity for adaptation as defined by the IPCC. After exposure, adaptation capacity, and sensitivity have been computed, the three contributing factors are combined using equation (5).

$$LVI - IPCC_h = (e_h - a_h) * S_h \quad (5)$$

where e_h is the household's calculated exposure score (corresponding to the major component of natural hazards and climate variability), and LVI–IPCCh is the LVI for household *h* as expressed using the IPCC vulnerability framework. Monthly minimum and maximum temperatures as well as monthly

rainfall over a 42-year period are averaged to determine the degree of climate variability (Hahn, et al 2009; Ashok and Sasikala, 2012; Etwire et al., 2013; Adu et al, 2018; and Jamshidi, et al, 2019). Additionally, household *h's* calculated adaptation capacity score is denoted by ah (weighted average of livelihood strategies, sociodemographic factors, and social networks), and household h's calculated sensitivity score is denoted by S_h (weighted average of health, food, and water major components). The LVI-IPCC Index ranges from approximately minus on (–1) (least vulnerable) to 1 (most vulnerable). The LVI was estimated using Microsoft Office Excel 2023 in accordance with Hahn et al (2009) methodology. Tables 1 and 3 in Hahn et al (2009) provides extended description of the seven major components and their respective sub-components of the LVI, while Table 2 in the same publication classifies the major components that contribute to the IPCC vulnerability definition in order to calculate the LVI-IPCC.

4 RESULTS AND DISCUSSION

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4.1 Gender livelihood vulnerability index assessment for combined provinces

Th LVI for male headed households (MHH) and female headed households (FHH) for the combined four provinces are depicted in Table 1. Though the optimal value of the LVI is between 0 (least vulnerable) and 1 (most vulnerable), the computed indices for the main components in this study range from 0.212 (least susceptible) to 0.686 (most vulnerable). The calculated vulnerability indexes for both major and sub-components are presented in Table 1. The findings show a substantial difference between families led by men and women with regard to health and water; moderate difference with regards to livelihood strategies and social networks, while the LVI for socio-demographic characteristics, food, and climate change and disasters are nearly the same.

4.1.1 Socio-demographic profile

According to the calculated vulnerability indices for the socio-demographic profile (SDP) major component of the livelihood vulnerability index (LVI), households headed by female (SDP_{LVI} = 0.489) were found to be more vulnerable than households headed by men (SDP_{LVI} = 0.473). Male-headed households were more vulnerable with regards to percentage of households with orphans (63%) than female-headed households (56%). The results from focus group discussions (FGDs) indicated that most male-headed households were taking the burden of adopting the orphans from their relatives from both their families and the families of their spouses to look after once the respective biological parents have passed on. A relatively large percentage of FHH (4%) had not attended school when compared to their counterparts MHH (3.7%). These observations are comparable with the national literacy indicated in the Zimbabwe 2022 Population and Housing Census Report which showed an average rate of 93.6%, while the urban literacy rate of 97% was relatively higher than the rate for the rural areas which stood at 91.2% (ZimStat, 2023). Endowment in education helps households to appreciate the importance of various aspects which increases one's ability to adapt or reduce vulnerability to climate change and such aspects includes capacity to use irrigation, plating of appropriate seed variety (appropriate in terms of soil texture, rainfall pattern, etc). In this case a relatively higher percentage of MHH are educated than FHH, making the former better able to fight climate change vulnerability, than the later. In terms of the dependency index, female-headed households (0.89) were slightly more vulnerable than male-headed households (0.88). The larger dependency ratio suggests that a large number of individuals were reliant on the labour of a small number of people. Discussions from FGDs alluded to the fact that in most households, (extended) family members who will be sick, or unemployed, disabled etc normally prepare to go and stay with women relatives as opposed to male relatives, given the higher possibility of getting better care from a women relative.

4.1.2 Livelihood strategies

The livelihood strategies make up the second major component of the LVI. According to the computed vulnerability indices, families headed by men (LVI_{LS}=0.448) were more likely than households headed by female (LVI_{LS} = 0.413) to be vulnerable in terms of livelihood strategies. Compared to male-headed

families (0.4%), a comparatively larger proportion of members (14%) of female-headed households work outside the community. Approximately 87% of households headed by women earn their only income from agriculture, compared to 93% of those headed by men. The fact that majority of MHH depend on agriculture for their income has resulted in them diversifying within the agriculture, for instance by growing wider variety of crops and practicing other agriculture activities, thus making them less vulnerable as far as average agricultural livelihood diversification index (0.25) when compared to female headed households (0.333). The focus group discussion's (FDGs) outcome showed that while men are typically involved in piece work within the communities, and masonry work, women are more frequently involved in non-farm pursuits like gardening, burning and selling fire wood, petty trading, and food vending.

Table 1: Normalized sub-components, major components and overall LVI for female and male-headed households in Zimbabwe's 4 tobacco provinces

Sub-component	Female-headed HH	Male-headed HH	Major components	Female-headed HH	Male-headed HH
Dependency ratio	0.890	0.88	**Socio-demographic profile**	0.489	0.473
Average age of head of household	0.410	0.408			
Percent of households where head of household has not attended school	0.040	0.037			
Percent of households with orphans	0.560	0.63			
Percent of households dependent solely on agriculture as a source of income	0.87	0.93	**Livelihood strategies**	0.413	0.448
Average agricultural Livelihood Diversification Index	0.333	0.25			
Percent of households with family member working in a different community	0.140	0.04			
Percent of households dependent solely on family farm for food	0.718	0.739	**Food**	0.515	0.502
Average Crop Diversity Index	0.167	0.167			
Average number of months households struggle to find food	0.333	0.50			
Percent of households that do not save crops	0.40	0.53			
Percent of households that do not save seeds	0.95	0.93			
Farm land size (ha)	0.444	0.22			
Percent of households that have not gone to their local government for assistance in the past 12 months	1.00	0.99	**Social networks**	0.661	0.622
Average borrow: lend money ratio	0.333	0.667			
Average receive: give ratio	0.533	0.40			
Average time to health facility	0.286	0.421	**Health**	0.686	0.616
Average Malaria Exposure*Prevention Index	1.5	1.5			
Percent of households with family member with chronic illness	0.063	0.063			
Percent of households that utilize a natural water source	0.26	0.34	**Water**	0.415	0.212
Average time to water source	0.333	0.391			
Percent of households that do not have a consistent water supply	0.515	0.515			
Average number of flood, drought, and cyclone events in the past 6 years	0.571	0.571	**Natural disasters and climate variability**	0.516	0.526
Percent of households that did not receive a warning about the pending natural disasters	0.44	0.39			
Mean standard deviation of the daily average minimum temperature by month (years: 1980-2022)	0.524	0.524			
Mean standard deviation of the daily average maximum temperature by month (years: 1980-2022)	0.642	0.642			
Mean standard deviation of average precipitation by month (years: 1980-2022)	0.451	0.451			
Overall LVI				**0.528**	**0.486**

Source: Authors computations from Field Survey (2023)
Key: MN = Manicaland; MC = Mashonaland Central; ME = Mashonaland East; MW = Mashonaland West

4.1.3 Social network

There are three smaller components that make up the LVI's major social network component. All female-headed households never requested assistance from their local government or members of parliament (MPs), in contrast to 99% of male-headed households who said they had never asked for any kind of help from them. According to the computed indices, male-headed households (0.667) reported borrowing money from friends and relatives more often than female-headed households (0.333), but female-headed households (0.535) gave assistance more frequently than they received (0.40). Households headed by women (0.686) were found to be more vulnerable than households headed by men (0.622) according to the overall vulnerability index of the social network major component. The focused group discussions' outcomes showed that, most men receive remittances from their children from outside the country and urban areas more than their women counterparts. This social network loop has helped male headed households to reduce borrowing and exposure from severe vulnerability when compared to their female headed households. Female only relied on borrowing from their social networks, and are therefore more vulnerable than male-headed households.

4.1.4 Health

In terms of the health major component of the LVI, families headed by women (LVI_{FHH} = 0.686) seemed to be relatively more vulnerable than households headed by women (LVI_{MHH} = 0.616). The primary component of health consists of three subcomponents. On average, families headed by men take 42 minutes longer than households headed by women to get to health services (28.6 minutes). The calculated vulnerability indices show that families led by women (0.063) are equally vulnerable to chronic illness when compared to households headed by men (0.063). That is in comparison to 6% of homes headed by men, an equally proportion of 6% of households headed by women reported having at least one member who was chronically ill. In comparison to homes headed by women (1.5), male-headed households (1.5) were equally vulnerable in terms of average malaria exposure. In families headed by women, the average number of months of malaria prevalence was around five and this was the same period (i.e., 5 months) in households led by men. It was revealed that families headed by women owned 4.5 mosquito nets on average, whereas households headed by men had 3.65. FGDs interactions indicated that in general, women attend most of community health related meetings, gatherings and workshops called for by health workers and they tend to have more appreciation of the importance of owning mosquito nets as a means of reducing exposure to malaria.

4.1.5 Food

Compared to female-headed households (LVI_{FHH} = 0.515), households headed by men (LVI_{MHH} = 0.502) were less vulnerable to food insecurity. In contrast to 40% and 95% of female-headed households who reported not having stored crops and seeds, respectively, roughly 54% and 93% of male-headed households did not save harvested crops (farm product) and seeds. Farmers that were able to preserve their goods were better able to recoup their investment through higher pricing and increased food security. Furthermore, farmers who were able to save seeds from their agricultural produce find it easier to obtain seeds for planting in the next growing season. The calculated indices showed that families headed by men were more vulnerable than those headed by women in terms of farm produce, while female headed households were more vulnerable in terms of seed availability.

Crop diversity averages for households headed by women and men were 0.167 apiece. Compared to households headed by women (71.8%), a greater proportion of households headed by men (73.9%) rely on family farms for their food. As a result, in terms of agricultural diversity, households headed by men were more vulnerable than those headed by women, particularly in years when the weather did not favour the growth of particular crops. With regards to food security, male-headed households had an average of 3.5 months of food insecurity, compared to 4 months for female-headed households. This typically happens between November and February, when farmers are just starting the crop season and have depleted their food supply. According to the calculated vulnerability indices, households headed by women (0.444) were found to be more vulnerable to the size of farmland ownership than households headed by men (0.22), with 44% of female-headed households and 22% of male-headed households respectively owning only less than 2 hectares. The focus group discussions' findings demonstrated that women frequently cultivate on small plots of land near to their communities, where the land is not very fertile and has been left fallow. Because of this, women's

agricultural outputs are typically low, which means they cannot rely on them throughout the year, leaving female-headed households more food insecure than male-headed households.

4.1.6 Water

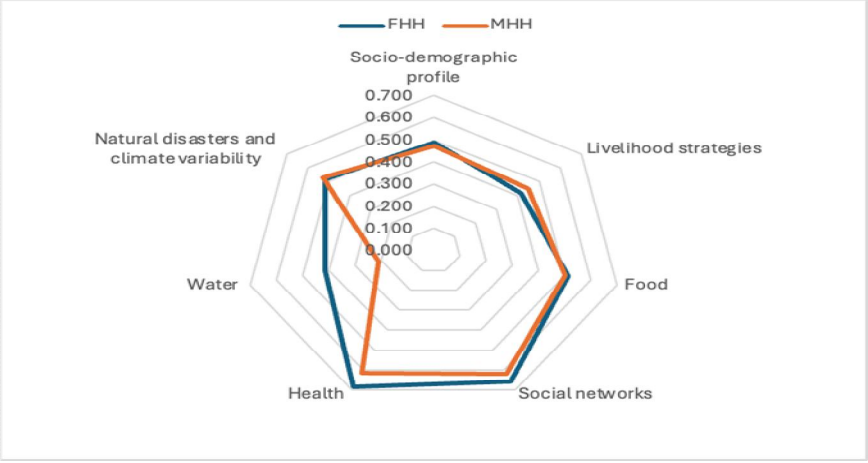
Water is the sixth major component of the LVI and is made up of three sub-components. Streams, dams, rain, lakes, and rivers are the sources of water for 26% of homes headed by women and for 34% for male-headed households. Waterborne illnesses like bilharzia can occasionally arise from the contamination of natural sources of water. That means that a quarter of homes led by women and a third led by men are at a higher risk of getting sick from water-borne infections. Male-headed households took an average of 39.1 minutes to reach a water source, whereas female-headed households took 33.3 minutes on average. This implies that men go further in search of water than do women. The percentage of families headed by men and women that lack a reliable source of water is around 51.5%. The average of the five sub-component indices showed that households headed by women were considerably more vulnerable to the water major component (LVI_{FHH} = 0.415) than households headed by men (LVIW = 0.212). That is, 61.6% of female-headed households were vulnerable to water as major component when compared to 41.5% of male-headed households. During the focus group discussions, it was discovered that women are exclusively responsible for getting water for home consumption. On the other side, men get water for animal, bathing and watering as well as for construction, particularly for building a house. Men frequently go to rivers, dams, lakes, and springs for water, while women typically get their water from wells, boreholes, and rainstorms. The explanation that came up in the focused group discussions was that men are more equipped than women with motorbikes, bicycles and scotch cats to go to remote locations and gather water. In addition, women's water is used for drinking and cooking, but men's water is used for other purposes and does not necessarily need to be as pure and clean.

4.1.7 Natural disasters and climate variability

The LVI's key component indexes for natural disasters and climate change do not significantly differ from one another. The study explained only elements that significantly differed in the computed indices for households headed by men and women. Men and women agreed, nevertheless, that the rainy season has shifted and now lasts from December to April instead of October to April as it used to. However, the annual rainfall was reported to be irregular.

When all seven key components of the LVI were combined, female-headed households were found to be more vulnerable to climate change and variability, with an overall LVI of 0.528, compared to male-headed households with an overall LVI of 0.486. The gender vulnerability radar diagram in Figure 1 displays the computed vulnerability indices of the major LVI components and the overall LVI for households headed by women and men.

Figure 1: Gender vulnerability radar spider diagram



Source: Authors construction from field survey (2023)

4.2 Assessment of LVI based on the IPCC for women and men

The IPCC defines vulnerability as a system's ability to adapt, its sensitivity, and its exposure to climatic pressures as contributing variables. The index varies between minus one (-1) (least vulnerable) to positive one (+1) (most vulnerable). The three contributing factors were initially formed by combining the major components: exposure (corresponding to the major component of natural disaster and climate change) and sensitivity (weighted average of the major components of health, food, and water), and adaptive capacity (weighted average of the demographic profile, livelihood strategies, and social network major components). Table 2 displays the calculated indices for the vulnerability contributing elements.

Table 2: Gender LVI-IPCC for Zimbabwe's combined four tobacco provinces

Contributing factors	Major components	Major components values (i.e., LVI values)		No. of sub-components per major component	Contributing factor values (i.e., sum LVI values)		LVI-IPCC value	
		FHH	MHH		FHH	MHH	FHH	MHH
Adaptive capacity	Socio-demographic profile (SDP)	0.49	0.47	4	0.510	0.525	-0.005	0.007
	Livelihood strategies (LS)	0.41	0.45	3				
	Social networks (SN)	0.69	0.62	3				
Sensitivity	Health	0.66	0.62	3	0.527	0.458		
	Food	0.52	0.50	6				
	Water	0.42	0.21	3				
Exposure	Natural disasters & climate variability (NDCV)	0.52	0.53	5	0.526	0.516		

Source: Authors computations from field survey (2023)

According to the overall calculated LVI_{IPCC}, households headed by women were more vulnerable to climatic variability and change (LVI_{IPCC} = -0.005) than households headed by men (LVI_{IPCC} = 0.007). In terms of vulnerability to climatic variability and change as indicated by computed contributory factor indices (CFI), households headed by women ($CFI_{Exposure}$=0.526) were more vulnerable with regards to exposure when compared to male-headed households ($CFI_{Exposure}$= 0.516) were nearly comparable. This is despite the fact that they were in the same general area and had comparable weather. Compared to male-headed families ($CFI_{Sensitivity}$ = 0.458), female-headed households ($CFI_{Sensitivity}$ = 0.527) were more sensitive to climate change and variability. Despite the fact that female-headed households were more exposed and sensitive to climate change than their male counterparts, when it comes to adaptable capacities, and according to the computed vulnerability contributing factor indices (CFI), FHH ($CFI_{adaptive\ capacity}$ =0.510) were more vulnerable than male-headed households MHH ($CFI_{adaptive\ capacity}$=0.525). When reading the adaptive CFI, the implication is that the higher the index is, the higher the level of adaptive capacity of a given household the lower their vulnerability to climate change. Figure 2 displays the three LVI-IPCC contributing elements between the two gender.

Figure 2: Three contributing factors to LVI-IPCC between two gender

Source: Authors construction from field survey (2023)

4.2 Female and male livelihood vulnerability index assessment for four provinces

Overall, the study discovered that the most significant factors influencing the gender vulnerability were health, social networks, natural disasters and climate variability and food, among others. Of the seven components used to calculate LVI, the first two had the highest vulnerability score, while the remaining components helped identify the vulnerability score across various social groups.

4.2.1 Gender: LVI

Table 3, which compares the livelihood vulnerability of households headed by men and women across the four tobacco growing provinces, indicates that households headed by men are less vulnerable than households led by women. Tabulated indices demonstrate that compared to male-headed families, female-headed households were significantly more vulnerable in terms of socio-demographic profile, social networks, health, water, while male-headed households were more vulnerable with regards to livelihood strategies, and food. Both genders were equally vulnerable in terms of natural disasters and climate variability.

A closer look at overall vulnerability level with regard to socio-demographic profile shows that female-headed households (FHH) from Manicaland (MN) province (FHH_{MN}=0.626) were the group that was under severe vulnerability followed by FHH from Mashonaland West (MW) province (FHH_{MW}=0.537). The most severely vulnerable gender group with regards to dependency ratio was FHH from Manicaland province whose score was 1.44 and the least vulnerable group was FHH from Mashonaland Central (MC) which had an index of 0.68. The challenge of households with orphans was most common in MC where the LVI for FHH was 0.67 while that of MHH from the same province was 0.59. For the other provinces, the severity of orphans averaged around 0.53 across the two gender.

The overall vulnerability index with regards to livelihood strategies was high for Manicaland (MN) province's male-headed households (MHH) whose index value was 0.459 while least vulnerability

was recorded FHH in the same province. FHH in MC province was more vulnerability (0.963) in terms of households which dependent solely on agriculture as a source of income given that 96.3% of female-headed households from this province were dependent on income solemnly from agriculture sector. Overall, the percentage of households who dependent on agriculture as a source of income was above 85%. Focus group discussions (FGDs) lamented the fact that there were not many opportunities which offer meaningful income outside agriculture given the remoteness of these areas from urban areas. Existence of a family member who work in a different community was considered as one of the avenues for extra and better income source, and as such, the higher the percentage of family members working in other communities, the less vulnerable to climate change's aspect of livelihood strategies a given family was. The most vulnerable group in this sub-component constituted FHH from MN province which had just 1% (i.e., index value of 0.01) of family members who were working in other communities, and it was followed by FHH from MC province where 2% of family members worked in other communities. MHH from ME province was the least vulnerable as it had 20% (i.e., index of 0.20) of its family members who were working in other communities, while MHH from MN province was the second least vulnerable group (0.19).

Male-headed households (MHH) in MN with a LVI value of 0.642 faced severe vulnerability in terms of the impact of climate change on food and was followed by FHH (0.602) in the same province. Manicaland (MN) province was the more vulnerable when compared to other provinces with regards to percent of households dependent solely on family farm for food, with 100% of FHH (i.e., 1.00) solemnly dependent family farm for food with 89.3% of MHH (0.893) being in the same situation. FHH from MW was the least vulnerable group given that only 38.9% dependent solely on family farm. Participants from focus group discussions (FGDs) indicated that most households from the four provinces, by nature of being rural economies, had nearly zero economic opportunities from which they can earn money to use to buy food from the market. Male-headed households (MHH) from Mashonaland West (MW) were the least vulnerable group in terms of food. Both MHH and FHH showed resilient in terms of average crop diversity given that the index values ranged between 0.11 and 0.20, implying low level of vulnerability. FHH were more vulnerable when it comes to average numbers of months households struggle to find food given that they both experience an average of 5 months per year struggling to get food. On the other hand, MHH were the least vulnerable given that this group struggled for only 2.7 months to find food.

Table 3: Normalized sub-components, major components and overall LVI for female and male-headed households in Zimbabwe's 4 tobacco provinces

Sub-component	MN		MC		ME		MW		Major components	MN		MC		ME		MW	
	MHH	FHH	MHH	FHH	MHH	FHH	MHH	FHH		MHH	FHH	MHH	FHH	MHH	FHH	MHH	FHH
Dependency ratio	1.06	1.44	0.73	0.68	0.85	0.97	0.97	1.10	**Socio-demographic profile**	0.519	0.626	0.454	0.426	0.458	0.489	0.482	0.537
Average age of head of household	0.447	0.40	0.463	0.342	0.42	0.432	0.418	0.429									
Percent of households where head of household has not attended school	0.04	0.074	0.034	0.01	0.03	0.02	0.03	0.09									
Percent of households with orphans	0.53	0.59	0.59	0.67	0.53	0.53	0.51	0.53									
Percent of households dependent solely on agriculture as a source of income	0.853	0.925	0.899	0.963	0.873	0.904	0.859	0.889	**Livelihood strategies**	0.459	0.367	0.406	0.383	0.441	0.418	0.400	0.403
Average agricultural Livelihood Diversification Index	0.333	0.167	0.25	0.167	0.25	0.200	0.25	0.25									
Percent of households with family member working in a different community	0.19	0.01	0.07	0.02	0.20	0.15	0.09	0.07									
Percent of households dependent solely on family farm for food	0.893	1.00	0.742	0.787	0.806	0.856	0.508	0.389	**Food**	0.642	0.602	0.519	0.509	0.580	0.509	0.406	0.516
Average crop diversity index	0.20	0.20	0.20	0.20	0.111	0.125	0.167	0.167									
Average number of months households struggle to find food	0.50	0.50	0.333	0.33	0.333	0.50	0.273	0.333									
Percent of households that do not save crops	0.53	0.72	0.49	0.53	0.510	0.57	0.47	0.55									
Percent of households that do not save seeds	0.95	0.75	0.97	0.85	0.94	0.78	0.92	0.88									
Farm land size (ha)	0.778	0.444	0.378	0.356	0.778	0.667	0.10	0.778									
Percent of households that have not gone to their local government for assistance in the past 12 months	1.00	0.926	1.00	1.00	1.00	1.00	1.00	0.99	**Social networks**	0.595	0.731	0.653	0.421	0.489	0.600	0.506	0.652
Ave. Borrow: lend money ratio	0.337	0.733	0.47	0.20	0.20	0.467	0.25	0.667									
Average Receive: Give ratio	0.447	0.533	0.49	0.06	0.267	0.333	0.267	0.30									
Average time to health facility	0.052	0.105	0.211	0.392	0.211	0.252	0.147	0.189	**Health**	0.705	0.845	0.467	0.654	0.627	0.677	0.645	0.750
Average Malaria Exposure*Prevention Index	2	2.5	1.00	1.5	1.6	1.6	1.75	2									
Percent of households with family member with chronic illness	0.063	0.13	0.19	0.23	0.07	0.18	0.038	0.06									
Percent of households that utilize a natural water source	0.156	0.156	0.20	0.34	0.183	0.21	0.295	0.34	**Water**	0.173	0.207	0.212	0.284	0.156	0.202	0.233	0.239

Average time to water source	0.292	0.375	0.36	0.39	0.225	0.267	0.283	0.283										
Percent of households that do not have a consistent water supply	0.07	0.09	0.07	0.12	0.06	0.13	0.12	0.14										
Average number of flood, drought, and cyclone events in the past 6 years	0.571	0.571	0.71	0.714	0.423	0.423	0.143	0.143	**Natural disasters and climate variability**		0.538	0.550	0.504	0.502	0.425	0.442	0.408	0.388
Percent of households that did not receive a warning about the pending natural disasters	0.57	0.56	0.38	0.37	0.430	0.40	0.43	0.33										
Mean standard deviation of the daily average minimum temperature by month (1980-2022)	0.525	0.524	0.43	0.43	0.290	0.40	0.618	0.618										
Mean standard deviation of the daily average maximum temperature by month (1980-2022)	0.642	0.642	0.06	0.06	0.533	0.553	0.470	0.47										
Mean standard deviation of average precipitation by month (years: 1980-2022)	0.451	0451	0.42	0.42	0.49	0.433	0.377	0.377										
Overall LVI											**0.519**	**0.561**	**0.459**	**0.454**	**0.454**	**0.477**	**0.440**	**0.498**
											MHH	**FHH**	**MHH**	**FHH**	**MHH**	**FHH**	**MHH**	**FHH**
											MN		**MC**		**ME**		**MW**	

Source: Authors construction from field survey (2023)
Key: MN = Manicaland; MC = Mashonaland Central; ME = Mashonaland East; MW = Mashonaland West

The performance on social networks shows that FHH (0.421) from Mashonaland Central (MC) were the least vulnerable while FHH (0.731) from Manicaland were the most vulnerable group. With the exception of FHH (0.926) from MN and FHH (0.99) from MW, both MHH and FHH from the other provinces had 100% of households that have not gone to their local government for assistance in the past 12 months. The main reason why households were not going to get assistance from local government as was alluded by FGDs was due to the fact that households had long since lost confidence from getting any assistance from these institutions given that the same institutions have nothing to offer.

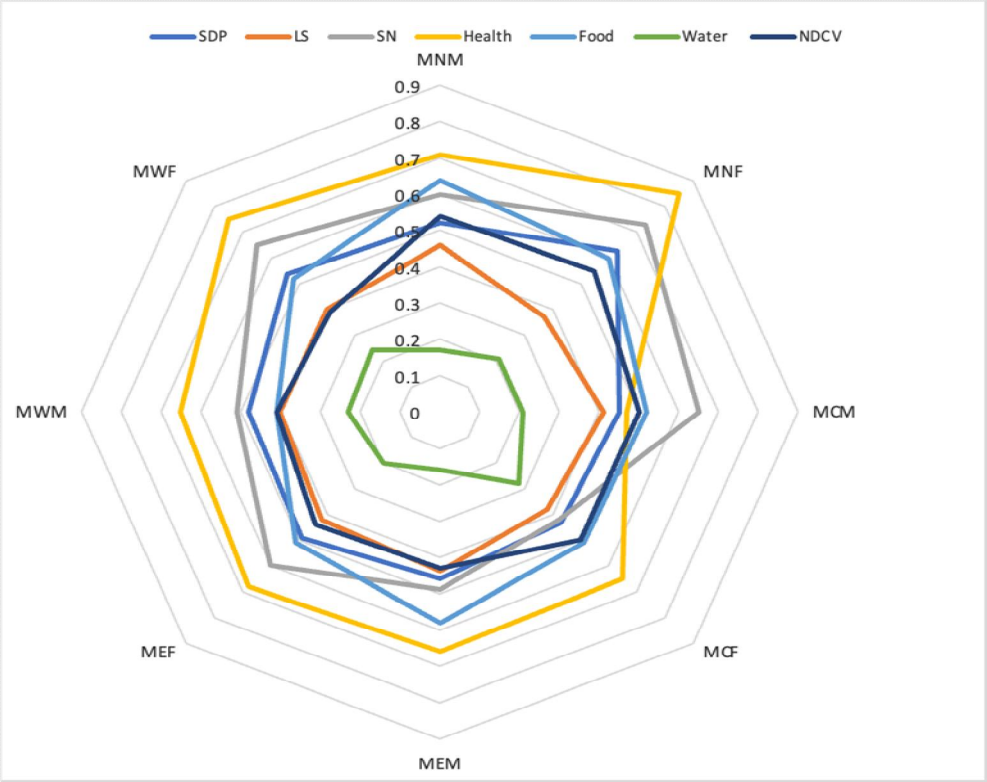
Vulnerability to health due to climate change was pervasive across the four provinces with LVI of above 0.6 (highest was FHH from MN province which had 0.845) with the exception MHH from MC which had an index of 0.467. Participants in the focus group discussions (FGDs), whilst they admitted that there were clinics and health facility in some of their respective areas, they however said that most of those facilities were more like white elephants in that, the buildings and other physical facilities were there, but there were no medication and various medical ancillaries.

FHH from MC where the most vulnerable group in terms of time taken to health facility as it took them 39.2 minutes to the nearest health facility, while MHH from MC province was the least vulnerable as it only took them an average of 5 minutes to the nearest health facility. Households from all the four provinces were generally vulnerable to malaria exposure as measured by the average malaria exposure x prevention index which ranged from 2.5 for FHH in Manicaland province to 1.5 for FHH from Mashonaland Central (MC) province. With an index value of 0.23, FHH from MC had the highest proportion (23%) of households who which housed a family member with chronic illness. For the same sub-component, the least vulnerable households were FHH (0.06) from MW province which had just 6%.

Water is on major component where both MHH and FHH from all the four provinces were less vulnerable when compared to the other six major components. Overall LVI for water by gender and by spatial distribution ranged between 0.156 and 0.284. FHH (0.34) from both MC and MW provinces had the highest percent of households that utilized natural water sources such as streams, dams, shallow wells and other sources. Average time to water source was longest for FHH (0.39) from MC as they took 39 minutes to walk to water source (one way) and the group was followed by FHH from MN which walked 29.2 minutes to the nearest water source.

Overall vulnerability index for natural disasters and climate variability showed that FHH from MN was the most vulnerable as it had an index of 0.550, while FHH from MW provinces were the least vulnerable given their index value of 0.388. Manicaland province was more vulnerable to lack of disaster warning information as it had the highest percent of households that did not receive a warning about the pending natural disasters, with 57% of MHH (0.57) and 56% of FHH (0.56) falling in this category. On the other extreme, FHH from MW was the least vulnerable group as only 33% did not received disaster warnings. Figure 3 shows the vulnerability spider diagram.

Figure 3: Vulnerability spider diagram of the major components of the LVI



Source: Authors construction from field survey (2023)

4.2.2 Gender: LVI - IPPC

According to a gender-based analysis utilising the LVI-IPCC model, families led by women were more sensitive (MN_F=0.564; MC_F=0489; and MW_F=0.505) and exposed (MN_F=0.550) than households headed by men (Table 4). Additionally, male-headed households demonstrated a stronger adaptive capacity (MNM=0.538; and MCM=0.502) than female-headed households.

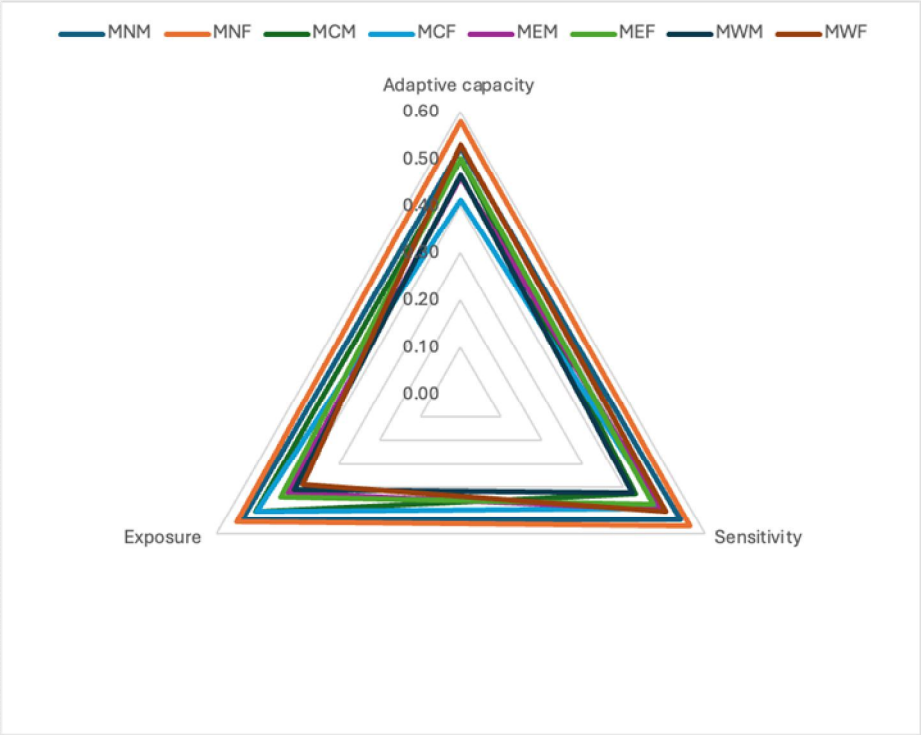
Table 4: Gender LVI-IPCC for Zimbabwe's four tobacco provinces

Contributing factors	Major components	Major components values (i.e., LVI values)				Contributing factor values (i.e., sum LVI values)				LVI-IPCC value			
Panel A: MN and MC													
		MN		**MC**		**MN**		**MC**		**MN**		**MC**	
		M	**F**	**M**	**F**	**M**	**F**	**M**	**F**	**M**	**F**	**M**	**F**
Adaptive capacity	SDP	0.52	0.63	0.45	0.43	0.524	0.580	0.499	0.412	0.008	-0.017	0.002	0.004
	LS	0.46	0.37	0.41	0.38								
	SN	0.60	0.73	0.65	0.42								
Sensitivity	Health	0.71	0.85	0.47	0.65	0.541	0.564	0.429	0.489				
	Food	0.64	0.60	0.52	0.51								
	Water	0.17	0.21	0.21	0.28								
Exposure	NDCV	0.54	0.55	0.50	0.50	0.538	0.550	0.504	0.502				
Panel B: ME and MW													
		ME		**MW**		**ME**		**MW**		**ME**		**MW**	
		M	**F**	**M**	**F**	**M**	**F**	**M**	**F**	**M**	**F**	**M**	**F**
Adaptive capacity	SDP	0.46	0.49	0.48	0.54	0.462	0.501	0.465	0.531	-0.018	-0.028	-0.024	-0.072
	LS	0.44	0.42	0.40	0.40								
	SN	0.49	0.60	0.51	0.65								
Sensitivity	Health	0.66	0.68	0.65	0.75	0.493	0.474	0.423	0.505				
	Food	0.58	0.51	0.41	0.52								
	Water	0.16	0.20	0.23	0.24								
Exposure	NDCV	0.43	0.44	0.41	0.39	0.425	0.442	0.408	0.388				

Source: Authors construction from field survey (2023)
Key: MN = Manicaland; MC = Mashonaland Central; ME = Mashonaland East; MW = Mashonaland West; F= Female headed household; M= Male headed household; MC_F= Female-headed household from Mashonaland Central province.

The gender vulnerability radar diagram in Figure 4 shows the calculated vulnerability indices of the major LVI components and the overall LVI for households headed by women and men across the four provinces.

Figure 4: Gender vulnerability triangle diagram



Source: Authors construction from field survey (2023)

5 CONCLUSIONS AND POLICY IMPLICATIONS

This article has examined the appropriateness of the livelihood vulnerability index (LVI) in order to comprehend the female- and male-headed household-based dimension of local susceptibility to climate variability and social determinants. We discovered that the indicators employed are appropriate for tobacco farming rural areas and have a critical role in determining livelihood vulnerability. As a result, these indications may also be highly helpful in assessing susceptibility in other mountainous areas. The household vulnerability analysis based on those indicators and the LVI and LVI-IPCC technique proved to be an effective tool for comprehending the variety of vulnerabilities.

Across all LVI components and LVI-IPCC criteria, the combined vulnerability of the entire population under study is comparatively similar. Even though female-headed households are comparatively more vulnerable, there was no significant variation in the vulnerability score across any of the components. The components pertaining to health, food and socio-demographic profile are ranked higher than the vulnerabilities pertaining to water and livelihood strategies. Although factors linked to food, socio-demographic profile, and health all helped widen the difference between groups which are more and less vulnerable, the latter factors are more important in defining the study's combined vulnerability.

Overall, findings showed that tobacco farmers (both~~er~~ male-headed and female-headed households) are vulnerable to the main elements of every framework for livelihood vulnerability developed by Drinkwater and Rusinow (1999); Carney et al. (1999). The livelihood frameworks encompass several essential variables, such as food, health, social network, water, natural hazards and climate variability, socio-demographic profile, and livelihood methods. The power dynamics, accessibility to healthcare and water supplies, and political, social, and economic systems are all reflected in these elements.

Comment [D310]: In which province more vulnerable add it?

Comment [D311]: Policy recommendations are missed here?? Add please as any adaptation and mitigation climate actions to reverse the vulnerability to climate change as well any future research work as Gaps not covered by this research?

The findings suggest that in the event of climate change and variability, natural disasters like floods, and any type of shock that negatively impacts the availability of food and water, as well as their livelihood strategies, social networks, and socio-demographic profiles, these households would require some temporary assistance to recover. This is particularly true for households headed by women, who have lower capabilities for adaptation and are therefore more susceptible to the contributing elements of vulnerability. They are also more vulnerable to the effects of climate change and variability.

Studies indicate that women are the backbone of sustainable development, and that increased gender equality across the board will have a huge positive impact on society (Denson, 2002). Unfortunately, there is a lack of progress in mainstreaming gender issues into the relationship between climate change and sustainable development. Progress has been incredibly slow, piecemeal, and sometimes done after the fact. The issue is made worse by the underrepresentation of women in decision-making at all levels and the lack of effort put out in the climate debate thus far to present the concerns in a way that the general public can even comprehend. Nevertheless, securing women's involvement does not ensure that the myriad problems that women face in coping with climate change will be resolved. Denson (2002) argues that power dynamics define the nature of relationships between men and women in developing countries, with women having less options for providing for their families and being more reliant on the climate-dependent agriculture and forestry industries.

Compared to male-headed households, female-headed households were considerably more vulnerable to the sociodemographic profile, livelihood methods, social network, water, and food. This renders female-headed households more susceptible to the fluctuations and changes in the climate, as well as less able to adapt than households headed by men. Generally, households led by women were far more susceptible to fluctuations in the climate than those headed by men. This finding was common in all the tobacco growing provinces. The study's recommendations, based on these findings, suggest that women should be given precedence in ongoing and new climate change and agriculture intervention projects. They should also be empowered to engage in other income-generating activities by providing financial resources, which will help them diversify their sources of income and increase their resilience to climate change and variability. Initiatives aimed at mitigating climate change shouldn't completely exclude men. Importantly, women should be prioritised when it comes to participation in these kinds of programmes.

There are two main ways in which this research has implications for policy. First, in order to solve livelihood issues, the study recommends policy actions that are meant to decrease the sensitivity of habitat conditions, increase the resilience of society, and improve the stability of individuals. This necessitated the government's external investment to give marginalised people special consideration. Second, considering that Zimbabwe is a low-income nation, it asks for international assistance to help develop local adaptation ability in dealing with climate change.

Comment [D312]: Any policy issues to be addressed

Comment [D313]: How? By whom?

References

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