AKADEMIYA 2063

CACCI
COMPREHENSIVE ACTION FOR CLIMATE CHANGE INITIATIVE

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CACCI FIELD NOTES

Vulnerability to Climate Change in Rwanda

Sambane Yade and Getaw Tadesse

About the CACCI Field Notes

AKADEMIYA2063 CACCI Field Notes are publications by AKADEMIYA2063 scientists and collaborators based on research conducted under the Comprehensive Action for Climate Change Initiative (CACCI) project. CACCI strives to help accelerate the implementation of Nationally Determined Contributions (NDCs) and National Adaptation Plans (NAPs) by meeting the needs for data and analytics and supporting institutional and coordination capacities. In Africa, CACCI works closely with the African Union Commission, AKADEMIYA2063, the African Network of Agricultural Policy Research Institutes (ANAPRI), and climate stakeholders in selected countries to inform climate planning and strengthen capacities for evidence-based policymaking to advance progress toward climate goals.

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1. Introduction

Since 2015, Rwanda's government has undertaken assessments of the country's socio-economic and spatial vulnerabilities to climate change. The first such assessment was presented in a document released in 2015 which was considered the baseline report on Rwanda's vulnerability to climate change. This was followed by a 2018 report which sought to update the assessment and provide evidence for planning government programs and strategies on climate change. One of the outcomes of these activities was Rwanda's Green Growth and Climate Resilient Strategy (GGCRS), adopted in 2020. The Government of Rwanda planned to conduct vulnerability assessments every three years, but it was not able to do so in 2021 due to several challenges around data collection and analysis.

The aim of this report is to provide an updated household vulnerability assessment to support the design and implementation of ongoing climate adaptation actions. To this end, we followed the Intergovernmental Panel on Climate Change (IPCC) framework to estimate the composite Vulnerability to Climate Change (VCC) Index using household data collected by the National Institute of Statistics of Rwanda (NISR) in 2021, under the Comprehensive Food Security and Vulnerability Analysis (CFSVA) Survey.

The Rwanda Environment Management Authority (REMA) is the official agency responsible for tracking assessments of vulnerability to climate change every three years. The most recent assessment was done in 2018 and the next one should have been in 2021, but was not conducted. The assessment presented in this report can therefore be regarded as the third round of vulnerability tracking and can be used in comparison with the results from previous assessments. However, it should be noted that the specific indicators used vary slightly in each round of assessments.

The rest of this report is organized as follows: The next section briefly describes the methods used to estimate the composite VCC Index, and is followed by a presentation of the overall index at the national level. This section compares the VCC Index over 2018 and 2021 to shed light on changes in vulnerability to climate change. Section 4 presents the VCC Index by district, while sections 5-7 present vulnerability status based on the three dimensions of vulnerability: i) Exposure to climate risk; ii) Sensitivity to climate risk; and, iii) Adaptive capacity to climate change.

2. Data and Methods

2. 1 Data

Unlike the previous vulnerability assessment reports which used data collected in household surveys specifically for that purpose, data for this report mainly came from the 2021 Comprehensive Food Security and Vulnerability Analysis (CFSVA) survey, a collaborative effort involving NISR and the World Food Programme (WFP) (NISR, 2023). The CFSVA survey has been conducted every three years since 2006 across all of Rwanda's 30 districts. It focuses on the socioeconomic and demographic determinants linked to food and nutrition insecurity. In addition, the survey formulates specific recommendations for social protection, food security and nutrition interventions, including geographic and household-level targeting criteria. The 2021 CFSVA survey introduced a new module analyzing the impacts of the COVID-19 pandemic on livelihoods and food security.

Use of the CFSVA survey data has its advantages and drawbacks in comparison to the use of survey data collected specifically for vulnerability assessments (as was the case for the 2015 and 2018 reports). One advantage is that it reduces data collection time and costs. It also regularizes preparation of the report due to the periodic nature of the CFSVA survey. As long as the NISR continues to conduct the CFSVA survey as part of its regular program and work schedules, there should be no need to incur additional costs in data collection. One disadvantage is that not all the variables/indicators required for estimating the VCC Index are captured under the CFSVA survey. However, most of the required variables are already included, with just a few of them omitted from the CFSVA survey. For this report, use of existing CFSVA variables will suffice for the development of key conclusions on Rwanda's status and progress in terms of vulnerability to climate change. In future however, the variables that are not included under the CFSVA survey could be included as part of a collaborative agreement between NISR and REMA. Conducting a sperate survey is not justifiable as long as NISR continues with the regular CFSVA survey.

2. 2 Estimation Approach

Estimation of the composite household vulnerability indicator, considered an important indicator for tracking vulnerability and resilience under Rwanda's Integrated Result Framework (IRF) for climate action, is guided

by the conceptual framework of climate-related risks contained in the Fifth Assessment Report (AR5) of the Intergovernmental Panel on Climate Change (IPCC) Working Group that explores the potential impacts of climate change on agriculture and food security (Adger, 2006; O'Brien et al., 2007; Sharma and Ravindranath, 2019). The IPCC defines vulnerability as "the extent to which a natural or social system is likely to be damaged by the impacts of climate change, and is a function of exposure, sensitivity and adaptive capacity" (IPCC, 2014).

In line with this definition, household vulnerability in each district in Rwanda is estimated by calculating the household score **'i'** for each of the three dimensions (exposure, sensitivity, and adaptation capacity). Subsequently, these dimension scores are summed up to obtain the overall Vulnerability to Climate Change (VCC) Index. The results obtained support the comparison and assessment of household vulnerability to climate change for each district.

Formula:

$$\boldsymbol{VCC_i = \frac{1}{3}(Exposure\ score_i + Sensitivity\ score_i + Inability\ to\ Adapt\ score_i)}$$

With:

$$\begin{cases} \text{Exposure score}_i = \dfrac{1}{n_E}\displaystyle\sum_{k=1}^{n_E} V_{k,i}^{\text{Exposure}} \\ \text{Sensitivity score}_i = \dfrac{1}{n_S}\displaystyle\sum_{k=1}^{n_S} V_{k,i}^{\text{Sensitivity}} \\ \text{Inability to Adapt score}_i = \dfrac{1}{n_{IA}}\displaystyle\sum_{k=1}^{n_{IA}} V_{k,i}^{\text{Inability to Adapt}} \end{cases}$$

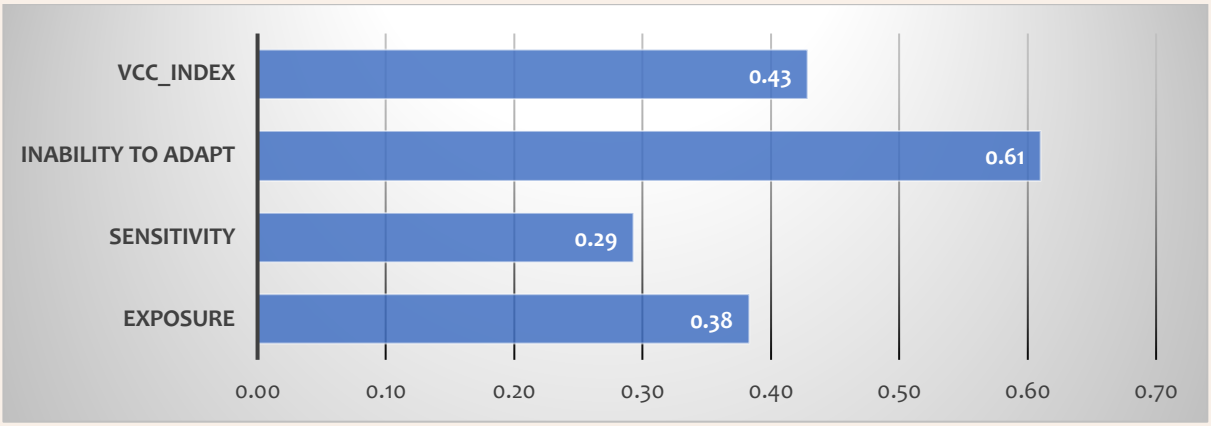
index $\boldsymbol{i}$ *represents district;* $\boldsymbol{n_E, n_S, n_{IA}}$ *correspond to the number of select variables for each dimension*

$\boldsymbol{V_{k,i}^{Exposure}}$ *correspond to the* $\boldsymbol{k^{th}}$ *normalized variable of the region* $\boldsymbol{i}$ *for exposure dimension*

3. Overall Vulnerability to Climate Change

Results of the Vulnerability to Climate Change (VCC) Index shown in Figure 1 reveal that the overall level of household vulnerability in Rwanda is 0.43 on a scale of 0 to 1 (the closer the value is to 1, the higher the vulnerability level). The composite VCC Index is largely attributable to the inability of households to adapt to climate shocks (0.61), followed by their exposure to climate change risks (0.38) and finally the level of household sensitivity (0.29). These results indicate that although the level of sensitivity is somewhat low, households in Rwanda have a high exposure to climate change risks and have limited capacity to adapt to adverse effects. The major source of vulnerability among households in Rwanda is their limited adaptative capacity to climate shocks, indicating that policy actions should focus on strengthening this. Sources of this limited adaptative capacity will be discussed in Section 7.

Figure 1: Vulnerability to Climate Change (VCC) Index score by component in 2021

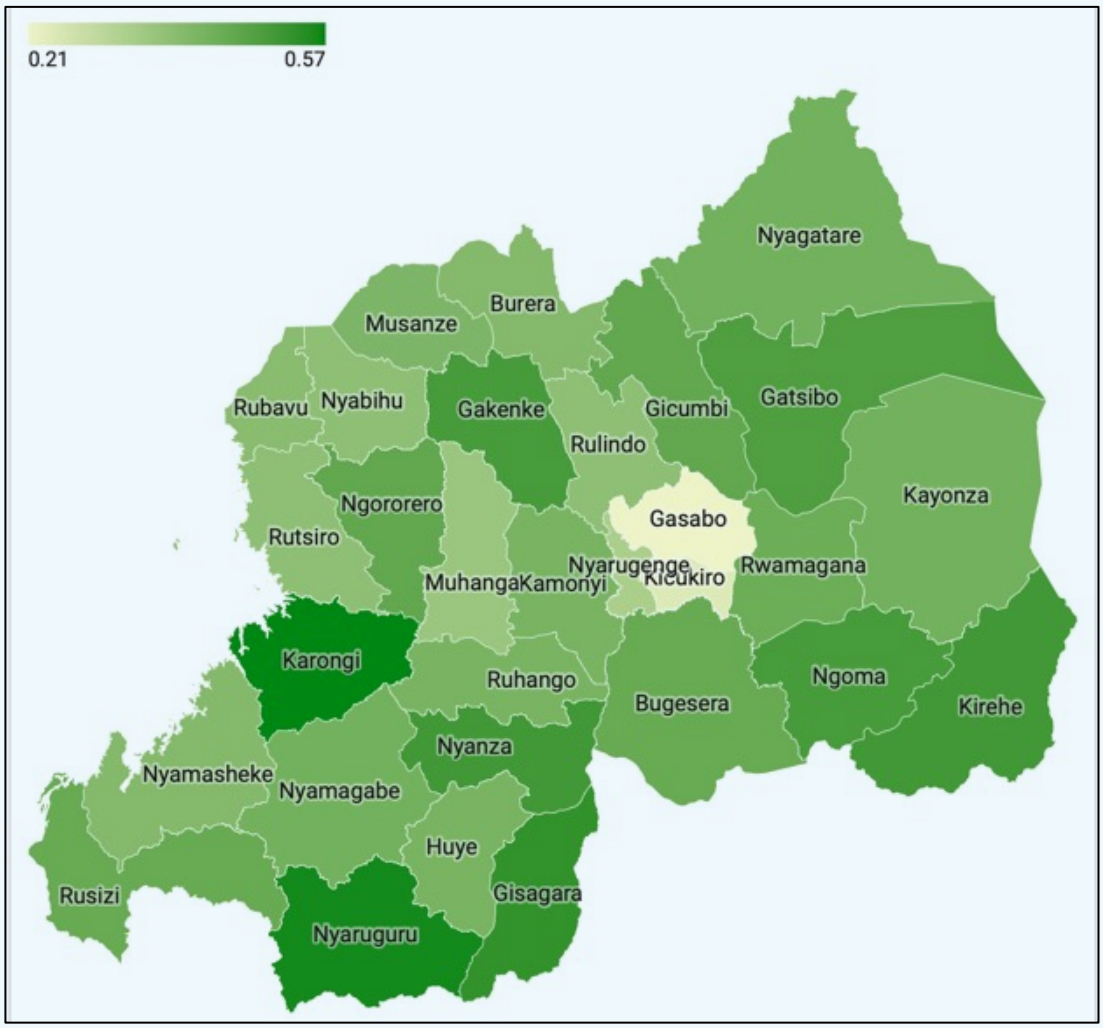


Source: Authors' calculations using the 2021 CFSVA data (NISR,2023)

4. Climate Change Vulnerability by District

This section analyzes and compares the levels of household vulnerability to climate change among Rwanda's districts. Map 1 shows that Karongi, Nyaruguru and Gisagara were the three districts with the largest score of vulnerable households among all districts in 2021, as they recorded scores that ranged between 0.53 and 0.56. These three were followed by Kirehe Nyanza, Gakenke and Ngoma which all recorded scores above 0.5. The two districts with the least vulnerable households were Gasabo (0.21) and Kicukiro (0.24), which are both located in Kigali province. This indicates that households in urban areas are less vulnerable to climate change as they have options for income diversification, as well as better access to markets and public services. The other districts have a medium level of vulnerability with scores ranging between 0.38 and 0.49. In addition to these results, we also showed the distribution of each of the three vulnerability dimensions in the different districts **(Annex 1)**.

Map 1: Household climate change vulnerability by district in Rwanda



Source: Authors' calculations using the 2021 CFSVA data (NISR, 2023)

Table 1 shows vulnerability indices by district in 2018 and 2021. On average, the VCC index has declined from 0.49 to 0.44, indicating that five percent of the vulnerable households have become less vulnerable and more adaptive to climate change within the last three years. Although the indicators used in the two years are slightly different, this decline may indicate that households are generally recording strong improvements in terms of reducing vulnerability to climate change. The changes vary across provinces and districts (Table 1). While overall vulnerability has decreased, five of the 30 districts recorded a slight increase in climate change vulnerability. The other 25 districts recorded reductions that ranged between 1 and 24 percentage points. The largest reduction was observed in Gasabo district which also had the lowest level of vulnerability. This indicates that even though overall vulnerability is declining, the reduction is not occurring in areas where the problem is persistent. Targeting of interventions is therefore neither preferential nor fully effective.

Table 1: VCC Index score by district and by year

	District/province	2018	2021	Change
1	*Nyarugenge*	0.475	0.331	-0.144
2	*Gasabo*	0.444	0.208	-0.236
3	*Kicukiro*	0.478	0.238	-0.24
	City of Kigali	0.465	0.303	-0.162
4	*Nyanza*	0.525	0.510	-0.015
5	*Gisagara*	0.537	0.535	-0.002
6	*Nyaruguru*	0.527	0.556	0.029
7	*Huye*	0.566	0.422	-0.144
8	*Nyamagabe*	0.52	0.427	-0.093
9	*Ruhango*	0.536	0.418	-0.118
10	*Muhanga*	0.472	0.356	-0.116
11	*Kamonyi*	0.502	0.420	-0.082
	Southern Province	0.523	0.455	-0.068
12	*Karongi*	0.543	0.574	0.031
13	*Rutsiro*	0.498	0.383	-0.115
14	*Rubavu*	0.5	0.392	-0.108
15	*Nyabihu*	0.502	0.379	-0.123
16	*Ngororero*	0.503	0.458	-0.045
17	*Rusizi*	0.487	0.446	-0.041
18	*Nyamasheke*	0.514	0.401	-0.113
	Western Province	0.507	0.433	-0.074
19	*Rulindo*	0.451	0.382	-0.069
20	*Gakenke*	0.452	0.503	0.051
21	*Musanze*	0.454	0.413	-0.041
22	*Burera*	0.471	0.398	-0.073
23	*Gicumbi*	0.472	0.457	-0.015
	Northern Province	0.46	0.431	-0.029
24	*Rwamagana*	0.484	0.436	-0.048
25	*Nyagatare*	0.513	0.434	-0.079
26	*Gatsibo*	0.459	0.492	0.033
27	*Kayonza*	0.5	0.429	-0.071
28	*Kirehe*	0.487	0.511	0.024
29	*Ngoma*	0.498	0.499	0.001
30	*Bugesera*	0.494	0.455	-0.039
	Eastern Province	0.491	0.465	-0.026
	National	0.489	0.440	-0.049

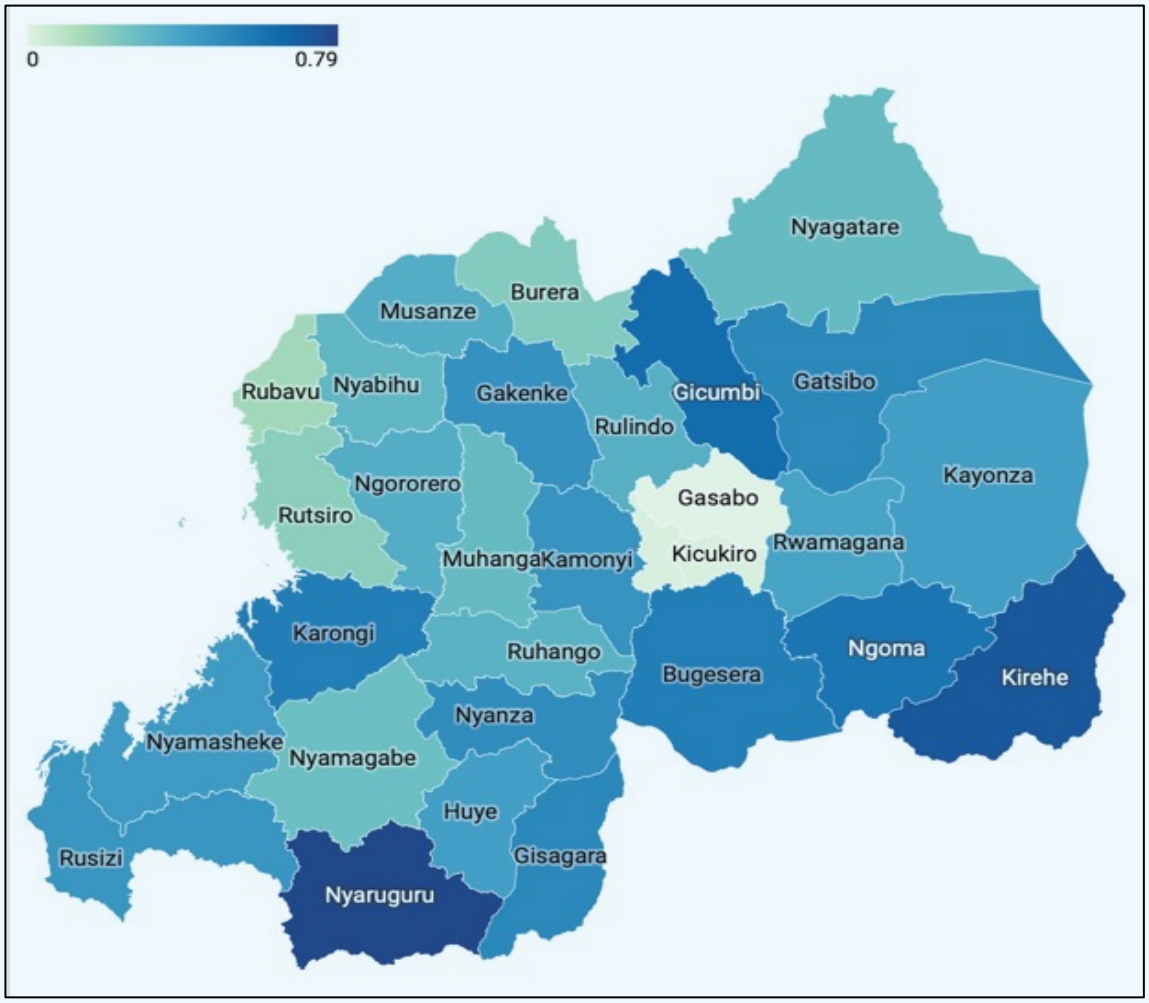
Source: Authors calculation based on 2021 CFSVA data (NISR, 2023) and REMA, 2019.

5. Exposure to Climate Change Risks

Exposure refers to the magnitude of climatic variations which households in a district are expected to face. Map 2 shows the estimated levels of household exposure to climate change risks by district. The indicators considered for construction of the exposure index are described in Annex 2.

The results show that households in the districts of Nyaruguru, Kirehe, Gicumbi, Ngoma, Karongi, Bugesera, Gisagara and Gatsibo face high exposure to climate change risks which is reflected in their scores above 0.5. Households in the districts of Gasabo, Kicukiro, Nyarugenge, Rubavu, Rutsiro, Burera, Nyamagabe and to a lesser extent, Nyagatare and Muhanga, have the lowest exposure to climate change risks with scores of under 0.3. Households residing in the other districts are moderately exposed to climate change risks.

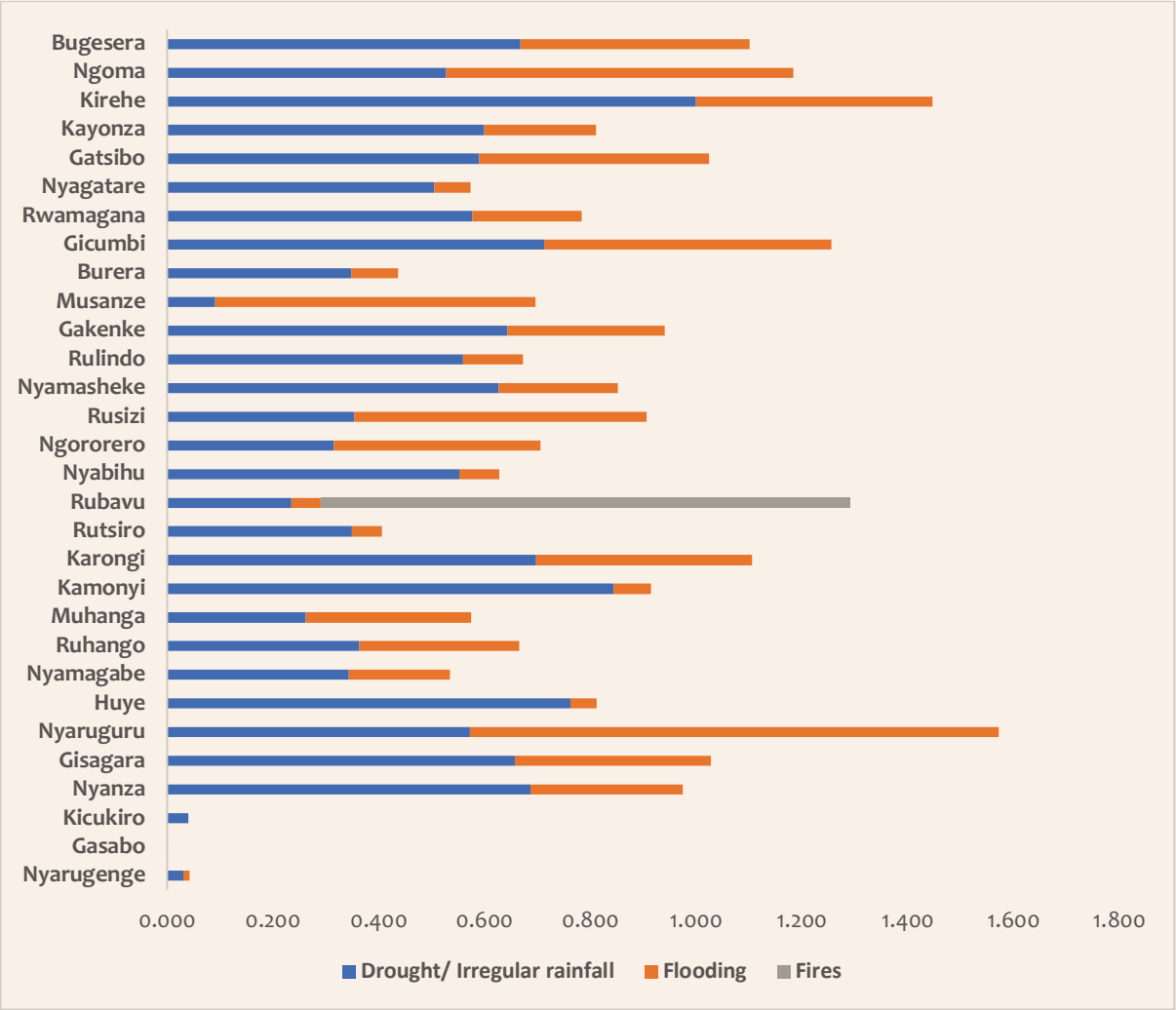
Map 2: Household exposure to climate change risk by district in Rwanda



Source: Authors' calculations using CFSVA data (NISR,2023)

Computation of the exposure dimension was based on three variables: i) Drought/Irregular rainfall, ii) Flooding, and iii) Fires. At the national level, the results show that heavy rainfall, as well as frequency and intensity of flooding are the variables that most explain the exposure of households to climate change risks, while fire plays a minor role. However, based on the results shown in Figure 2, distribution of the explanatory variables varies from one district to another. For the districts of Gasabo, Musanze, Nyaruguru, Ngoma, Rusizi, Ngororero and Muhanga, exposure to climate change risks is more attributable to flooding than drought/irregular rainfall or fires. For Huye, Kamonyi, Nyagatare, Nyabihu, Rutsiro, Rulindo, Rubavu, Kicukiro and Burera districts, household exposure is more attributable to drought/irregular rainfall than flooding or fires. For the districts of Ruhango, Gicumbi, Gatsibo, Bugesera, Karongi, Gisagara, and Nyamagabe, household exposure is explained by both drought/irregular rainfall and flooding.

Figure 2: Distribution of exposure to climate change risk by district

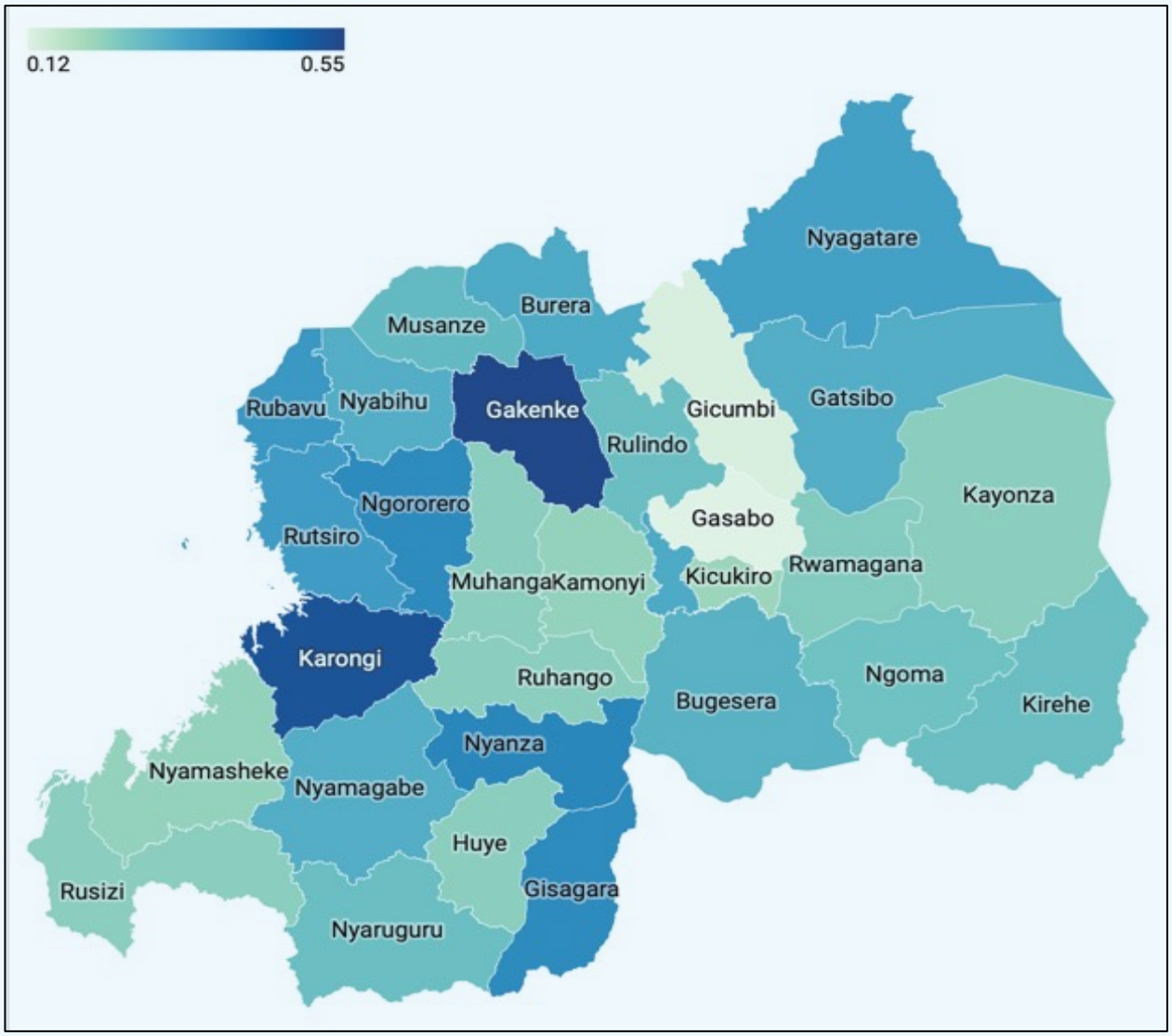


Source: Authors' calculations using CFSVA data (NISR, 2023)

6. Sensitivity to Climate Change Risks

This section presents an analysis and comparison of the levels of household sensitivity to climate change risks by district. Sensitivity in this case refers to the degree to which households may be affected by exposure to climate change risks. The results of the sensitivity analysis presented in Map 3 show that households in Gakenke and Karongi districts are the most sensitive to climate change risks with scores over 0.5. In contrast, the districts of Gasabo, Gicumbi, Kicukiro, Kamonyi, Nyamasheke, Ruhango, Kayonza, Rusizi, Muhanga, Huye and Rwamagana districts have the lowest scores, as does Ngoma to a smaller extent. Households in the other districts are moderately sensitive to climate change risks.

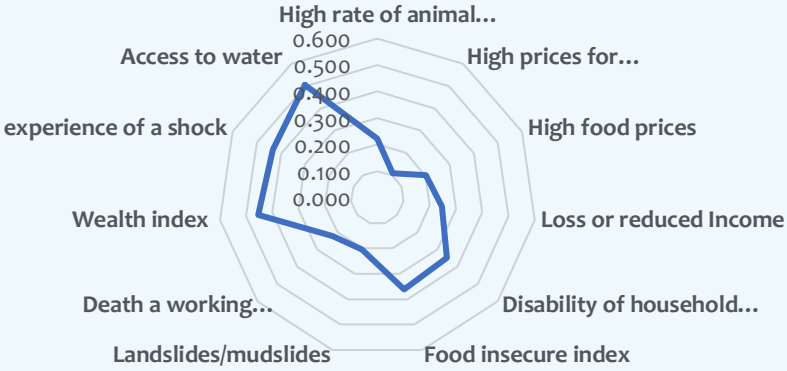
Map 3: Household sensitivity to climate change risks by district in Rwanda



Source: Authors' calculations using CFSVA data, NISR (2023)

The results of the sensitivity analysis were obtained by normalizing 12 indicators (see Annex 3) with a Z-score[1] approach and then summing them to obtain the mean. These indicators help explain the nature of household sensitivity at national and district levels. Figure 3 shows that the sensitivity of households to climate change risk is mainly associated with low access to water. Other associated variables are low wealth index scores, experiences of shocks and food insecurity.

Figure 3: Sensitivity to climate change vulnerability



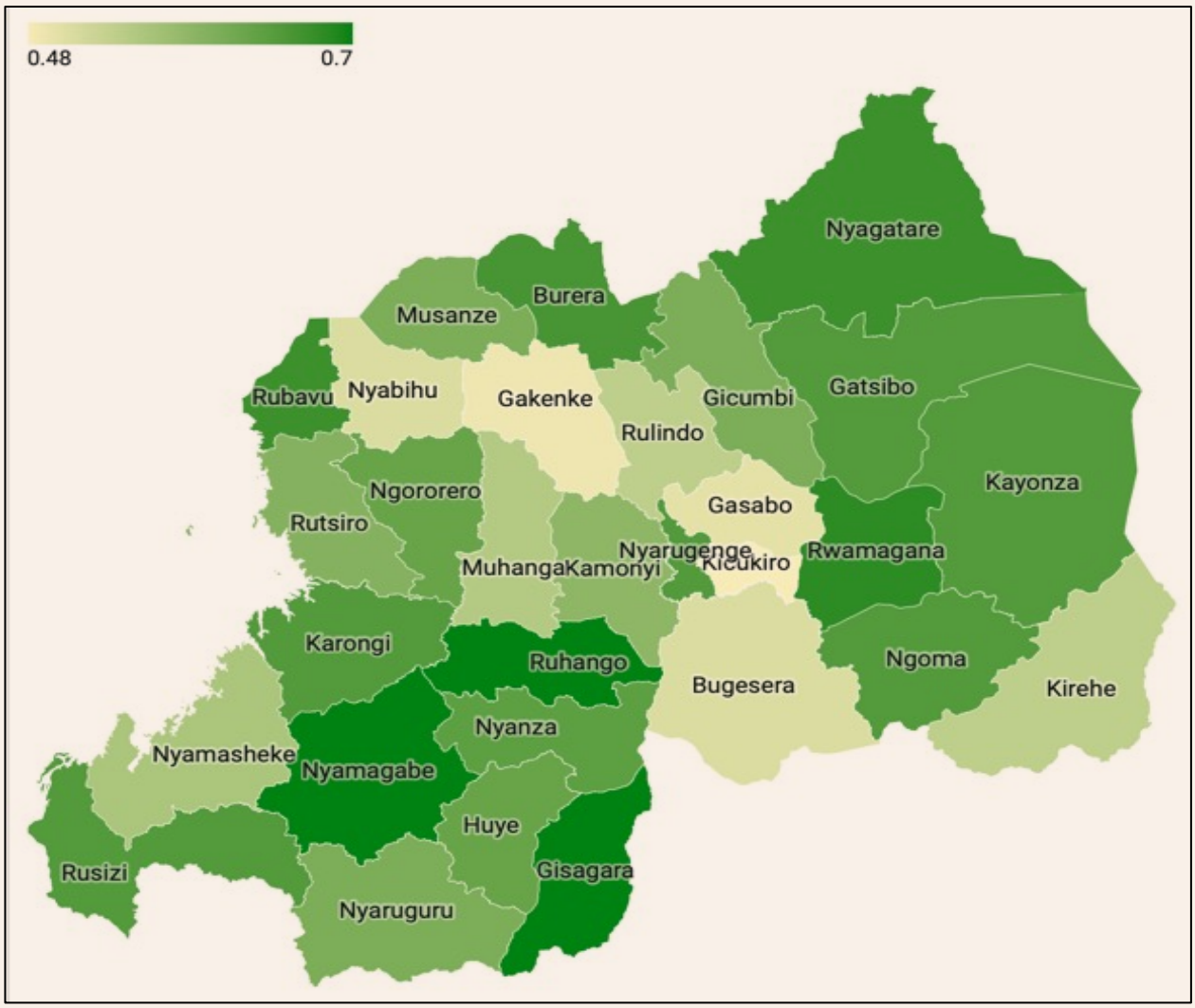
Source: Authors' calculations using CFSVA data, (NISR, 2023)

1 Z-score approach was used to normalize indicators. So, for each value of variable V, V(Z-score)=(V-minimum)/(maximum-minimum).

7. Adaptive Capacity to Climate Change Shocks

The two dimensions of vulnerability already considered in this report assess the impacts of climate change on households. To fully capture the resilience or vulnerability of households to climate change impacts, we further estimated the household's adaptive incapacity as shown in Map 4. As household vulnerability is positively correlated with their inability to adapt and negatively correlated with their adaptive capacity, our analysis considers adaptation incapacity and not adaptation capacity. Based on this argument, the results show that households in the districts of Gisagara, Nyamagabe and Ruhango have the highest incapacity (or the lowest capacity) to adapt to climate change with a score equal to 0.70. This interpretation remains valid for households in the districts of Rwamagana (0.68), Rubavu (0.67), Nyagatare (0.67), Burera (0.66), Gatsibo (0.65), Kayonza (0.65), Rusizi (0.65), Nyarugenge (0.65), Ngoma (0.65) and Karongi (0.65). Kicukiro and Gakenke districts have the lowest scores for this dimension among all the districts. This means that households in these two districts have greater capacity to adapt to climate change shocks than households in other districts.

Map 4: Household adaptive incapacity to climate change risks by district in Rwanda



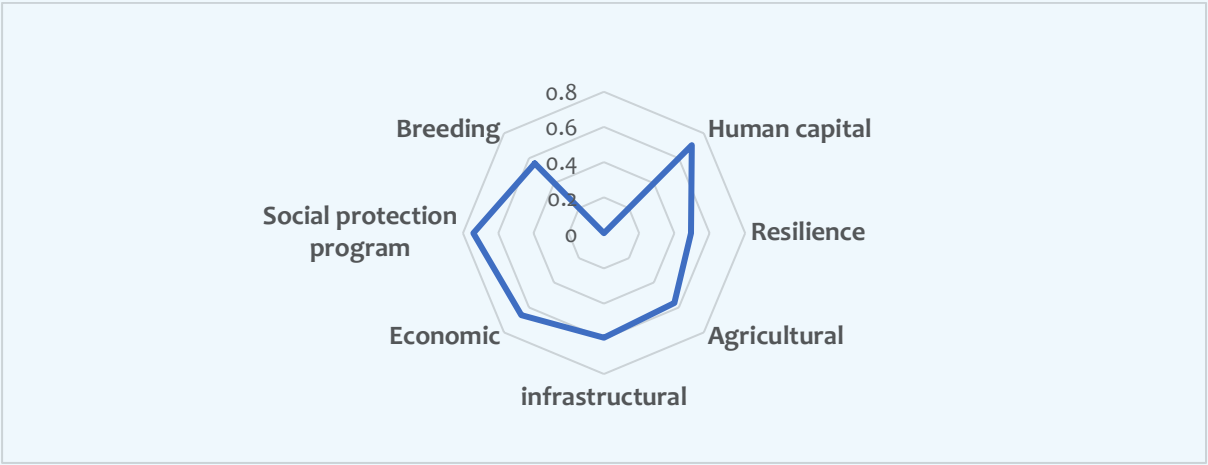
Source: Authors' calculations using CFSVA data, (NISR, 2023)

Figure 4 displays the variables or sub-dimensions that contribute to the overall household scores for adaptation incapacity. In terms of the seven sub-dimensions used to calculate this score, low access to social protection programs (0.74), limited human capital (0.70) and low-income level (0.66) best explain the inability of households to adapt to climate change. The indicators considered in construction of the Adaptive Incapacity Index are described in Annex 4.

The high score for the social protection sub-dimension is associated with the small proportion of households who have access to social safety programs. The human capital score is generally attributable to the low levels of membership in any association or cooperative, limited weather and climate information, as well as the lack of training and technical assistance in improved agricultural and livestock practices.

While these sub-dimensions help explain the adaptation incapacity of households, the results also show that some variables can improve household adaptation capacity. In the case of Rwanda, these sub-dimensions include resilience and the indicator 'adaptation of shock' as well as the breeding sub-dimension which includes indicators such as 'ease of access to health posts for diseased animals', 'animal vaccination' and 'artificial insemination'.

Figure 4: Adaptation issues and climate change vulnerability



Source: Authors' calculations using CFSVA data, (NISR, 2023)

Conclusion

This report assesses Rwanda's vulnerability to climate change using the 2021 CFSVA survey data collected by NISR in collaboration with WFP. The purpose of this assessment is to update the vulnerability status reports completed in 2015 and 2018 by REMA, using data from their own surveys, as well as to examine the changes seen over time. While this assessment does not use specific survey data as in 2015 and 2018, it presents comparable and robust evidence based on existing CFSVA survey data, thereby saving time and resources.

Our analysis shows that a significant number of households in Rwanda remain vulnerable to climate change. On average, 44 percent of households in Rwanda are vulnerable to climate change mainly due to the lack of sufficient adaptative capacity to cope with climate shocks. However, the overall level of vulnerability in 2021 is lower than that in 2018, even though the indicators used in the two years differ slightly. Close to 5 percent more households strengthened their resilience to climate change in 2021 compared to 2018. The vulnerability score improved in 25 of the 30 districts in Rwanda, while the scores in five districts worsened slightly. Improvements occurred in areas where vulnerability was initially low.

The analysis indicates a strong need for targeted interventions to build adaptive capacity. Adaptive capacity is a functional transformation that involves the use of available opportunities more effectively and efficiently. For example, farm households may have access to irrigation, but unless they use it effectively, their adaptative capacity does not change. Similarly, while farmers may have access to weather and climate information, they remain vulnerable to climate shocks if they do not use this information in their decision making. Efforts to strengthen resilience should therefore focus on effective and efficient utilization of available opportunities and emerging options.

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Annexes

Annex 1: Distribution of vulnerability to climate change by district

District	Exposure	Sensitivity	Inability to adapt	VCC Index
Bugesera	0.55	0.30	0.51	0.45
Burera	0.22	0.32	0.66	0.40
Gakenke	0.47	0.55	0.49	0.50
Gasabo	0.00	0.12	0.50	0.21
Gatsibo	0.51	0.31	0.65	0.49
Gicumbi	0.63	0.13	0.61	0.46
Gisagara	0.51	0.39	0.70	0.53
Huye	0.41	0.23	0.63	0.42
Kamonyi	0.46	0.22	0.59	0.42
Karongi	0.55	0.52	0.65	0.57
Kayonza	0.41	0.23	0.65	0.43
Kicukiro	0.02	0.21	0.48	0.24
Kirehe	0.72	0.27	0.54	0.51
Muhanga	0.29	0.23	0.55	0.36
Musanze	0.35	0.28	0.61	0.41
Ngoma	0.59	0.26	0.65	0.50
Ngororero	0.35	0.39	0.63	0.46
Nyabihu	0.31	0.31	0.51	0.38
Nyagatare	0.29	0.34	0.67	0.43
Nyamagabe	0.27	0.31	0.70	0.43
Nyamasheke	0.43	0.22	0.56	0.40
Nyanza	0.49	0.40	0.64	0.51
Nyarugenge	0.02	0.32	0.65	0.33
Nyaruguru	0.79	0.27	0.61	0.56
Rubavu	0.15	0.36	0.67	0.39
Ruhango	0.33	0.23	0.70	0.42
Rulindo	0.34	0.27	0.54	0.38
Rusizi	0.45	0.23	0.65	0.45
Rutsiro	0.20	0.35	0.60	0.38
Rwamagana	0.39	0.24	0.68	0.44

Source: Authors' calculations using CFSVA data.

Annex 2: Indicators used in constructing the exposure index

Indicators	Correlation with VCC
Exposure to drought/Irregular rainfall	Positive
Exposure to flooding	Positive
Exposure to fires	Positive

Source: Authors' calculations using CFSVA data

Annex 3: Indicators used in constructing the sensitivity index

Indicators	Correlation with VCC
% of households that experienced high rates of crop disease	Positive
% of households that experienced high rates of animal diseases	Positive
% of households that experienced high prices for agricultural inputs	Positive
% of households that experienced high food prices	Positive
Loss or reduced employment/income for a household member	Positive
Does household head have any disability? (YES)	Positive
Food insecure index	Positive
Landslides and mudslides	Positive
Death of a working household member	Positive
Wealth Index (Poor)	Positive
Experience of any shock	Positive
Access to water (YES)	Negative

Source: Authors' calculations using CFSVA data

Annex 4: Indicators used in constructing the adaptive incapacity index

Indicators	Correlation with VCC
Membership in any association or cooperative	Negative
Education	Negative
Weather and climate information	Negative
Training and technical assistance in improved agricultural/livestock practices	Negative
Adaptation to shock (YES)	Negative
Fertilizer use	Negative
Irrigation	Negative
Multiple cropping (YES)	Negative
Use soil conservation measures; protection from soil erosion	Negative
Have a vegetable plot/garden	Negative
Access to land (YES)	Negative
Used biomass for cooking	Positive
Electricity access	Negative
Income level (high)	Negative
Savings (YES)	Negative
Access to Social Safety Nets	Negative
Health post access for diseased animals (not easy)	Positive
Treatment of animal diseases	Negative
Animal vaccination	Negative
Artificial insemination	Negative

Source: Authors' calculations using CFSVA data

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