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**Article — Published Version**

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Food Security

**Provided in Cooperation with:**

Springer Nature

*Suggested Citation:* Ochieng, Nelson A.; Grote, Ulrike (2025) : Agricultural crime victimization and food security outcomes among smallholder farmers in rural Tanzania, Food Security, ISSN 1876-4525, Springer Netherlands, Dordrecht, Vol. 17, Iss. 3, pp. 703-720, <https://doi.org/10.1007/s12571-025-01541-9>

This Version is available at:

<https://hdl.handle.net/10419/323635>

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# Agricultural crime victimization and food security outcomes among smallholder farmers in rural Tanzania

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Received: 20 August 2024 / Accepted: 11 April 2025 / Published online: 28 April 2025  
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## Abstract

This article explores the relationship between agricultural crime victimization, including theft and vandalism of crops and livestock, and food security of smallholder farming households. We use a distinctive panel dataset from rural Tanzania collected in 2016, 2018, and 2021 and measure various dimensions of food security using the Food Consumption Score (FCS), the Household Food Insecurity Access Score (HFIAS) and the Reduced Coping Strategies Index (rCSI). We use the linear two-way fixed effects model to analyze the association between victimization and FCS, and Tobit regression model for HFIAS and rCSI. Our findings reveal that on average, households suffer losses from crime equivalent to 6% of total food expenditure in a year. While vandalism is consistently linked to lower food security across all indicators, theft of crops and livestock is associated with higher HFIAS and rCSI scores, suggesting greater food insecurity. These findings necessitate the need to recognize agricultural crime victimization as an emerging threat to food security that requires attention and intervention in rural communities.

**Keywords** Agricultural crime · Food security · Crop theft · Crop vandalism · Livestock theft · Crime victimization

## 1 Introduction

Food insecurity is an urgent global problem, affecting millions through hunger, malnutrition, and economic instability (FAO et al., 2022; Giller, 2020). The United Nations (UN) Sustainable Development Goal (SDG) 2 focuses on achieving zero hunger by 2030 through transforming agricultural communities to ensure access to safe and nutritious food. However, achieving this goal faces multiple challenges (Molotoks et al., 2021), including the ongoing economic impact of the COVID-19 pandemic (Béné et al., 2021), climate change (Muluneh, 2021), and violent conflicts (Martin-Shields & Stojetz, 2019). Currently, the world continues to struggle with an increasing problem of food insecurity, which is reflected in the rising number of people affected by hunger, an increase in the prevalence of severe food insecurity, and a growing number of undernourished individuals globally (FAO et al., 2022).

There is increased food insecurity in Sub-Saharan Africa (SSA). The escalating demand for food in this region, triggered by rapid population growth (Giller, 2020; Mohajan, 2022), collides with the negative effects of land conflicts, climate change, and low agricultural productivity (Connolly-Boutin & Smit, 2016; Ofori et al., 2021), resulting in a shortage of supply. Various international and national organizations in Africa are working to improve food security (Adem, 2023). However, rural communities in SSA face multidimensional causes of food insecurity that go beyond natural factors and in which humans play a dual role as perpetrators and victims (Clapp et al., 2022; Ofori et al., 2021). Agricultural crime is a particularly under-researched topic in rural Africa (Bunei & Barasa, 2017; Neubacher et al., 2019; Sidebottom, 2013), so its potentially dramatic consequences for these communities are unknown. To address this research gap, we pose the following important research question: To what extent is agricultural crime victimization associated with the food security of smallholder farming households? Three food security indicators are used to answer this question: the Food Consumption Score (FCS), the Household Food Insecurity Access Score (HFIAS), and the Reduced Coping Strategies Index (rCSI).

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Tanzania is a compelling case study as agriculture plays a central role in the national economy and provides livelihoods for over 65% of the population (NBS Tanzania, 2021). Furthermore, the prevalence of food insecurity is alarmingly high, indicating that a significant portion of the population suffers from malnutrition (Mbwana & Bundala, 2023). Nearly 20% of households in the country struggle to afford a diet with sufficient calories and over half are unable to afford a nutritious diet (World Food Programme, 2024). In addition, agricultural crime victimization is emerging as a threatening phenomenon for the country's farming households. An estimated 29% of rural households were affected by agricultural crime in 2016, particularly theft and vandalism of crops, working tools, and livestock (Neubacher et al., 2019), and the problem is considered one of the greatest public concerns (NBS Neubacher et al., 2024; Tanzania, 2021).

Our paper extends the current knowledge base on threats to food security by introducing a novel aspect of risk in the country: agricultural crime victimization, including theft and vandalism of crops and livestock. To our knowledge, there is no empirical evidence from quantitative studies analyzing the association between agricultural crime victimization and food security. This research gap can be attributed to the lack of primary surveys on this issue, and the lack of administrative data on crime victimization resulting from the underreporting of incidents by rural households to the relevant authorities (Abraham & Ceccato, 2022; Neubacher et al., 2019). Our unique Tanzania panel dataset provides us with comprehensive information on crime victimization and other important social and economic household variables, allowing us to address this critical gap in the literature.

We structure our paper as follows: Section two provides the literature review and conceptual framework. Section three presents the data and the methods. Section four shows the results. Section five discusses our findings. Section six summarizes, concludes and points at further research needs.

## 2 Literature review and conceptual framework

### 2.1 Measuring food security

The Food and Agriculture Organization of the United Nations defines the four dimensions of food security: food availability, access, utilization, and stability. Availability measures the sufficiency of food supply in a given area, regardless of whether it is produced domestically or imported. Food access refers to having physical, economic and social access to food. Food utilization means the availability of safe and nutritious food that meets dietary needs. Food stability is the state of being food secure at all times.

The three indicators, FCS, HFIAS, and rCSI, capture most of these important food dimensions.

The FCS is widely employed to evaluate the nutritional aspect of food security and assesses undernourishment (Kakwani & Son, 2016; Smith, 2015). It measures how frequently a household consumes different food items which are differently weighted from the following eight major food groups: cereals and tubers (weight = 2), pulses (weight = 3), vegetables (weight = 1), fruits (weight = 1), milk (weight = 4), fish, meat, and eggs (weight = 4), sugar (weight = 0.5), and oil (weight = 0.5) (Leroy et al., 2015).

We calculate the FCS using Eq. 1.

$$FCS_j = \sum_{k=1}^8 (W_k F_k) \quad (1)$$

where;  $FCS_j$  is the FCS of a household  $j$ ,  $W_k$  is the weight of food group  $k$ , and  $F_k$  is the number of days a household consumed food group  $k$  in a week. A household with relatively higher values for FCS is considered more food secure than households with lower values. More concretely, the FCS of a household is determined based on the following thresholds: 0–21: Poor; 21.5–35: Borderline; > 35: Acceptable (Leroy et al., 2015).

The Coping Strategies Index (CSI) and the rCSI evaluate the actions households take to manage food shortages when confronted with insufficient food or financial resources to purchase food (Maxwell, 2008). These indices are also used to measure the stability dimension of food security (Do et al., 2019). While CSI incorporates twelve coping strategies which may vary in significance across cultures, rCSI relies on a set of five standardized coping behaviors with universally assigned severity weightings. These coping behaviors and their respective weightings are as follows: limiting adult intake (weight = 3), borrowing food/money from friends and relatives (weight = 2), eating less-preferred foods (weight = 1), limiting portions at mealtime (weight = 1) and reducing the number of meals per day (weight = 1) (Leroy et al., 2015). A household with sufficient food or financial resources to purchase food at all times receives a score of zero ( $rCSI = CSI = 0$ ), indicating that it does not employ any of these coping strategies, and the higher the rCSI and CSI, the lower the food security. Generally, a household is considered food insecure when it falls into the category where  $rCSI > 8$  or  $CSI > 12$  (Maxwell et al., 2014).

We use Eq. 2 to calculate the rCSI for households.

$$rCSI_j = \sum_{i=1}^5 (SW_i \times F_{ij}) \quad (2)$$

where  $rCSI_j$  represents the rCSI of household  $j$ ,  $SW_i$  is the weight assigned to the  $i$ th strategy, and  $F_{ij}$  is the number of times the  $i$ th strategy used by household  $j$  within 7 days.

Finally, the HFIAS offers a subjective measure of a household's experience of food insecurity (access) within

four weeks (Grote & Waibel, 2016). We use a set of nine questions and follow the formula and methods outlined by Coates et al. (2007) for computing HFIAS. The score ranges from zero to 27, with a lower score indicating less food insecurity experienced by the household.

## 2.2 Agricultural crime victimization

Agricultural crime covers theft and vandalism of crops, livestock, farm supplies and working tools as well as damage to farms (Barclay, 2001; Barclay & Donnermeyer, 2002). However, in this study we refer to agricultural crime as theft and vandalism of crops and livestock. While vandalism is more prevalent in developing countries, theft incidents occur in both developed and developing countries. However, the methods and motives of the perpetrators can differ. In developed countries, organized and armed groups often target high-value items and steal them in large quantities (Barclay, 2001; Clack, 2013). Conversely, in developing countries, where many farmers engage in small-scale farming, organized or armed groups are less prevalent. Instead, perpetrators are frequently members of the local community, including neighbours or residents of nearby villages, some of whom are even members of the victimized households (Bunei & Barasa, 2017; Neubacher et al., 2024). Which crops and livestock are stolen depends largely on the motivations of the perpetrators, whether for food or commercial purposes.

In SSA, where climate change is increasingly evident (McGuirk & Nunn, 2024; Ofori et al., 2021), agricultural theft is closely linked to weather shocks. Extreme weather events, such as floods and droughts, can significantly reduce food availability for a period of time (Blakeslee & Fishman, 2018; Grote et al., 2024). Consequently, the value of available food increases, making it a highly attractive target for theft (Nguyen et al., 2022, 2023; Sidebottom, 2013). Additionally, floods and droughts may force temporary displacement of people from affected areas (Kai et al., 2021; Osman & Abebe, 2023), leading to a breakdown in informal social control. At the same time, formal control by authorities, such as the police or village leaders, may weaken in flood-affected areas due to restricted road access or officials being preoccupied with disaster response efforts.

Weather shocks can also increase economic hardship and strain on individuals, pushing some to resort to crime as a coping mechanism (Agnew, 2012; Nguyen et al., 2023). These broad structural drivers, combined with high unemployment rates, play a significant role in shaping agricultural theft (Grote et al., 2025). However, other localized factors also contribute, such as proximity to main roads, ease of harvesting, the multiple uses of certain crops, and the availability of hiding spots for thieves within or near fields (Grote & Neubacher, 2016). Unlike the wider economic

and environmental pressures, these localized factors tend to influence theft at a more immediate and site-specific level.

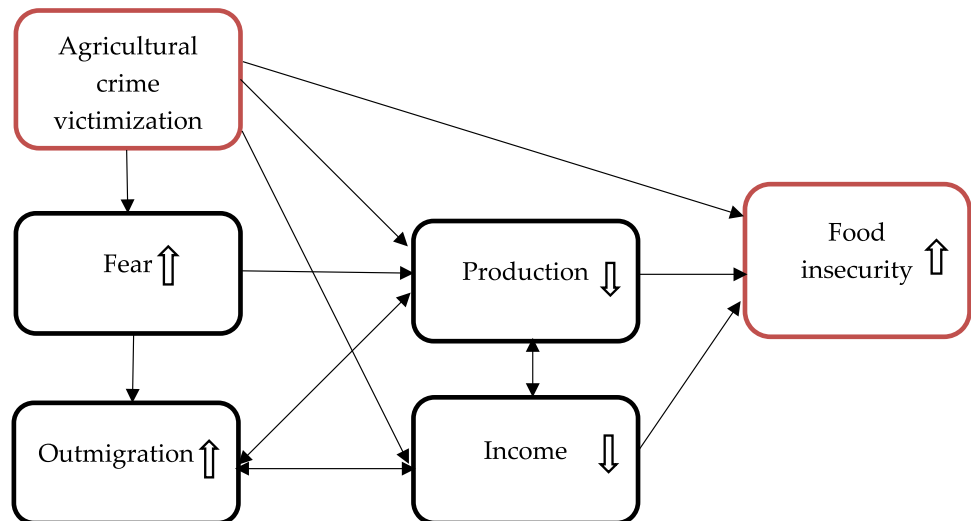
Vandalism is mostly associated with conflicts between farmers and pastoralists arising from competition for resources such as land for grazing and farming, as well as water for irrigation and livestock watering (Benjaminson et al., 2009; Kitchell et al., 2014). Most countries in Africa practice both sedentary farming and transhumance (McGuirk & Nunn, 2024). While sedentary farming refers to farming that takes place in a single location by a settled farmer, transhumance involves seasonal movement to find pasture and water for livestock. However, in recent years, this system has shifted to daily herding, where herders commute to different locations daily to feed their livestock and then return to their permanent or semi-permanent dwellings. African farmers and herders have long coexisted and maintained a symbiotic relationship within their communities (Moritz, 2010). In rural areas where village land use plans are defined and the land tenure system is in order, this symbiotic relationship is sustainable and fruitful (Benjaminson et al., 2009). Farmers provide free land and crop waste for pasture after harvest and benefit from animal waste as fertilizer (Audu & Audu, 2023). The benefits extend beyond the provision of these resources to food consumption, where farmers and herders provide the food supply generated from their respective products.

However, land use plans and property rights are either lacking or poorly implemented in most rural areas of SSA, leading to harmful competition for resources between farmers and herders (Mwamfupe, 2015). Each group believes that it has the right to use fields and water for its activities at any time. This competition is the primary cause of vandalism, with herders' livestock intentionally or unintentionally feeding on unharvested fields while grazing nearby. Alternatively, farmers encroach on and cultivate land formerly used for grazing, thus putting their farms at risk of vandalism. Most vandalism pertains crops, as livestock vandalism occurs only when the farmer catches the livestock in the act. For a long time, policymakers have paid more attention to farmers than pastoralists, shaping land use policies in ways that favour farming while overlooking the needs and land rights of pastoralist communities (Gaye, 2018; Ugwueze et al., 2022). To make matters worse, cultivated areas are visible and create clear demarcations for land use, in contrast to grazing land that eases encroachment. As a result, herders lack free grazing land and are forced to find pastures between locations where farmers operate.

## 2.3 The link between victimization and food security

Agricultural crime victimization can affect rural household food security in various ways, as shown in Fig. 1. Firstly,

**Fig. 1** Conceptual framework to describe the link between agricultural crime victimization and food security



since the crops grown by these communities are used both for personal consumption and as a source of income to meet their needs, theft and damage directly affect food consumption and household finances, leading to general food insecurity. For example, research in Southeast Asia has found that agricultural theft is negatively and significantly correlated with per capita food consumption and total per capita consumption (Grote et al., 2024). Similarly, the importance of livestock, which serves as a vital food source and an asset for income generation, cannot be overstated. Thefts not only reduce the availability of animal products, such as milk, meat, and eggs, but also disrupt income flows (Khoabane & Black, 2012), thereby intensifying food insecurity.

Other impacts can be indirect; for example, incidents of crime embed fear within rural communities (Neubacher et al., 2019, 2024), causing households to hesitate in engaging in intensive farming due to concerns about potential loss of investment in farming land (Benjaminsen et al., 2009). Furthermore, farming households have been found to change cropping patterns, i.e., switching from maize to barley, which is less vulnerable to theft (Neubacher et al., 2024). The persistence of such events undermines the motivation for extensive farming and animal husbandry, hence reducing food availability and diversity from local production, or by hampering income generation for food purchases. In addition, due to victimization by agricultural crime, people are deprived of their livelihoods and outmigration of often younger people from the rural areas to the cities is encouraged (Ganpat & Isaac, 2018). This can have serious implications for farming and hence for food security (Neubacher et al., 2019). The diversion of business and trade due to crime can also impair investments and savings which can lead to indirect costs in terms of psychological costs and lost work time when victimized households feel unsafe at home (Barclay, 2001; Ceccato, 2016). Furthermore,

rural households are compelled to allocate their time and resources to guarding farms and livestock (Neubacher et al., 2024), consequently reducing the time and resources available for other income-generating activities necessary for purchasing food that meets dietary needs.

In this context, studies are also worth mentioning which deal with the impact of crime victimization on food security in times of armed conflicts. Thus, conflict-related victimization has been found to lower dietary diversity of households and individuals in Cote d'Ivoire (Dabalen & Paul, 2014). Farm households in Nigeria are deprived of their livelihoods with severe effects on food security in cases of property crime when livestock, crops or tools are stolen from their homesteads or fields (Kaila & Azad, 2019).

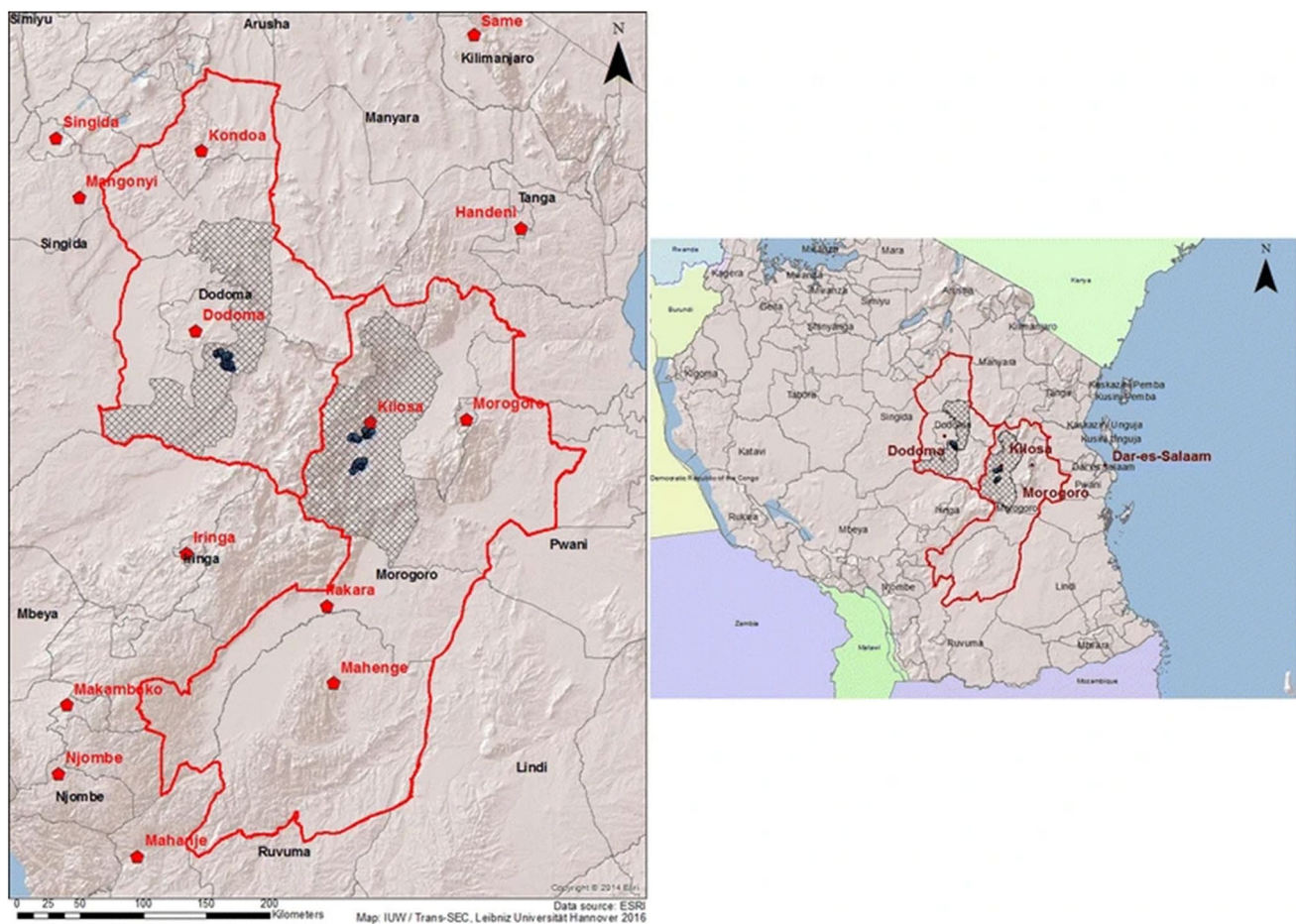
Since there is little empirical evidence from quantitative studies on the links between agricultural crime victimization and food security in general, and no evidence in the African context, we hypothesize that victimization affects negatively household food security, taking Tanzania as a case study.

### 3 Data and methods

#### 3.1 Data

Our study uses panel survey data of smallholder farming households in two regions of Tanzania: Dodoma and Morogoro (Fig. 2). This survey, conducted by Sokoine University of Agriculture in Morogoro and Ardhi University in Dar es Salaam in collaboration with the Leibniz University Hannover and the TUM Campus Straubing, spans the years 2014, 2016, 2018, and 2021. However, we focus on the data from last three rounds (2016 – 2021), as the initial round did not include some sections on crime. Dodoma and Morogoro regions are predominantly inhabited by small-scale





**Fig. 2** Dodoma and Morogoro study regions in Tanzania (source: Trans-Sec, 2014)

farmers but fall into different ecological zones. Dodoma is a semi-arid region, where mainly millet, groundnuts, sorghum, grapes, sunflower, and maize are grown. In addition, livestock rearing plays an important role in the local economy. In contrast, Morogoro is a sub-humid region primarily known for the cultivation of maize, rice, vegetables, sesame, and legumes, with limited livestock farming. Although both regions experience food shortages, the situation is more prevalent in Dodoma than in Morogoro (Kissoly et al., 2020). The interplay between farming and cattle herding activities often leads to land use conflicts between farmers and herders (Benjaminsen et al., 2009).

The selection of the Chamwino district in Dodoma and Kilosa in Morogoro was guided by their representation of agro-ecological conditions, covering approximately 70 to 80% of land-based farming systems in Tanzania (Graef et al., 2014). Within each of these districts, three villages were selected: Ilolo, Ndebwe, and Idifu in Chamwino, and Changarawe, Nyali, and Ilakala in Kilosa. The selection criteria considered similarities in market access, climatic conditions, reliance on rain-fed cropping systems, integration

of crop-livestock practices, and relatively consistent village size of 800 to 1500 households. In the first wave of the survey conducted in 2014, 150 households were randomly selected for interview in each village, making a total of 900 households at the start. Importantly, the same households were followed across each wave. However, due to household attrition, the sample decreased to 820 households in 2016 and 818 households in both 2018 and 2021.

Regarding the survey form, it included a dedicated section on food security, providing detailed information essential for calculating household food security indicators. In addition, a distinct crime section captured comprehensive data on the type, frequency, and severity of victimization over the past 12 months, along with reporting behaviour and the safety measures households implemented to prevent further crime. The survey also examined the types of items subject to theft or vandalism, including agricultural products such as maize, cowpeas, millet, grapes, pigeon peas, and vegetables both at home and in the fields. It also covered livestock such as cattle, goats, sheep, pigs, donkeys, and poultry, including chickens, ducks, and guinea fowls. Data

collection was conducted through computer-assisted personal interviews (CAPI).

We present descriptive statistics of our study sample in Table 1. Household heads are predominantly male (70%), and have an average age of 53 years with 4.5 years of schooling. In Tanzania, female household headship typically occurs in the absence of male partners. The low education level reflects limited school attendance, accompanied by the country's basic education span limited to seven years. In a six-year period, we observe a general improvement in food security over time with acceptable levels when measured using FCS, however, HFIAS and rCSI vary, with the best situation in 2018 and the worst in 2021. Household wealth variables also vary; while livestock ownership (Tropical Livestock Unit (TLU)) decreases over the six years, there are slight variations in the household asset index. In addition, crime victimization amounts to an average of 50% over the six years but increased significantly over time. Many households also have been exposed to various shocks; agricultural

shocks and health shocks steadily increased, while weather shocks varied but were notably high in 2016 and 2021.

It is important to note that TLU accounts for different livestock species using standard conversion factors. For example, an adult cow is equivalent to 1 TLU, while a goat or sheep corresponds to 0.1 TLU, a pig to 0.2 TLU, and a chicken, guinea fowl, or duck to 0.01 TLU. Similarly, the asset index comprises a range of items, including agricultural equipment (e.g., tractor, power-tiller, plough, hand hoe), household appliances (e.g., refrigerator, gas stove, water heater), electronics (e.g., TV, radio, laptop, smart-phone), means of transportation (e.g., bicycle, motorcycle, pushcart), furniture, and renewable energy sources such as solar panels.

We further present a comparison of key variables, including food security, crime victimization, household characteristics, and shocks, between our two study regions, Morogoro and Dodoma, across three survey waves (2016, 2018, and 2021) in Table 2. The differences between the two regions are reported in the last column for each wave (Diff), with

**Table 1** Description of the study variables

Variable	Description	Pooled Data (N= 2,456)		2016 (N= 820)		2018 (N= 818)		2021 (N= 818)	
		Mean	SD	Mean	SD	Mean	SD	Mean	SD
Food security									
FCS	Average FCS	51.1	14.9	47.5	15.2	52.7	14.0	53.1	14.7
HFIAS	Household food insecurity access scale	8.5	7.2	9.0	6.9	4.0	5.4	12.5	6.7
rCSI	Reduced CSI	7.6	9.0	8.2	8.7	3.0	5.5	11.5	10.0
Victimization									
Crime victimization	Dummy, = 1 if a household experienced theft or vandalism of crops or livestock, 0 otherwise	0.5		0.3		0.4		0.8	
Vandalism	Dummy, = 1 if household experienced crop/livestock vandalism	0.2		0.1		0.2		0.4	
Theft	Dummy, = 1 if household experienced theft of crops/livestock	0.4		0.2		0.3		0.7	
Household characteristics									
Asset	Asset score index	57.9	93.7	59.0	126.0	54.1	80.1	63.3	108.0
Livestock	Number of livestock, measured in Tropical Livestock Unit (TLU), owned by household	1.4	7.9	1.5	13.0	1.4	3.2	1.3	3.5
Age	Age of a household head (years)	53.1	16.1	51.1	16.6	52.7	16.0	55.6	15.6
Gender	Gender of household head, 0= female, 1= male	0.7		0.8		0.7		0.7	
Education	Years of education of household head	4.5	3.4	4.5	3.5	4.4	3.4	4.7	3.4
Occupation	Dummy, = 1 if household has another occupation than farming, 0 otherwise	0.6		0.4		0.7		0.6	
Household size	Adult equivalent number of household members	3.2	1.3	3.2	1.3	3.1	1.2	3.3	1.3
Shocks									
Agriculture shock	Dummy, = 1 if household's crops and livestock were affected by pests and diseases, 0 otherwise	0.4		0.2		0.5		0.7	
Weather shock	Dummy, = 1 if household experienced drought or unusual heavy rainfall, 0 otherwise	0.5		0.6		0.3		0.6	
Health shock	Dummy, = 1 if household experienced health shock i.e. serious sickness of household member, 0 otherwise	0.7		0.4		0.7		0.9	

**Table 2** Regional comparison of key variables across survey waves

Variable	2016		2018				2021			
	N= 399	N= 421	N= 397		N= 421		N= 397		N= 421	
	Morogoro	Dodoma	Morogoro	Mean	Dodoma	Mean	Morogoro	Mean	Dodoma	Mean
	Mean	Mean	Diff	Mean	Mean	Diff	Mean	Mean	Diff	Diff
<b>Food security</b>										
FCS	50.3	44.8	5.5***	54.3	51.2	3.1***	56.3	50.1	6.2***	
HFIAS	8.8	9.2	- 0.4	4.4	3.6	0.8**	11.9	13.0	- 1.1**	
rCSI	8.4	7.9	0.5	3.7	2.5	1.0***	11.7	11.3	0.4	
<b>Victimization</b>										
Crime vic- timization (yes = 1)	0.4	0.2	0.2***	0.5	0.3	0.2***	0.9	0.8	0.1***	
Vandalism (yes = 1)	0.12	0.04	0.08***	0.30	0.02	0.27***	0.63	0.10	0.54***	
Theft (yes = 1)	0.3	0.2	0.1***	0.3	0.3	0.0	0.6	0.7	- 0.1***	
<b>Household characteristics</b>										
Asset score	61.7	52.8	8.8	56.7	51.7	5.0	66.6	58.5	8.1	
Livestock (TLU)	0.4	1.8	- 1.3***	0.4	2.3	- 1.9***	0.3	2.1	- 1.7***	
Age (years)	49.9	52.1	- 2.3**	51.4	53.7	- 2.6**	54.2	56.8	- 2.6***	
Gender (male = 1)	0.8	0.7	0.1	0.7	0.7	0.0	0.7	0.7	0.0	
Education (years)	5.0	4.0	1.0***	4.7	4.0	0.8***	5.2	4.2	1.0***	
Alternative occupation (1 = yes)	0.3	0.4	- 0.1**	0.7	0.7	0.0	0.6	0.7	- 0.1**	
Household Size	3.0	3.5	- 0.5***	2.9	3.3	- 0.4***	3.1	3.4	- 0.3***	
<b>Shocks</b>										
Agriculture shock (yes = 1)	0.2	0.2	0.0	0.6	0.4	0.2***	0.6	0.5	0.1	
Weather shock (yes = 1)	0.8	0.5	0.3***	0.2	0.3	- 0.1***	0.5	0.7	- 0.2***	
Health shock (yes = 1)	0.4	0.4	0.0	0.7	0.7	0.0	0.9	0.9	0.0	

\*\*\* $p < 0.01$ , \*\* $p < 0.05$



significance levels indicated based on t-tests and  $\chi^2$ -tests. Regarding food security, Morogoro consistently maintained a higher food consumption score than Dodoma throughout the study period. While there was no significant difference in the rCSI, the HFIAS differed in the last two periods: in 2018, Morogoro had slightly higher values, whereas in 2021, its values were lower compared to Dodoma.

In terms of crime victimization, Morogoro consistently had a higher proportion of victimized households and higher vandalism rates across all three periods. While theft was more prevalent in Morogoro in 2016, by 2021, it was lower than in Dodoma. In addition, households in Dodoma, on average, owned more livestock than those in Morogoro throughout the study period. Household heads in Dodoma were older, had larger household sizes, and were more likely to engage in non-farming economic activities as their second occupations, though they were generally less educated than their counterparts in Morogoro.

Lastly, while shocks generally affect both regions heavily, variations were observed. Health and agricultural shocks were prevalent in both areas, but in 2018, Dodoma experienced more agricultural shocks than Morogoro. Weather shocks, however, had a more variable impact. For instance, in 2016, Morogoro was more affected by weather shocks, whereas in 2018 and 2021, Dodoma experienced more weather-related shocks than Morogoro.

### 3.2 Methods

**Estimating the association between victimization and FCS** FCS follows a continuous distribution resembling normality. Therefore, to examine how agricultural crime victimization relates to food security, we use a linear two-way fixed effects regression model. We execute the linear regression with unit and time fixed effects to reduce the effects of unobservable and time-invariant factors (Gormley & Matsa, 2014). We perform Hausman tests, selecting the fixed effects model over random effects, with detailed results provided in Appendix Table 8. In addition, the relationship between agricultural crime victimization and FCS may involve reverse causality, as victimization might not be random making it endogenous. The routine activity theory of crime victimization suggests the convergence of three elements for crime to occur, these include the motivated offender, a suitable target, and absence of guardians (Cohen & Felson, 1979; Mears et al., 2007). The suitable target element entails what the victim possesses, therefore, people with high FCS levels are likely to have more agricultural production and livestock, making them more likely to become victims.

However, based on the proposed links through which agricultural crime victimization affects household food security (as discussed in Section 2.3), the pathways are more likely to show lagged effects that extend over at least

one farming season. For instance, the effect of victimization through fear, outmigration, production, and income on food security are processes whose effects are most likely to manifest in the following season. Under this assumption, we include a lag of one victimization period and current values of food security indicators in our models. With this approach, we expect a minimal probability of reverse causality (Bellemare et al., 2017). Our estimation, therefore, includes one lag of victimization ( $V_{it-1}$ ) on the current FCS of individual  $i$  in year  $t$  ( $FCS_{it}$ ), as outlined in Eq. 3.

$$FCS_{it} = \alpha_i + \lambda_t + \beta_1 V_{it-1} + \beta_x X_{it} + \mu_{it} \quad (3)$$

where  $FCS_{it}$  is the current FCS of households  $i$ ,  $\lambda_t$  is the year-specific fixed effect,  $\alpha_i$  is the individual household-specific fixed effect,  $V_{it-1}$  is the victimization status in the previous year,  $X_{it}$  is the set of other covariates, and  $\mu_{it}$  is the error term.

**Estimating the association of victimization with HFIAS and with rCSI** Our variables HFIAS and rCSI exhibit left-censored characteristics with 24.8% and 28.6% zeros, respectively. Considering the nature of these variables, we employ Tobit models (Chesher et al., 2023) to examine the relationship between agricultural crime victimization (one lag) and HFIAS and rCSI. Our model estimating the rCSI is represented in Eqs. 4 and 5.

$$rCSI_{it}^* = \alpha + \gamma V_{it-1} + \beta X_{it} + \mu_{it} \quad i = 1, 2, \dots, n \quad \mu_i \sim N(0, \delta_\mu^2) \quad (4)$$

$$rCSI_i = \begin{cases} rCSI_i^* & \text{if } rCSI_i^* > 0, \\ 0 & \text{if } rCSI_i^* \leq 0 \end{cases} \quad (5)$$

In these equations,  $\alpha$  is a constant,  $\mu$  is the error term,  $V$  is crime victimization and  $X$  is a vector of exogenous predictors. It is assumed that  $rCSI_i$  and the covariates are observed for household  $i = 1, 2, \dots, n$  but  $rCSI_i^*$  is unobserved if  $rCSI_i \leq 0$ . For the estimation of HFIAS, we apply the same model structure as for rCSI.

## 4 Results

### 4.1 Descriptive results

#### 4.1.1 Types and trends in victimization

In Fig. 3, we observe a substantial increase in the proportion of victimized households over six years, with a sharp rise from 40 to 80% between 2018 and 2021. The notable increase in victimization rates in 2021 can be largely attributed to the adverse effects of the COVID-19 pandemic,

which impacted rural communities in several critical ways. Prior to the pandemic, many rural residents in our study regions Dodoma and Morogoro migrated to towns and cities in search of employment and business opportunities (Duda et al., 2018; Kibonde, 2024). However, as lockdown measures and the decline of informal sector jobs took effect, a large number of these urban migrants were forced to return to their home villages. With limited economic opportunities in rural areas, many returnees remained unemployed (Kibonde, 2024; Saldanha et al., 2021), increasing their likelihood of engaging in illegal activities for survival. This is further supported by the observed rise in other unlawful activities, such as illegal logging, timber theft, and poaching, in many developing countries during this period (Singhal et al., 2023).

In addition to internal migration challenges, cross-border traders, notably truck drivers, faced numerous challenges including delays, harassment, and stigmatization at border points during the pandemic (Barack & Munga, 2021). These difficulties hindered crop exports, leading to reduced prices and discouraging timely harvesting among local farmers. Crops like maize and cowpeas, which can be left in fields to dry, and tubers such as cassava and sweet potatoes left unharvested, particularly attracted risks of theft and vandalism amidst delayed harvesting efforts. These factors collectively contributed to a sharp increase in victimization cases during the year.

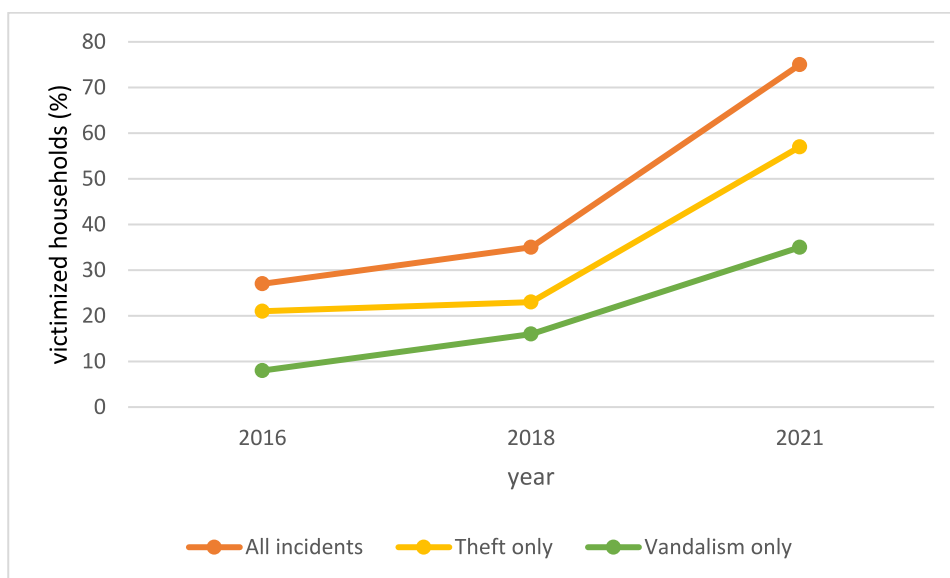
#### 4.1.2 Victimization patterns, losses, and household responses

We observe a pattern of repeated victimization, with an average of 2.2 incidents per victimized household per farming season (Table 3). Furthermore, households experience losses

of US\$102.8 (PPP 2010), equivalent to 6% of total food expenditure in a year. Despite suffering losses and repeated victimization, many households are reluctant to report crime incidents. Only 60% of victims report the incidents to relevant authorities, including sub-village or village authorities and the police. These are the common authorities to which the majority of rural households in our study regions report their crime cases (Neubacher et al., 2019, 2024). However, some individuals opt to report to elderly members of their families, mostly if they suspect the offender to be among family members. Moreover, only 50% took preventive measures to avoid further victimization after the initial incidents, such as guarding, neighborhood watch, and installing locks. The installation of locks was more prevalent among theft victims, while guarding was used mostly by vandalism victims.

When comparing theft and vandalism, we find a disparity between the two (Table 3). Although there is an increasing trend in both types of victimization, vandalism occurs more frequently (2.4 times) than theft (2.1 times), which is consistent with the number of cases reported, with more cases of vandalism (60%) reported than cases of theft (50%) (Table 3). At US\$151.8 (PPP 2010) per victimized household, the losses caused by vandalism are significantly higher than the losses caused by theft which amounted to USD \$73.4 (PPP 2010). This might explain the higher reporting rate for vandalism compared to theft. Furthermore, households affected by vandalism are eligible to a compensation payment in case they can provide evidence on the case (Neubacher et al., 2024). However, cases of vandalism are often complex, as many of them stem from land conflicts involving the destruction of crops on farms and injuring or killing livestock involved if caught in the act (Benjaminsen et al., 2009; Massoi, 2015).

**Fig. 3** Victimized households in rural Tanzania, 2016–2021



Despite the higher frequency, losses and reporting rates associated with vandalism, we find that victims of theft take more proactive measures to prevent further incidents. The reason for this could be the ease of installing locks, particularly if thefts occur at home or in storage rooms in the fields. To protect against vandalism, it may be necessary to hire someone to constantly guard the farm, which could involve higher costs.

Examining trends of these attributes (frequency, reporting behaviour, financial losses, and measures taken) across three survey waves, we find that, while the frequency of theft per household declined from an average of 3 cases in 2016 to 2 cases in 2021, vandalism incidents rose from 2 to 3 cases per household over the same period. This suggests that theft is spreading more broadly across the population, occurring sporadically rather than repeatedly targeting specific households, whereas livestock-induced crop vandalism tends to repeatedly affect the same households. This pattern likely results from livestock following fixed transit routes to and from pasture areas, thereby repeatedly impacting farms along these routes.

Reporting rates for both crime types increased between 2016 and 2021, with theft reports rising from 40 to 60% and vandalism reports from 60 to 70%. Financially, losses from theft remained relatively stable, declining slightly from US\$88 to US\$86 per household, while losses from vandalism decreased from \$208 to \$150, though they remained higher than those from theft. Over time, the proportion of victimized households implementing preventive measures also increased. The share of households taking action after an initial theft incident rose from 38 to 70%, while those adopting measures against vandalism increased from 45 to 60% over the same period.

#### 4.1.3 Target selection: Livestock and crops at risk

The attractiveness of specific targets in rural Tanzania should be noted. On average, 232 chickens, 20 goats, and 19 pigs were stolen annually in our survey regions, making

them the most commonly stolen livestock. These are also the most popular livestock kept by households in the area. Other stolen livestock include ducks, sheep, and cattle; however, the number of cattle thefts is minimal, likely due to their size which makes them unsuitable targets for stealing as thieves can be easily spotted.

Among crops, maize is the most frequently stolen in our sampled villages because it is edible at different stages of ripeness, making it valuable for both food and business. This makes it a common target across the SSA region (Bunei et al., 2013, 2016). For instance, in East African countries such as Tanzania and Kenya, green maize is commonly used to prepare dishes such as *Makande* in Tanzania and *Gith-eri* in Kenya, often combined with beans. In addition, the green maize is widely sold and consumed roasted on the streets, in village centers, and at home. Maize's tall stature also provides cover for offenders, allowing them to operate inconspicuously in the fields, making it a challenge for the owner to detect them for several days. Other crops reported stolen include bananas, tomatoes, and fruits such as mangoes and watermelons.

Maize fields are also the most damaged by livestock, primarily owned by the Maasai, who are pastoralists, and the Sukuma, who are agro-pastoralists. These communities migrated to the study area, particularly Morogoro, in search of pasture (Benjaminsen et al., 2009; Massoi, 2015), with cowpea fields being the second most affected.

#### 4.1.4 Food security and victimization

Turning our attention to household food security, the FCS indicates that food security is higher among victimized households than non-victims (Table 4). In contrast, non-victims exhibit lower HFIAS and rCSI showing that victimized households face greater challenges in accessing food and resort to more severe coping strategies compared to non-victims.

Disaggregating this data by year in Table 5, we observe a consistency in the differences in food security status between victimized and non-victimized households. FCS

**Table 3** Comparison of agricultural crime types per victimized households: theft and vandalism of crops and livestock

Variable name	Pooled sample of victims (N = 1,131)		Theft (N = 829)		Vandalism (N = 485)		Test statistics
	Mean	SD	Mean	SD	Mean	SD	
Frequency of occurrence	2.2	2.1	2.1	2.3	2.4	1.9	0.3**
Case reported (yes = 1)	0.6		0.5		0.6		0.1***
Value lost (US\$ PPP 2010)	102.8	208.6	73.4	176.9	151.8	245.3	78.4***
Measure taken (Yes = 1)	0.5		0.6		0.5		– 0.1***

SD is Standard Deviation: \*\*\* $p < 0.01$ , \*\* $p < 0.05$ ; Note that some individuals were victims of both theft and vandalism

is higher among the victims than non-victims across all three years. The HFIAS shows only a slight difference in 2018, whereas the rCSI remains consistently higher for victims in all years.

## 4.2 Empirical findings

### 4.2.1 Association between victimization and FCS

Table 6 presents the linear two-way fixed effects model estimation of the association between crime victimization and the FCS, focusing specifically on past victimization. In Column 1, we examine the relationship of the overall victimization, including both theft and vandalism of crops and livestock, and the FCS. Next, we separate these incidents into vandalism (Column 2) and theft (Column 3). The results indicate that past victimization is correlated with a 4% lower FCS (Column 1). This negative association appears slightly stronger for vandalism, which is linked to a 6% lower FCS (Column 2). In addition, the findings suggest positive association between household livestock holdings, measured in TLU, and FCS.

### 4.2.2 Association between victimization and HFIAS and rCSI

Table 7 presents the association between past agricultural crime victimization and household food security, as measured by the HFIAS and the rCSI, using Tobit regression models. The results indicate that victimization is correlated with higher HFIAS (Column 1) and rCSI (Column

4), suggesting lower food security in these dimensions. Similar patterns emerge when examining theft and vandalism of crops and livestock separately: both types of victimization are associated with higher HFIAS (Columns 2 and 3) and higher rCSI (Columns 5 and 6), suggesting that each may contribute to food security challenges independently.

Beyond agricultural crime victimization, the results show that weather shocks and health shocks are negatively correlated with food security, as indicated by higher HFIAS and rCSI values. In contrast, household assets and livestock holdings are positively associated with food security, reflected in lower HFIAS and rCSI scores. In addition, household characteristics such as the age of the household head and household size correlate with higher values of both HFIAS and rCSI. On the other hand, male-headed households show a negative association with both HFIAS and rCSI.

## 5 Discussion

This study represents the first quantitative exploration of the relationship between agricultural crime victimization and food security, highlighting a relatively under-researched area within SSA's literature.

Our findings reveal a significant negative association between past agricultural crime victimization and Food Consumption Score (FCS), indicating reduced food security among affected households. The repercussions of victimization appear gradually, as households contend with challenges stemming from these incidents that affect their future

**Table 4** Food security status of victimized and non-victimized households (2016–2021, pooled sample)

Food security indicators	Pooled sample (N = 2,456)		Victimized (N = 1,131)		Non-victimized (N = 1,325)		Test statistic
	Mean	SD	Mean	SD	Mean	SD	
FCS	51.1	14.9	53.1	14.9	49.4	14.6	3.7***
HFIAS	8.5	7.3	9.6	7.2	7.6	7.2	2.0***
rCSI	7.6	9.0	8.7	9.4	6.6	8.4	2.0***

SD is Standard Deviation: \*\*\* $p < 0.01$

**Table 5** Food security status differences between crime victims and non-victims by year

Food security indicators	2016			2018			2021		
	Victims N = 239	Non-victims N = 581	Difference	Victims N = 321	Non-victims N = 497	Difference	Victims N = 672	Non-victims N = 146	Difference
FCS	50.4	46.2	4.2***	54.4	51.7	2.7***	53.5	51.2	2.3*
HFIAS	9.4	8.8	0.6	4.5	3.7	0.8*	12.3	13.3	1.0
rCSI	9.1	7.8	1.3*	3.5	2.7	0.8**	11.2	12.9	1.8**

\*\*\* $p < 0.01$ , \*\* $p < 0.05$ , \* $p < 0.1$

**Table 6** Two-way fixed effects estimation of association between agricultural crime victimization and FCS

Variables	FCS <sup>a</sup>		
	(1)	(2)	(3)
Victimization (theft or vandalism) (t- 1)	- 0.04* (0.02)		
Vandalism (t- 1)		- 0.06** (0.03)	
Theft (t- 1)			- 0.03 (0.02)
Asset index <sup>a</sup>	0.01 (0.02)	0.01 (0.02)	0.01 (0.02)
Livestock (TLU)	0.01*** (0.01)	0.02*** (0.01)	0.01*** (0.01)
Age (years)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
Gender (male = 1)	0.01 (0.05)	0.01 (0.05)	0.02 (0.05)
Education (years)	0.01 (0.01)	0.01 (0.01)	0.01 (0.01)
Second occupation (yes = 1)	- 0.01 (0.02)	- 0.01 (0.02)	- 0.01 (0.02)
Household Size	0.01 (0.01)	0.01 (0.01)	0.01 (0.01)
Weather shock (yes = 1)	- 0.025 (0.02)	- 0.025 (0.02)	- 0.025 (0.02)
Agriculture shock	- 0.01 (0.01)	- 0.02 (0.02)	- 0.01 (0.02)
Health shock	- 0.02 (0.03)	- 0.02 (0.03)	- 0.02 (0.03)
Year dummy (year 2021 = 1)	0.016 (0.02)	0.017 (0.02)	0.014 (0.02)
Constant	3.83*** (0.12)	3.83*** (0.12)	3.83*** (0.12)
Model Statistics			
R-square	0.02	0.02	0.02
No. of observations	1,579	1,579	1,579

Standard errors in parentheses: \*\*\* $p < 0.01$ , \*\* $p < 0.05$ , \* $p < 0.1$ <sup>a</sup>Variable in log form

food security. For instance, victimization induces fear (Neubacher et al., 2024; Zhao et al., 2015), discouraging affected households from investing in farming due to concerns over potential losses (Benjaminsen et al., 2009). This hesitancy can lead to prolonged declines in agricultural productivity. Moreover, victimization disrupts household finances, forcing families to prioritize immediate food consumption stability over investments in future agricultural production. While this coping strategy may sustain dietary intake temporarily, it ultimately diminishes resources that could have otherwise been used to bolster food production through farming and

livestock keeping, intensifying food insecurity in subsequent seasons.

Notably, our descriptive analysis showed a higher FCS among victimized households compared to non-victimized ones. This could be because economically well-off households, those with greater food reserves, crop yields, or livestock holdings, are more likely to be targeted by offenders (Cohen & Felson, 1979; Mears et al., 2007). Given that FCS reflects food access (Leroy et al., 2015) and captures both the availability and diversity of food types consumed (Islam & Al Mamun, 2020), it is plausible that these households become primary targets precisely because they possess valuable agricultural resources that offenders seek to exploit. However, as these households deplete their available resources to cope with victimization shocks, their production capacity gradually declines, leading to lower food security in the seasons following victimization. This trajectory aligns with our main finding that past victimization negatively correlates with FCS.

Moreover, the finding that vandalism is negatively associated with FCS to a greater extent than theft may be attributed to the higher value losses typically incurred through vandalism compared to theft. We also observe that vandalism is more prevalent in Morogoro than in Dodoma, despite households in Dodoma generally keeping more livestock on average. Morogoro, historically dominated by local farmers benefiting from adequate rainfall, has seen an influx of agro-pastoralists such as the Maasai and Sukuma from the north, establishing themselves in the region (Massoi, 2015). However, as these areas were originally designated for farming, the infrastructure to support livestock keeping is insufficient, leading to conflicts with existing agricultural plots. This lack of suitable infrastructure, coupled with the presence of livestock, contributes to the area's designation as one of the high-conflict zones between farmers and herders in the country (Benjaminsen et al., 2009).

Our findings align with previous studies linking victimization to diminished dietary diversity and coping strategies indicative of high food insecurity. Dabalen and Paul (2014) demonstrate that dietary diversity is impacted by experiences of armed conflict victimization. Conflicts expose victims to property theft and vandalism, leading to significant losses similar to those caused by crime victimization. In addition, Grote et al. (2024) show that agricultural theft affects food consumption in Southeast Asia, which may also contribute to lower household FCS.

The positive association between past agricultural crime victimization and both HFIAS and rCSI indicators of high food insecurity, suggest that affected households face increased hardships in securing sufficient food, leading to increased anxiety and uncertainty about meeting their food demands. Moreover, it indicates that victimization forces



**Table 7** Tobit model estimation: The association of agricultural crime victimization with HFIAS and with rCSI

Variables	HFIAS <sup>a</sup>			rCSI <sup>a</sup>		
	(1)	(2)	(3)	(4)	(5)	(6)
Victimization (theft or vandalism) (t- 1)	0.68** (0.29)			0.78** (0.31)		
Vandalism (t- 1)		0.93** (0.43)			1.19*** (0.45)	
Theft (t- 1)			0.54* (0.33)			0.58* (0.35)
Asset index <sup>a</sup>	− 0.55*** (0.18)	− 0.54*** (0.18)	− 0.53*** (0.18)	− 0.82*** (0.19)	− 0.82*** (0.19)	− 0.81*** (0.19)
Livestock (TLU)	− 0.20*** (0.05)	− 0.19*** (0.05)	− 0.20*** (0.05)	− 0.18*** (0.05)	− 0.17*** (0.05)	− 0.18*** (0.05)
Age (years)	0.03*** (0.01)	0.03*** (0.01)	0.03*** (0.01)	0.04*** (0.01)	0.04*** (0.01)	0.04*** (0.01)
Gender (male = 1)	− 0.58* (0.33)	− 0.58* (0.33)	− 0.60* (0.33)	− 0.82** (0.35)	− 0.82** (0.35)	− 0.84** (0.35)
Education (years)	− 0.01 (0.05)	− 0.01 (0.05)	− 0.00 (0.05)	0.01 (0.05)	0.01 (0.05)	0.02 (0.05)
Second occupation (yes = 1)	− 0.08 (0.31)	− 0.08 (0.31)	− 0.08 (0.31)	0.10 (0.33)	0.11 (0.33)	0.10 (0.33)
Household Size	0.35*** (0.12)	0.35*** (0.12)	0.35*** (0.12)	0.49*** (0.13)	0.49*** (0.13)	0.49*** (0.13)
Weather shock (yes = 1)	1.35*** (0.28)	1.36*** (0.28)	1.34*** (0.28)	1.55*** (0.30)	1.56*** (0.30)	1.54*** (0.30)
Agriculture shock (yes = 1)	− 0.26 (0.28)	− 0.24 (0.28)	− 0.25 (0.28)	− 0.46 (0.29)	− 0.44 (0.29)	− 0.45 (0.30)
Health shock (yes = 1)	2.63*** (0.40)	2.61*** (0.43)	2.66*** (0.40)	2.98*** (0.43)	3.00*** (0.43)	3.01*** (0.43)
Constant	− 3.98*** (1.05)	− 3.91*** (1.05)	− 3.96*** (1.05)	− 4.94*** (1.12)	1.19*** (0.45)	0.58* (0.35)
Model Statistics						
No. of observations	1,579	1,579	1,579	1,579	1,579	1,579
Uncensored	1,145	1,145	1,145	1,082	1,082	1,082
Left censored	434	434	434	497	497	497
Wald $\chi^2$	154.1***	153.6***	151.5***	180.9***	181.7***	177.3***

Standard errors in parentheses: \*\*\* $p < 0.01$ , \*\* $p < 0.05$ , \* $p < 0.1$ <sup>a</sup>Variable in log form

households to adopt coping strategies more frequently or with greater intensity to survive. These findings, although in an indirect way, align with the study from Kaila and Azad (2019), which found a positive association between armed conflict victimization and CSI. Similar to rural crime, conflicts expose victims to theft and vandalism, often targeting agricultural assets.

We further find that while weather shocks are negatively associated with food security, livestock keeping and asset holding are positively associated with it. With ongoing climate change in SSA (McGuirk & Nunn, 2024; Ofori et al., 2021), food insecurity may worsen alongside rising levels of

agricultural crime victimization, amplifying the challenges already faced by smallholder farmers, leading to a vicious cycle of vulnerability. As weather shocks potentially disrupt food production and livelihoods (Devereux, 2007; Kakpo et al., 2022), rural crime could further undermine efforts to enhance food security, making it even more critical to address both issues simultaneously. Conversely, livestock holdings and asset ownership emerge as protective factors linked to improved food security. Livestock such as chickens, ducks, sheep, goats, and cows provide consumable products essential for household food security (Megersa et al., 2014; Sekaran et al., 2021). Similarly, asset ownership acts as a

buffer against food insecurity, mitigating its severity during crises (Shifat et al., 2024).

While this study provides critical insights, it is important to acknowledge its limitations. The analysis primarily establishes associations rather than causal relationships, warranting future research to use methodologies that more rigorously explore causality between victimization and food security. Moreover, the study's scope is confined to two neighbouring regions in Tanzania with similar agricultural systems, suggesting a need for broader studies covering diverse agroecological contexts and farming systems to enrich understanding of this issue.

## 6 Conclusion

Food insecurity remains a significant issue in many rural areas of Tanzania, warranting attention. Meanwhile, agricultural crime victimization, including theft and vandalism of crops and livestock, is emerging as a threat to rural livelihoods, yet it remains a neglected and under-researched topic. In this paper we analyze the association between agricultural crime victimization and food security of rural households in Tanzania. To address this gap, we use a three-wave panel dataset from rural Tanzania, covering two regions in the central and eastern parts of the country, collected in 2016, 2018, and 2021. We measure food security using three indicators: (1) Food Consumption Score (FCS), (2) Household Food Insecurity Access Scale (HFIAS), and (3) Reduced Coping Strategy Index (rCSI).

In our study area, we find that on average over the six years, 50% of households experience victimization, with an average of 2.2 incidents per victimized household. Theft affects more households (40%) compared to vandalism (20%), however, vandalism results in greater value loss than theft. We also observe that victims are reluctant to report crime incidents, with only 60% of households doing so, although the rate is increasing over years. In our empirical analysis, we use linear two-way fixed effects model to analyze the association between victimization and FCS. In addition, Tobit regression models are used to examine how victimization relates to HFIAS and rCSI. In these cases, we use one lag of victimization in our analysis recognizing the delayed effect of victimization on food security and minimize the possibility of reverse causality. Our findings reveal that past agricultural crime victimization has a negative association with food security, as it correlates with lower values of FCS, and higher values of HFIAS, and rCSI. We further show that vandalism separately also negatively correlates with food security

through all the three indicators, while theft positively associates with the HFIAS and rCSI, thereby increasing food insecurity. We also show that livestock keeping and asset accumulation play a crucial role in strengthening food security in the rural settings.

Our finding that victimization affects FCS has long-term implications for rural communities; lower FCS means less diverse food items are consumed which may result in undernourishment and affect population health and child development – problems that are already prevalent at the national level (WFP, 2023). Secondly, the negative association of victimization and food security through the HFIAS and rCSI hinders the achievement of zero hunger in rural populations, as outlined in the 2030 Agenda for Sustainable Development and national strategies. Lack of access to food and food instability both affect households' focus on economic and development activities, worsening and hampering efforts to combat poverty in the long run. Therefore, these findings call for more attention and a comprehensive approach to combat agricultural crime, which has a rising trend in rural communities. Such efforts should be in line with government initiatives to improve food security. In addition, we recommend promote asset accumulation and livestock keeping among rural farmers as strategies to strengthen food security and build resilience against shocks from crime victimization and weather extremes.

We finalize this section by pointing out further research needs. First, it is essential to develop conflict management strategies for herders and pastoralists since vandalism is a major cause of food insecurity. The alternative farmer-herder conflict management strategy that was adopted in Northwest Cameroon demonstrates the possibility of resolving the problem safely and with mutual benefits (Mbih, 2020). However, more critical studies are needed in the context of rural Tanzania where both farmers and herders coexist in the village during both the dry and rainy seasons. Second, since many victims fail to report agricultural crime incidents, despite their significant effect on food security, we advocate for further comprehensive studies on this matter. Furthermore, the question remains why many households do not take any preventive measures to avoid victimization. Understanding the underlying reasons and establishing mechanisms for widespread prompt reporting of such incidents will shed light on the severity of agricultural crime, paving the way for more decisive and effective actions against it.

## Appendix

**Table 8** Hausman test for fixed effects and random effects 2FE model

Variables	Random-effect	Fixed-effect	Difference	Standard errors of difference
Lag of victimization (theft and vandalism)	- 0.004	- 0.039	- 0.035	0.015
Asset index <sup>a</sup>	0.066	0.013	- 0.053	0.012
Livestock (TLU)	0.011	0.014	0.003	0.005
Age (years)	- 0.001	0.000	0.002	0.002
Gender (male = 1)	0.014	0.014	- 0.000	0.050
Education (years)	0.002	0.005	0.003	0.005
Second occupation (yes = 1)	- 0.017	- 0.008	0.009	0.015
Household Size	- 0.004	0.012	0.016	0.012
Weather shock (yes = 1)	- 0.039	- 0.025	0.014	0.013
Agriculture shock (yes = 1)	- 0.007	- 0.014	- 0.007	0.013
Health shock (yes = 1)	0.002	- 0.021	- 0.024	0.018
Year dummy (year 2021 = 1)	0.014	0.016	0.002	0.010
Chi <sup>2</sup> (12)	<b>35.45</b>			
Prob. > Chi <sup>2</sup>	<b>0.000</b>			

<sup>a</sup>Variable in log form

**Acknowledgements** This paper is written in the context of a larger project on “crime and development”. We thank Anja Faße, Luitfred Kissoly, Claudio Ngassa, Eva Seewald, Brigitte Ruesink, and a team of enumerators from Tanzania for collecting the data. Special thanks also go to Frank Neubacher for developing the crime-related questions, and Trung Thanh Nguyen for suggestions on the paper.

**Author contributions** Nelson A. Ochieng: writing – review and editing, writing – original draft, methodology, formal analysis, data curation, conceptualization. Ulrike Grote: writing – review and editing, Supervision, Project administration, Methodology, Conceptualization.

**Funding** Open Access funding enabled and organized by Projekt DEAL. This research is based on data collected under the Trans-SEC project (<https://trans-sec.zalf.de>), which was funded by the German Federal Ministry of Education and Research (BMBF) and the German Federal Ministry for Economic Cooperation and Development (BMZ). The views expressed are those of the authors and may not under any circumstances be regarded as stating an official position of the BMBF and BMZ. The publication of this article was funded by the Open Access Fund of the Leibniz University Hannover.

**Data Availability** The data will be made available upon reasonable request.

## Declarations

**Competing interests** The authors declare that they have no competing interests relevant to the content of this article.

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