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RESEARCH

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# Household food security in the agropastoral communities of rural southern Kyrgyzstan

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## Abstract

**Background** In mountainous nations like Kyrgyzstan households face substantial environmental and infrastructural challenges as they strive to achieve food security. Measuring food security in montane and agropastoral communities is difficult due to seasonal variations, varied livelihood strategies, and the difficulty of reaching respondents. This study examines intricacies associated with measuring household food security in the southern Kyrgyz highlands and discusses the wider implications for measuring food security in an agropastoral setting. To do this, we deployed multiple types of household food security measures (economic, experiential, and consumptive) via survey ($n = 1234$) within one southern *rayon* (district).

**Results** Households are largely successful in mitigating acute food insecurity, yet issues of chronic food insecurity persist. Conceptual and statistical similarities between measures support the identification of food security indicator typologies. However, comparing measures of different types presented contradictory narratives in which one type indicates advantageous and the other disadvantageous results. In analyzing the disconnect, natural and socioeconomic shocks are found to be highly influential.

**Conclusion** It is posited households are successful in responding to shocks through the deployment of coping strategies, such as using loan funds to purchase food. Socioeconomic indicators, such as asset ownership, are implicated as drivers of food security. Findings, discussion, and conclusions contribute to the shared understanding of the measurement of food security in agropastoral communities.

**Keywords** Food security, Food insecurity, Food security measurement, Kyrgyzstan, Agropastoralism

## Background

We use a survey of 1234 households to analyze household food security in a rural Kyrgyz community. Because it is difficult to measure household food security in high-elevation, agropastoral communities, where seasonal variation and differences in *perceived* food security status create a unique measurement challenge, we have incorporated different measures of food insecurity to capture consumptive, experiential, and economic indicators. This study takes on this challenge and discusses some of the lessons we learned from conducting a wide-scale survey initiative in the agropastoral communities of rural southern Kyrgyzstan.

Measuring food security can be undertaken at differing levels of measurement. This study focuses on the household level of analysis because a singular household representative can be used as the focal point for measurement when they answer questions about the food security status for all members of their household. Community level food security analysis stands in contrast to other food security research, which are often centered on a global [1, 2] or regional scale [3].

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Previous food security studies have examined indicators focusing exclusively on one aspect, such as access [4] or consumption [5]. Geographically targeted studies have been primarily focused in sub-Saharan Africa [6]. Limited data are available to study aspects of food security in agropastoral communities in Central Asia, especially within Kyrgyzstan, because of the infrequency of wide-reaching studies throughout the region [7, 8]. By focusing on one rural *rayon* (district) in southern Kyrgyzstan, this study addresses this research gap. The findings and discussion seek to inform the discussion around the complex measurement of food insecurity in agropastoral communities and shed light on issues of agricultural livelihoods, disaster preparedness, and rural development.

Kyrgyzstan is a mountainous former Soviet Union nation located in the heart of Central Asia. Kyrgyzstan gained independence in 1991 and has since undergone rapid economic and political changes. Two-thirds of the nation's population reside in mountainous rural areas, where the climate is difficult for traditional agriculture [9]. Kyrgyz people have a proud longstanding tradition of agropastoralism. Kyrgyz agropastoral livelihoods are characterized by the practice of seasonal vertical transhumance, in which herders and families move according to livestock grazing patterns. Some families or family members may remain in lower elevation villages and cultivate a select variety of crops. There are ecological grounds for the continued primacy of transhumance, as 42.9% of the country's land is pasture and only 7.2% is arable land [10]. Pasture management and animal husbandry are of increasing relevance to food security, as protein and dairy consumption have increased in recent years [11]. The cycles of livestock, pastures, and movement remain cornerstone of life in rural Kyrgyzstan [8, 12, 13].

In a traditional, agrarian, mountainous, and subsistence context, many families struggle to make ends meet because of the unforgiving natural environment and low incomes [8, 12]. Economically, the nation is highly susceptible to effects from global food price fluctuations, international trade agreements, market saturation, and currency inflation. Rural areas tend to be even more susceptible than other areas because of limited infrastructure, reliance on foreign food imports, and a limited government social support system [14, 15]. Despite the government's efforts, few rural employment opportunities exist.

Mountain communities in particular are vulnerable to environmental shocks such as earthquakes, landslides, and flooding that occur more frequently as a result of climate change [16, 17]. In addition to these shocks, many households exist in a relative state of geographic and social isolation because of the mountainous topography. This isolation limits access to numerous human development amenities and opportunities, including healthcare facilities, markets, asset accumulation, sanitation infrastructure, financial institutions, land tenure, and advanced education [18, 19]. The concentration of poverty in rural Kyrgyz communities puts families at a greater risk for acute and chronic diseases, as well as under- and malnutrition [9].

It is estimated that one-third of the nation's gross domestic product (GDP) is derived from the remittances sent back by migrants to their communities of origin, the second highest rate globally [20]. Because of the high under- and unemployment, many Kyrgyz people, especially those of working-age, turn to international labor migration to support their households. High levels of remittances and labor outmigration frequently signify low levels of human capital and surplus labor. With a large portion of the workforce migrating away, rural communities are increasingly short on the human capital and labor needed for subsistence. The shortage leads to a feedback loop with more economic emphasis on labor migration [21].

These factors combine to make Kyrgyzstan one of the poorest countries in Central Asia, with 25.6% of the population living below the poverty line [22]. Poverty is thus the major driver of chronic food insecurity in Kyrgyzstan. It is estimated that one-quarter of the population faces chronic poverty [23]. Seventy percent of the poorest families live in rural areas and rural areas are where two-thirds of all the nation's food-insecure households are [9]. The harmful effects of food insecurity are amplified among women of childbearing age and children, especially those under age 5 [24]. Nationally, one-third of women of childbearing age are anemic due to poor nutrition [25]. Eighteen percent of children are malnourished and reside in a household that is food insecure and nutritionally deficient [15]. Thirteen percent of children under 5 suffer from stunting, of which 43% are anemic [9]. Twenty-two percent of mortality cases for children under the age of 5, including neonatal deaths, in Kyrgyzstan have been attributed to undernutrition [15]. In addition to increasing child mortality, food insecurity in Kyrgyzstan also contributes to elevated rates of birth defects and hinders children's long-term cognitive development [26]. These statistics highlight the critical importance of food insecurity research and the initiatives in the agropastoral communities that seek to alleviate it.

### Household food security and agropastoralism

The United Nations (UN) Food and Agriculture Organization (FAO) classically defined food security as "when all people, at all times, have physical, social and economic

access to sufficient, safe and nutritious food which meets their dietary needs and food preferences for an active and healthy life [27]." Food security conceptualization was previously oriented around three pillars: availability, access, and utilization [28]. More recently, a fourth pillar was included to examine elements of stability [29] or sustainability [30]. Food security can be temporally analyzed by examining short- and long-term indicators that demonstrate acute and chronic insecurity [31].

The UN Millennium Development Goals (MDGs) and the UN Sustainable Development Goals (SDGs) have focused the international development community on the issue of food security. These massive intergovernmental initiatives have been met with a mixed reactions [32, 33]. Much of the debate has revolved around the complexities in measuring of the development goals [34]. Despite disagreements, a number of scholars have been successful in measuring food security/hunger with a high degree of external and internal validity [6, 35]. However, many of these measures are on limited timescales of 24 h, 7 days, or 30 days and they fail to account for the dramatic seasonal differences in diets and consumption strategies that are present within agropastoral livelihoods. Because of this difficulty, the food security measures in this study sought to embrace these complexities by using multiple measures (Table 1) and classifying them into typologies.

Of the limited studies that do explicitly examine food security in agropastoral communities, many use one or more of these externally validated consumptive or experiential indicators [36–38]. Geographically, most of the published works that take this focus are set in Africa [39–43]. Surveying these works, a variety of finings yield potentially useful insights into our examination of household food security in southern Kyrgyzstan. Some studies found that agropastoral livelihoods are largely successful in ensuring a base level of food security across a community [37]. In contrast, others find a high rate of food insecurity throughout the agropastoral community [38]. While others emphasize the seasonality of food security in agropastoral communities with periods of food abundance and food shortages [8, 36]. Mayanja et al. [36] provide an example of seasonal impact in their research in Uganda demonstrating that households are more food secure during the dry season than the rainy season. They not only noticed a difference in food security status but also found that the predictors of food insecurity differed depending on the season. During the dry season, food insecurity was most closely linked with households that had limited land holdings. During the rainy season, food insecurity was higher in agropastoral households that had low livestock holdings and were more socially isolated [36]. In a similar Ugandan context, Esenu et al. [43] found a gendered difference in household food security determinants. They found that, among pastoral women, food security was closely linked to livestock holdings, access to veterinary service, formal education, increased market access, and access to credit, whereas for pastoral men, land ownership was negatively associated with food security [43]. This distinction is noted by studies in other areas that stress the importance of gendered dynamics of food security within agropastoral communities [8, 41, 44].

In Ethiopia, multiple studies have identified the importance of market infrastructure improvement and investments in aiding food security in agropastoral communities, pointing to the increasing importance of commodification of certain aspects of formerly traditional livelihood strategies to ensure food access and resilience [38, 40]. Bekele, et al. [38] noted that the proximity to large-scale land investments aided food consumption in agropastoral communities. In agropastoral Kenya, Lusike [45] finds that increased size of land holdings was a significant predictor of food security. Similarly, in Kenya, Amwata et al. [41] finds that land size holds a special relationship with food insecurity in agropastoral communities. They also find that household size, rainfall, livestock holdings, access to information, off-farm employment opportunities, and female access to resources all relate to household vulnerability to food insecurity [41]. Other studies in Africa also note the importance of household size, land tenure, and livelihood diversification in achieving food security for agropastoral households [37, 39, 46]. A common theme among many of these studies is a focus on engaged and culturally competent policy and development initiatives to aid food security in agropastoral communities [8, 40, 41, 44, 45]. This study builds upon this previous research by focusing on agropastoral communities.

## Methods

### Study overview and research questions

Research focusing on food security in the agropastoral communities in rural Kyrgyzstan has the potential to yield applied and theoretical benefits. The functional significance of the analysis speaks to the practical aspects of measuring food security in agropastoral communities. With this in mind, this study examines the state of food security in the southern Kyrgyz highlands through the use of multiple food security measures: Household Dietary Diversity Score (HDDS), Food Consumption Score (FCS), Household Food Insecurity Access Scale (HFIAS), Reduced Coping Strategy Index (rCSI), Household Hunger Scale (HHS), and the Percent of Total Household Expenditures on Food (Food_Exp). The analysis takes on the challenge of measuring household food security during one defined period of time, the summer of 2017.

**Table 1** Measures of household food security

| Indicator | Type | Timeline | Description | Strength | Weakness | Sample question | Seminal author(s) |
|---|---|---|---|---|---|---|---|
| Household Dietary Diversity Score (HDDS) | Consumptive | 24 h | This food security indicator is a quick snapshot of a household's quality of diet. It allows for precise dietary nutrient composition and involves a short recall period | High internal validity; provides detailed breakdown of food types consumed | Short time period is only a snapshot; sensitive to seasonal and market variation | Now I would like to ask you about the types of foods that you or anyone else in your household ate yesterday during the day and night<br>• Any eggs? | [60] |
| Food Consumption Score (FCS) | Consumptive | 7 days | Food consumption score is a consumptive indicator of food security that extends the HDDS into a longer temporal period. It allows for consumptive thresholds and micronutrient dietary contributions to be examined | Experiential indicator; easy to launch in the field | Reliability risk with precise food groups; limited timescale | How many days for the last 7 days did your family consume these food items?<br>• Any fruits? | [52] |
| Household Food Insecurity Access Scale (HFIAS) | Experiential | 30 days | This is a social indicator of food insecurity that is easily broken down into 3 categories. It captures activities and anxiety for when food is low | Examines acute food insecurity; experiential; able to be closely examined in categories | Limited scope; cultural relevance | During the past 30 days, have there been times when your family had to do the following in order to get money or food?<br>• Decrease expenditures for healthcare | [54] |
| Reduced Coping Strategy Index (rCSI) | Experiential | 7 days | This is a quickly deployed and elegantly simplistic experiential indicator of food insecurity when households are strained | Experiential indicator; broad assessment of household status | Pride causing limited internal validity; inexact counting of strategies with no severity variation within a given selection | In the past week, if food was low, how often did you use the following options:<br>• Rely on less preferred and less expensive food | [53] |
| Household Hunger Scale (HHS) | Experiential | 30 days | This is a simple indicator of acute food insecurity. It allows for an examination of households in what can be considered dire positions | Captures degrees of severity | Not sensitive to chronic aspects; pride causing internal validity problems | In the last 30 days, did you or any household member go to sleep at night hungry because there was not enough food?<br>• How often did this happen in the last 30 days? | [77] |
| Percent Expenditure (Food_Exp) | Economic | Typical month | This is a simple measure of how much a household spends on food in proportion to their income. It has theoretical and applied importance. As this number grows, it indicates more economic distress in ensuring food security | Easily interpreted; telling indicator of market forces | Survey error with participant recall; sensitive to seasonal and economic variations; food produced by the household not included | 1. In the last 12 months, how much income did your household make?<br>2. In a typical month, how much of your income is spent on the following items?<br>• Food | [56, 57] |

Table adapted from Headey and Ecker [31] and Maxwell et al. [6]

We compare the measures of household food security to one another in search of an emergent narrative. Across each metric, we explore household characteristics that might provide advantages and disadvantages in terms of household food security.

Household food security is a theoretically latent concept that requires an indirect method of measurement [47]. If the unobservable concept of food security could be perfectly measured, it would result in a cohesive explanatory narrative with correlated indicators. This narrative might indicate that households with a higher socioeconomic status would be more food secure due to receiving remittances, having productive assets, and producing/purchasing more nutritious food. Subsequently, impoverished households suffering from asset depletion, devoid of remittances, and having insufficient food production would be less food secure.

In the analysis and discussion to follow, it is clear that these generalities are ill-suited when cross-examining the measures of food security in these agropastoral communities. Findings support the theoretical distinctions of measure typologies. When comparing measures across typologies, clear differences emerge. For example, an increase in remittances is advantageous for one type of indicator (experiential) but disadvantageous for another indicator (consumptive). This finding prompted a different type of question that is critical to the examination of household food security in this context: why does a disconnect between indicators exist? We hypothesized that the disconnect between indicators is due to a number of migratory, economic, environmental, and social variables.

#### Data collection and site selection

The first two authors of this study administered 1234 household surveys during the summer of 2017 in Alay, a southern *rayon* (district) with an elevation range of 1482 to over 7000 m above sea level. The primary economy in Alay revolves around herding and animal husbandry (sheep, goats, cattle, horses, and yaks) [48]. In 2017 the *rayon* included 61 distinct villages with a population of 83,500 [49]. Individual village populations range from 191 to 11,691. The *rayon* is sparsely populated, 11 persons/km$^2$, compared to the national average of 30 persons/km$^2$. The poverty rate (74%) and extreme poverty (32.3%) in Alay is more than two times higher than that of neighboring Chon-Alay [48]. Additionally, levels of education and wages are lower in Alay when compared to neighboring *rayons* [50]. One report characterizes the situation in Alay this way: "Most part [sic] of the unemployed are young people under 28 years old, who have graduated… to become lawyers, financiers, managers. It is almost impossible to find work in such fields in the project rayons (Alai and Chon-Alai). After graduation, a third of young people stay in the villages, the rest leave [50]." Alay *rayon* has a high rate of labor out-migration, an abundance of agropastoral livelihoods, a prevalence of poverty, and variable community elevations.

We sampled 17 villages for the study within Alay from a stratification of Euclidian distance, political space, population, elevation, and market access (see Fig. 1). We excluded some areas because of safety considerations. We purposely selected households within villages to maximize sample size. Given this approach, we are confident that study findings are relevant for agropastoral communities across southern Kyrgyzstan.

#### Selected indicators of household food security

By examining different indicators, and sorting them into types, the study gains a more nuanced perspective of household food security in agropastoral communities. We used multiple externally validated measures, which Vhurumuku [51] has described as the "suite of food security measures", to measure the four pillars of food security (Table 1). We made minor language changes to some items to reflect cultural relevance. As previously noted, we grouped measures into three conceptual indicator types: consumptive, experiential, and economic. Collectively these indicators measure distinct aspects of the latent concept of food security (quality and quantity of food, frequency and intensity of hunger coping behaviors, and the proportion of food expenditures). Therefore, these measures are not directly comparable, even though they are related in their attempt to measure household food security status. Rather, by comparing these indicators, we hope to capture a broader picture of a household's food security status. For example, a household with a high food expenditure proportion is not necessarily a household that is undertaking dire hunger coping strategies; although it is likely that a food-insecure household with a high food expenditure indicates the use of more insecurity coping strategies.

Consumptive measures of household food security measure the quality and quantity of food. The two consumptive measures used in this study are the Food Consumption Score (FCS) and Household Dietary Diversity Score (HDDS). Higher consumptive scores indicate positive signs for household food security [52].

Experiential measures of food insecurity indicate the frequency and intensity of hunger coping behaviors in a household. The three experiential measures used in this study are the Reduced Coping Strategy Index (rCSI) [53], the Household Food Insecurity and Access Scale (HFIAS) [54], and the Household Hunger Scale (HHS)

[55]. Higher experiential scores indicate negative signs for household food security.

The economic measure of household food security is the food expenditure percentage of the total household expenditures (Food_Exp). A higher food expenditure percentage may indicate negative signs for household food security. This measure is based on the classical economic theory of Bennett's Law [56] and the complementary economic theory known as Engle's Law [57]. Engle's Law posits that as household income increases, the proportion of household expenditures spent on food decreases [58]. The theory suggests that buying food accounts for a large proportion of a poor household's total expenditures. Conversely, in well-to-do households, the proportion of expenditures on food decreases as income increases. This is because food has an upward bound for its cost, while other expenditures can grow to take up larger proportions of a household income (i.e., real estate or luxury goods) [57].

Bennett's law is used as the economic indicator because it allows for the estimation of food expenditures, as in Engle's Law, while also providing insights into dietary quality. The theory states that as income increases the proportion of the household diet made up of staple food items, also known as "starchy staples", decreases [56]. The theory suggests that poor households can only afford inexpensive food items. Once income rises, a household can afford to purchase more diverse, and therefore more nutritious, food items [57]. In other words, as the household's total percentage of expenditures on food decreases, the dietary diversity of the household increases. This may seem counter intuitive. If a household that is spending less (proportionally) of their household budget on food, that household's diversity increases. However, it is important to recognize that this value is a proportional value of total expenditures, which means that, in absolute terms, a household that spends more on food has greater dietary diversity. It is the overall proportion of the food expenditures that is the key distinction and relies on the assumption that, with regard to discretionary and mandatory expenditures, every household must always include spending on food to sustain itself. It is only when their total income increases that they can increase spending in other areas that are not food related. This is also because expenditures on non-food-related areas can rise rapidly with increasing income, but the amount that is spent on food is constrained by the relatively lower limit of the cost of food items.

## Results

### Respondent household overview

The average household size indicated by respondents was a little over 4 people (shown in Additional file 1: Table S1), with the average number of children living in the household being 2.7. A little more than half (57.5%) of respondents were women with an average age of 46.5. 14% of respondents indicated their household currently had a migrant who left the home for work; but 65.9% of households received financial support in the form of remittances from any migrant. 37.7% of respondents had obtained an education beyond high school, 79.7% were married, and 58.6% of the households indicated they owned land. The most common primary source of income for households was government benefits/pensions (34.4%), followed by salary/wages (27.0%), and animal husbandry (20.3%).

### Household food security results

Table 2 displays descriptive statistics for each measure of food security.

The consumptive measures show good overall nutrition and diversity, with some disparities. HDDS indicates consumed food groups and nutritional sufficiency [59]. HDDS results show household diets in Alay have elevated fat, oil, and sugar content. 72.69% of diets are found to be Vitamin A deficient, as measured by the calculated percent of households that regularly consume Vitamin-A rich fruits and vegetables [60]. A mean HDDS of 7.7 indicates there is substantial household dietary diversity. There is a large HDDS gap between the highest and lowest income quartile of respondents (7.556 compared to 8.313); indicating a socioeconomic disparity. FCS shows diets consist of cereals, white roots and tubers, spices, vegetables, fruit, meat, dairy, eggs, oils, and sweets. There are dietary deficiencies in three types of foods: fish, legumes, and dark leafy greens. Elevated consumption of oily and sugary foods is displayed by 1003 households (over 81%). Most households' diets are within FCS acceptable thresholds ($\geq 35$), indicating they meet their basic nutritional requirements. However, 3.4% of households fall short of an acceptable score ($< 35$), indicating an acute lack of nutritious foods.

Experiential measures likewise show resiliency in food security. Less than 20% of households employ drastic coping strategies, as evidenced in a rCSI mean of 7.72. HHS is low for 99.08% of households and moderate for the remaining 0.92%, indicating most households are not acutely food insecure. Evidence for less food insecurity is found in a low HIFAS value of 0.91%. The most common HIFAS food insecurity coping strategy is

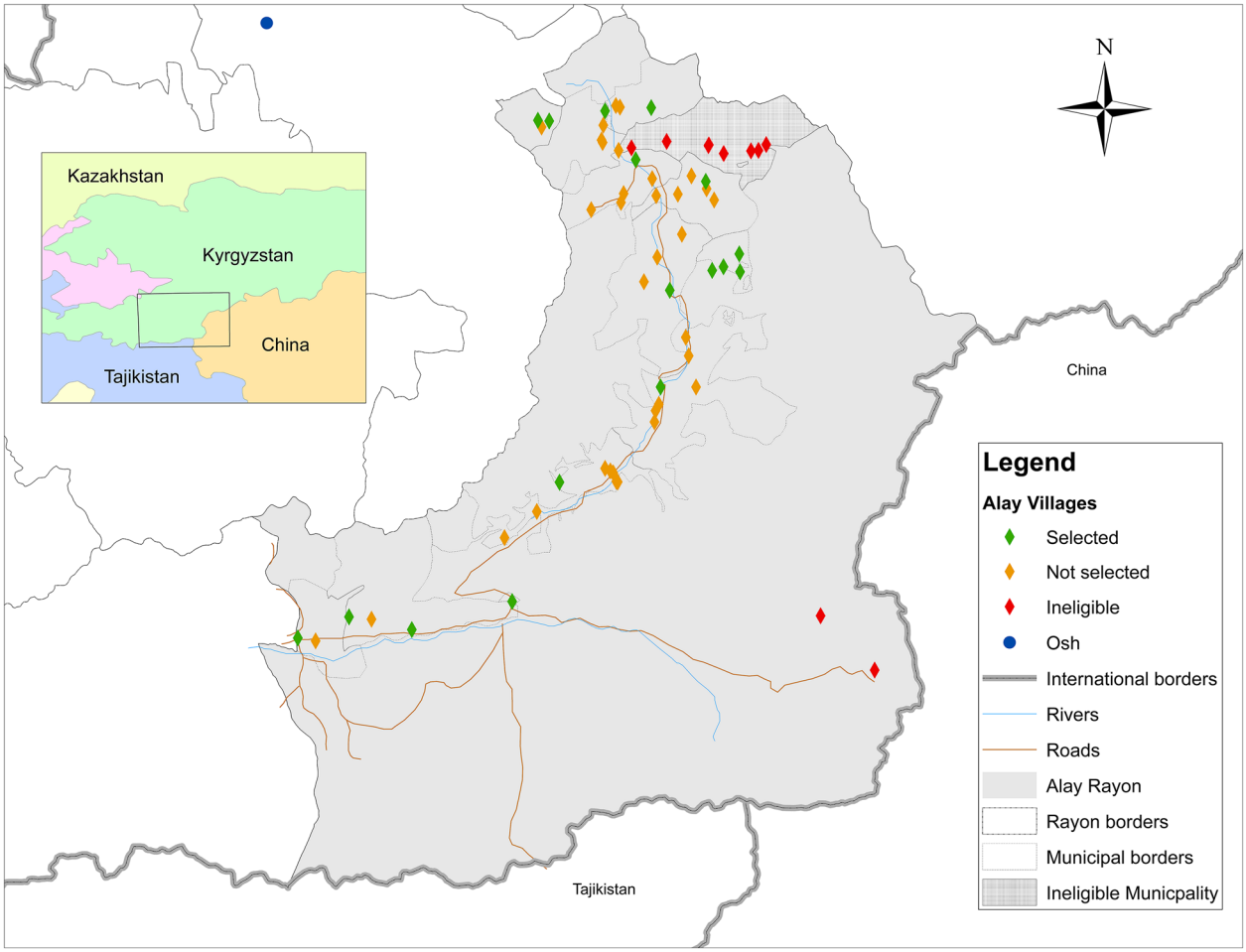


**Fig. 1** Map of study area. Total villages $n=60$, selected $n=17$, not selected $n=34$, ineligible $n=9$

economic strain, followed by consuming less preferred foods.

Economic measures support Bennett's law in the Kyrgyz context. Most households (98.38%) purchase the majority of the food they consume. The prominence of purchasing foods highlights the challenge of producing food at high elevations and the rapidly evolving Kyrgyz food system [14].[1] Frequent market interaction cements the necessity of an economic measure within the study. Over a quarter (25.96%) of total household expenditures were spent on food. Previous research found 55.6% of Alay household budgets were spent on food purchases and other household staples, compared to the national mean of 46% [48, 50]. The lower percentage is likely caused by seasonal differences in data collection. Percent of food expenditures is negatively associated and statistically significant (Table 3) with household dietary diversity (FCS and HDDS).

### Multidimensional measures

Analysis of the Spearman's rho correlations between measures yields evidence supporting the conclusion that all measures of food security are not mathematically related to one another in a uniform manner (Table 3). However, evidence does support the classification of measures into typologies.

FCS and HDDS display a strong, significant, and direct relationship with one another (0.39). This empirically supports the theoretical and conceptual link between FCS and HDDS as consumptive measure of food security. rCSI and HFIAS also display a strong and statistically significant relationship with each other (0.53). This empirically supports the conceptual link between them

[1] The role of agriculture in the national economy is slowly decreasing as the importance of the livestock sector increases. Rapid increases in consumer prices and fluctuations in purchasing power have taken place. Government direct market interventions have focused on improving national food security status. Improvements have been made in national infrastructure for transportation, food storage, agricultural extension services, and enhancing the food safety system [14].

**Table 2** Household food security descriptive measures

| Type | Measure | | Statistic |
|---|---|---|---|
| Consumptive | HDDS | 7.70 (3.04) | *1234* {7.71–8.22} |
| Consumptive | FCS | 76.63 (17.17) | *1234* {75.08–78.17} |
| Experiential | HFIAS | 0.91 (1.38) | *1234* {0.79–1.03} |
| Experiential | rCSI | 7.72 (9.91) | *1234* {6.99–8.47} |
| Experiential | HHS | 0.05 (0.28) | *1234* {0.02–0.07} |
| Economic | Food_Exp | 25.96 (0.26) | *1124* {24.51–27.41} |

Cell values display means. Standard deviations displayed in parentheses. Number of observations displayed in *italics*. 95% confidence interval displayed in brackets

as experiential measures of food insecurity. The strong relationships within typologies is a favorable indicator for the study's internal validity.

The experiential (rCSI and HFIAS) and consumptive measures (HDDS and FCS) are found to be directly related to one another. This is perplexing because, as the hypothesis suggested, measures within a typology would be directly related while measure of different types would be indirectly related. Paradoxically, higher advantageous consumption measures indicate higher disadvantageous experiential measures, and vice versa. This makes it difficult to identify predictive variables of household food security across all measures. An examination of *why* this relationship exists requires further multivariate analysis.

### Descriptive statistics

To examine the advantageous and disadvantageous household food security factors, the study includes a number of control variables (Additional file 1: Table S2). Among them is if a household recently experienced an environmental or socioeconomic shock, such as high food prices, severe weather, natural disasters. Many households responded that they had, highlighting the volatility of local economies and the natural conditions (Additional file 1: Table S1). The most common socioeconomic shocks are high food prices (33.47%), health problems (26.09%), and high fuel prices (11.59%). The most common agricultural shocks are poor weather for agriculture (53.62%), natural disasters (26.17%), and problems with irrigation (15.85%). The most common natural disasters experienced include severe weather conditions (66.86%), drought (22.20%), and landslides/flooding (20.34%).

Access to a market and household elevation are used for geographic variables. Socioeconomic indicators are included with income because of the area's traditional agrarian livelihoods and the vibrant Kyrgyz informal economy [61]. Land tenure, an index of household asset ownership, and a locally adapted Women's Empowerment in Agriculture Index (WEAI) [62] are incorporated in the survey. The locally adapted WEAI (seen in Additional file 1: Table S3) measures a number of domains of empowerment (control over production, access and ownership of resources, control over income, leadership opportunities, and time allocation) and ranged from 0–1 with 1 being the most empowered [62, 63]. Men were shown to have a higher WEAI value compared to women (shown in Additional file 1: Table S4), indicating a potential gender inequity in economic and social empowerment.

Household characteristic variables include the gender and age of the survey respondent. Household size, pensions, access to credit, and the use of loan funds to purchase food are included. The government provides a pension to elderly or disabled individuals as part of a social safety net. Pensions play a key role in ensuring the well-being of many households, especially those in rural areas [64]. In addition to pensions, access to credit plays a key role in ensuring a vulnerable household's well-being and food security [65]. Access to credit is often limited within rural Kyrgyz communities and microfinance programs are often the only available option for households [65]. Although we measured household size, we did not include it in the regression analysis because there was insufficient variation in household size in our data.

In many contexts, having a household member with an illness has been found to substantially hinder food security [66]. Due to this, the study inquired about acute and chronic illnesses of household members. Quantity of remittances and the absence of a labor migrant household member (referred to as a migrant household) are included because of the significant role that migration plays in the Kyrgyz rural economy and social landscape.

### Multivariate regression

We used ordered logistic regression to model HDDS, rCSI, and HFIAS because the measures of the relative rank of food insecurity characteristics and measure qualitative traits (experiences and access to different food groups) produce ordinal variables. The orders of HDDS represent the number of specific food groups that a household has consumed [60]. The orders of rCSI represent increasing adjustments that households make in response to food insecurity. The orders of HFIAS represent increasing household behaviors that reflect insufficient food quantity and quality; and the associated anxiety and consequences of insecurity. We used multiple linear regression to model FCS and household food expenditure percentage. Linear regression was used for analysis of these two ratio indicators due to their values ranging on a clear scale of 0 to a maximum (1 for food expenditure and 112 for FCS); with corresponding values that have an intrinsic order to interpret higher values as greater than lower values on

**Table 3** Spearman's rho correlation matrix among food security measures

| | HDDS | FCS | HFIAS | rCSI | HHS | Food_Exp |
|---|---|---|---|---|---|---|
| HDDS | 1 | 0.39* | 0.33* | 0.33* | −0.01 | −0.09* |
| FCS | – | 1 | 0.43* | 0.25* | −0.03 | −0.29* |
| HFIAS | – | – | 1 | 0.53* | 0.10* | −0.29* |
| rCSI | – | – | – | 1 | 0.14* | −0.05 |
| HHS | – | – | – | – | 1 | −0.02 |
| Food_Exp | – | – | – | – | – | 1 |

* Correlations significant at the $p < 0.01$ level

an equidistant scale. HHS is excluded from regression analysis due to insufficient variation in the dataset. Selection of regression models was made drawing from theory, the selected indicator measurement guides, and a review of similar published studies that model the indicator. The results are shown in Table 4.

We found four significant dichotomous variables across all models: economic shocks, agricultural shocks, environmental shocks, and the use of loan funds to purchase food. Apart from gender, within each measurement typology, all variables are consistent in the direction of their relationship to food security. This empirical evidence supports the three typologies of measurement in the study. A household with an ill member correlates with an increase in experiential food insecurity statistically significantly (rCSI 3.003 and HFIAS 0.453). Although not statistically significant, all other measures support the finding that having an ill household member relates to a decrease in food consumption and an increase in food expenditure percentages.

Evidence is mixed across all models regarding the effect of gender on food security. The statistically significant variable with the greatest coefficient in reducing the proportion of household budget spent on food and increasing FCS is the WEAI scale. This relationship suggests that if a respondent has more agricultural and socioeconomic efficacy, their household will be able to earn more money or produce more food for consumption.

In all models, although not all statistically significant, households with more assets display an increase in food security. An increase in asset ownership is significantly correlated with an increase in FCS (2.514) and a decrease in rCSI (−1.048) and food expenditure proportion (−0.022). This is a valuable finding, as other socioeconomic variables, such as income and land ownership, do not form a coherent narrative across all food security indicators. Landed households, income, and the asset ownership index are socioeconomic variables that contribute to decreasing experiential indicators of food insecurity. Remittances, however, do not show a clear or statistically significant relationship to food security.

An increase in household size significantly correlates with an increase in experiential food insecurity and food expenditure percentage, as well as with an increase in consumptive food security. Joining household size as an enigmatic variable, an increase in household elevation correlates with an increase in all household food security measures. A potential explanation is the severity of the conditions at high elevation leads to a threshold of poverty that makes life impossible in the most environmentally harsh places.

Households receiving a pension had improved consumption; however, they also reported worsened experiential insecurity and food expenditure percentages. Like pensions, a household that uses loan funds to purchase food is found to have improved consumption, yet worsened experiential food insecurity. Unlike pensions, all the measures are statistically significant and households that spent loan funds on food correlate with a decrease in food expenditure percentages. This trend, and its robust statistical significance, also extends to household shocks. A household that experiences a recent shock has improved consumptive food security and decreased food expenditure percentages. Paradoxically, households that have suffered a recent shock display worsened experiential insecurity, demonstrated by their increased use of food insecurity coping strategies.

## Discussion

The consumptive measures of food security indicate that most households are successful in meeting their basic food needs during the summer. However, many household diets are deficient in fruits and vegetables and high in oils, fats, and sugars. These deficiencies may lead to elevated rates of chronic diseases like hypertension and diabetes that are difficult to manage in high-elevation rural communities and when many are practicing agropastoral livelihood strategies. Diets are also found to be deficient in legumes, fish, and dark leafy greens, indicating a shortfall in folic acid, omega-3 fatty acids, and non-fatty protein. These deficiencies, combined with limited access to healthcare, can result in increased rates of birth defects, such as cleft lip and anemia [9], all threats

**Table 4** Regression models for food security measures

| | HDDS | FCS | HFIAS | rCSI | Food_Exp |
|---|---|---|---|---|---|
| Statistical test | Ordered logit regression | Multiple regression | Ordered logit regression | Ordered logit regression | Multiple regression |
| Constant | | 59.858*** (3.967) | | | 0.596*** (0.054) |
| Econ shock | 0.810*** (0.125) | 8.215*** (1.079) | 1.965*** (0.187) | 2.238*** (0.583) | −0.079*** (0.015) |
| Ag shock | 0.331** (0.137) | 2.840* (1.198) | 0.785*** (0.184) | 1.753** (0.648) | −0.056** (0.016) |
| Env shock | 1.323*** (0.155) | 4.003** (1.348) | 2.382*** (0.389) | 3.699*** (0.729) | −0.039* (0.019) |
| MigHH | 0.051 (0.201) | 0.289 (1.688) | 0.241 (0.217) | 1.858* (0.912) | −0.025 (0.023) |
| Remittance ($10^{-4}$)^ | −0.030 (0.024) | −0.121 (0.179) | −0.009 (0.023) | −0.132 (0.097) | −0.0002 (0.002) |
| Market | 0.002* (0.001) | 0.010 (0.008) | 0.0002 (0.001) | 0.018*** (0.004) | −0.0002 (0.0001) |
| Altitude | 0.0005*** (0.0001) | 0.002** (0.001) | −0.0002 (0.0001) | −0.001* (−0.0005) | −0.00002 (0.00001) |
| WEAI | 0.384 (0.377) | 9.808** (3.369) | 0.965 (0.542) | 1.467 (1.821) | −0.195*** (0.046) |
| Landed | −0.305* (0.125) | −1.098 (1.120) | −0.476** (0.169) | −2.823*** (0.606) | −0.017 (0.015) |
| Income ($10^{-6}$)^ | 0.754* (0.310) | 1.71 (2.88) | −5.73*** (1.13) | −4.05** (1.56) | 0.118** (0.038) |
| zAssets | 0.110 (0.063) | 2.514*** (0.555) | −0.058 (0.088) | −1.048** (0.300) | −0.022** (0.008) |
| HHsize | 0.213*** (0.030) | 0.331 (0.258) | 0.152*** (0.037) | 1.223*** (0.140) | 0.010** (0.003) |
| Gender (female) | 0.679 (0.116) | −2.031* (1.027) | −0.137 (0.151) | −0.337 (0.555) | −0.036 (0.014) |
| Pension | 0.706*** (0.164) | 0.766 (1.470) | 0.266 (0.219) | 1.358 (0.795) | 0.108*** (0.020) |
| Hh_age | −0.014** (0.005) | −0.024 (0.041) | −0.008 (0.006) | −0.055 (0.022) | −0.002** (0.001) |
| Food loan | 0.497** (0.189) | 9.189*** (1.657) | 1.456*** (0.219) | 5.828*** (0.896) | −0.071** (0.022) |
| Illness | −0.084 (0.118) | −1.472 (1.044) | 0.453** (0.156) | 3.003*** (0.565) | 0.007 (0.014) |
| $R^2$ | 0.071 | 0.187 | 0.228 | 0.279 | 0.202 |
| *N* | 1080 | 1080 | 1080 | 1080 | 1034 |

Cell values display coefficients. Standard errors shown in parentheses. ^Values presented as base $10^{-x}$ number. *$p < 0.05$; **$p < 0.01$; ***$p < 0.001$

that are difficult to manage in these relatively isolated agropastoral communities.

One-fifth of households are found to employ more intensive food insecurity coping strategies during the summer (rCSI of 7.72). In response to food insecurity, households primarily experience financial strain and rely less on coping strategies that reduce consumption. These coping strategies are largely successful in alleviating immediate food insecurity, meaning there was little acute food insecurity in Alay during the summer of 2017. However, it is important to note that respondents indicated these practices are less successful during winter months. These seasonal differences highlight the seasonal variability that is inherent to the diets of people practicing agropastoral livelihood strategies. There is also evidence to suggest that the local food environment is impacted by the predominance of agropastoral livelihoods in the community. This suggests that seasonal variability in food security status is simply prevalent in agropastoral communities.

This study finds empirical evidence to support theoretical food security measurement typologies. This suggests the study survey possesses a high level of internal validity within measured typologies. The unique economic indicator is likely the result of a distinct informal economy with a cash undercurrent that is born from traditional agropastoral livelihoods, the prevalence of remittances, and labor outmigration. Because of the complexities surrounding the rural economy and regional food system (largely due to the distinctive livelihood strategies), food security and household finances in the southern highlands cannot be simply measured by a single metric. The substantial estimated amount of household income spent on food (25%) suggests a high degree of economic vulnerability among poorer households. Household assets play a key role in determining household food security status, with regression results indicating that lower socioeconomic status households have greater difficulty achieving food security.

Multivariate analysis shows that agricultural, economic, and environmental shocks clearly influence household food security. Households that had recently experienced a shock exhibit increased experiential food insecurity. In the aftermath of a shock, distressed households use coping strategies, typically economic in nature, to meet their needs. The trend of increased experiential insecurity following a shock has recently been documented in other regions of southern Kyrgyzstan [67]. However, contradictory evidence shows that there is an increase in consumptive food security measures following a shock. Why do households

experience improved food consumption in the aftermath of a harmful shock? Perhaps the coping strategies used by households following a shock are effective in their aims. If shock responses are truly alleviating of food insecurity, then they may be the reason for improved food consumption. Perhaps community, government, or organizational aid in the aftermath of a shock is effectively improving diets via immediate assistance but not effective in aiding households to abate insecurity coping strategies. This suggests an area for potential research on the impacts of shocks on food security among households in agropastoral communities. It also demonstrates the necessity of including explicit questions regarding economic and environmental shocks that may have profound impacts on agropastoral livelihoods and, by extension, have knock-on effects with household food security throughout the community. These possible explanations, and the accompanying discussions, have implications for the role of community support, aid delivery, and the social safety net in improving food security resilience.

This importance is supported by our empirical findings that coping strategies appear to have a high level of efficacy in addressing food insecurity. Harmful shocks may be felt most by households lacking the means to deploy effective strategies. Given the importance of asset ownership to food security, perhaps shocks are experienced more profoundly in asset-owning middle-income households. Evidence suggests particular shock responses, such as taking out a loan to purchase food, are highly effective in restoring food security. The indication of successful coping strategies is encouraging for those who advocate for or provide food insecurity relief (e.g., food aid or microfinance programs) following a disastrous event. In Kyrgyzstan, the effectiveness of microfinance programs in improving living conditions have been met with mixed results [68]. Despite mixed results, microcredit and loan opportunities remain the only credit option for many rural households [65].

Geographically and socially isolated rural households in Kyrgyzstan, and other places with similar agropastoral livelihoods strategies, often have limited access to social networks that yield economic assistance during difficult times [69]. The decrease in food expenditure percentages following a shock makes sense, as expenses increase for non-food purchases (i.e., rebuilding or repairing a homestead, replacing lost livestock). Recent research in southern Kyrgyzstan demonstrated that poorer households are more likely to utilize microfinancing to purchase food than they are to pursue entrepreneurial endeavors or increase productive asset holdings [65]. The indication that food loans are more frequently taken out by poorer households supports the conclusion that access to credit is effective in improving household food consumption.

While microfinancing is found to be an effective food insecurity coping strategy following a shock, there are concerns that a household may increase its vulnerability to subsequent shocks by relying on this strategy. The obligation to pay back loans may constrain household budgets and potentially result in long-term consequences for the sake of short-term relief. This concern highlights the need for an expanded social safety net as well as effective disaster preparedness and response programs. This further emphasizes that the relationship between shocks and food security requires heightened scientific inquiry and engagement by policymakers and humanitarian aid organizations.

Our findings suggest that the government's pension program is effective in aiding consumptive food security among vulnerable households. In the absence of national social security, government pensions are the only form of formal support available to the elderly and disabled, and they are the sole source of income in many vulnerable households [70]. Unfortunately, pension amounts often fall short of fully meeting a household's basic needs [69] and pension eligibility is highly restrictive due to limited funding [71]. It is clear that pensions play a substantial role in ensuring food security and financial well-being for many households. Yet it is unclear if governmental support is sufficient for the most vulnerable households. Future research exploring the sustainable expansion and increased efficiency of such programs could yield positive results in relation to food security.

Within Alay's rural economy, the influence of labor migration and agropastoral livelihoods are impossible to ignore, as they have profound impacts on the availability of human and financial capital. When migrants send money back home in the form of remittances, the household of origin can afford to purchase more diverse and nutritious foods. Labor-intensive agropastoral practices serve as a key livelihood strategy to supplement household diets and enhance food security resiliency [70]. Often the person possessing the most human capital in a household is the individual who migrates [18]. In times of food scarcity and/or during periods of intense agropastoral activities (like hay harvesting) the migrant household member cannot be relied on for labor. Conversely, households with available labor can employ coping strategies to improve their food production via agropastoral practices [70]. Households without a migrant do not have the same financial means to purchase food compared to households that receive remittances. This phenomenon has been observed in a number of other contexts and documents the process in

which labor migration can perpetuate a cycle of poverty and agricultural decline [72].

## Conclusion

Comprehensive measurements of household food security can enhance understanding of its causes and lead to better policies and development initiatives. This is especially important in contexts where food security measurement is difficult, like in places with agropastoral livelihoods or places with social and economic isolation. An improvement in household food security can lead to decreased infant and child mortality rates [73], improved educational outcomes [74], improved women's empowerment [75], increased household asset holdings [76], and other positive outcomes. In Kyrgyzstan, given the prominence of rural poverty, these improvements will yield immediate and long-term benefits, especially among women of childbearing ages and children.

Our analysis of 1234 household surveys reveals that households are largely successful in preventing acute food insecurity. However, there are indications that many vulnerable households still suffer from chronic food insecurity. Access to credit, asset ownership, and resilience to shocks emerge as prominent determinants for household food security. These findings are consistent with previous research on credit and assets reducing food insecurity during difficulty times [43]. Our findings are also consistent with previous scholarship focusing on vulnerable households in rural southern Kyrgyzstan that found that much of the microfinance funds among the rural poor are often spent on food purchases [65].

Previous research on food security in agropastoral communities, identified five key themes: (1) the importance of seasonality; (2) livelihood diversification and market access; (3) relationships with livestock holdings and land tenure; (4) gender dynamics; and (5) locally tailored solutions. Our study confirms the importance of these themes. The primary takeaways can be summarized in the following ways:

- The interpretation of the results should be put in the context of variation of social, economic, and environmental variation over different seasons in an agropastoral community. It is also recommended that for a more complete picture of food security in given agropastoral community, measurement at multiple time points throughout the season or year is highly advantageous.
- Consumptive measures of food security are valuable and important for the measurement of household food security but, due to the nature of agropastoral livelihoods involving transhumance practices of movement, a longer recall period will more comprehensively encapsulate the food environment of the household. This posits that the 24-h recall period found in the HDDS is less ideal when compared with the 7 days recall period of the FCS. Given that the evidence of this analysis suggests that they are closely correlated, the theoretical relevance of the longer recall period should improve the validity of consumptive household food security measurement in agropastoral communities.
- Agropastoral communities have a special relationship to their surrounding environment, distinct aspects of social interdependence, and diversified livelihood strategies. Therefore, questions should be asked about the impacts of shocks, gender relations, economic empowerment, and household social dynamics to better understand what measures of household food security mean in different communities.
- Finally, this study demonstrates the importance of measuring household food security through the use of multiple indicators. By using consumptive, experiential, and economic measures, we have captured a more comprehensive understanding of the state of household food security in an agropastoral community. Due to the unique aspects of agropastoral livelihoods, including movement, agrarian practices, and informal economies, we recommend measures from multiple typologies of food security (consumptive, experiential, and economic) in the design and implementation of future research in agropastoral communities.

It is important to study agropastoral communities in rural Kyrgyzstan because the social and geographic isolation presents unique challenges for development efforts [7, 8]. Our findings have implications for other agropastoral communities as well. These communities require multifaceted measurement of household food security due to the seasonal variations and agrarian livelihood strategies that profoundly impact their food system. The economic conditions of the study are similar to other communities that experience a high degree of out-migration and demographic transition and provide an example of research with the potential to inform policies targeted at addressing local and regional food insecurity. The study finding that vulnerable households display increased rates of food insecurity highlights the continuing relevance within the study's immediate area. Further longitudinal research examining the food insecurity in places like rural Kyrgyzstan is needed to inform policies (like disaster

response practice for food aid), from a local to global scale, that impact sustainable agriculture, food systems, and, ultimately, food insecurity.

## Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s40066-024-00468-2.

**Additional file 1: Table S1.** Independent variable descriptive statistics. **Table S2.** Independent variable descriptions. **Table S3.** Locally adapted Women's Empowerment in Agriculture Index. **Table S4.** T-test difference of mean test for WEAI scale between genders.

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**Author contributions**
Conceptualization—CS, GC; methodology—CS, GC; formal analysis—CS, GC; investigation—CS, GC; resources—GC; data curation—GC, CS; writing—original drafting—CS, GC; writing—review and editing—CS, GC, LG; supervision—GC, LG; funding acquisition—GC.

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**Availability of data and materials**
The data are not publicly available because they contain information that could compromise the privacy of research participants.

## Declarations

**Ethics approval and consent to participate**
This study was determined by the Pennsylvania State University Office for Research Protections to be exempt from full Institutional Review Board (IRB) review because the research met the exempt criteria according to the policies procedures regarding human subject research (STUDY00007529). Informed consent was obtained by all study participants.

**Consent for publication**
Not applicable.

**Competing interests**
The authors declare that they have no competing interests.

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## Publisher's Note



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