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Patterns and trends in household food security in rural Mpumalanga Province, South Africa

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ABSTRACT

This study examines patterns and trends in household food security in Bushbuckridge, Mpumalanga Province, South Africa, from 2010 to 2019. We use data from a household panel nested in the Agincourt Health and Socio-Demographic Surveillance System. Findings indicate that there have been improvements in household food security in this rural setting over the last decade. By polychoric principal component analysis, an aggregate food security index was constructed and we observed a small, yet important, proportion of households (7.8%) that remained chronically food insecure. An ordered probit model was used to estimate the determinants of food security. Findings reveal that the observed differences in household food security status are as a result of differences in socioeconomic status. We therefore recommend that focus must be placed on identifying economic opportunities and empowering the chronically food insecure households if universal household food security is to be attained in rural South Africa and beyond.

KEYWORDS

Food availability; dietary diversity; food access; food security; rural households

1. Introduction

Food insecurity remains a global challenge and as such, is an important aspect of the Sustainable Development Goals (SDGs) (Allen & de Brauw, 2018). While Sub-Saharan Africa continues to lag behind most regions in terms of food security (FAO, 2014), South Africa has made remarkable progress towards in the last decade towards meeting food and nutritional security targets (FAO, 2015). In fact, at a national level, South Africa is now considered food secure (Statistics South Africa, 2019), with the capacity to either grow enough staple food or import food when the need arises and to generally meet national food and nutritional demands.

(Chakona & Shackleton, 2019). Even so, despite meeting its Millennium Development Goal targets on food security (FAO, 2015), the nation still faces the challenge of

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addressing food insecurity in rural households, an issue common with many other countries in Sub-Saharan Africa.

In rural areas of South Africa food insecurity remains a substantial challenge (De Cock et al., 2013; Kepe & Tessaro, 2014). As a result, the South African government's National Development Plan (NDP) sets an ambitious target of eliminating rural food insecurity by 2030, in accordance with United Nations' Sustainable Development Goal (SDG) 2. In line with this national objective, research on patterns and trends of household food security in South African have typically (but not exclusively) been undertaken at national level which, as a consequence, misses regional variation and local nuance (Govender et al., 2017).

The South African NDP emphasised the need for regional and local, data-driven food security strategies that can contribute to improved food security for its rural population. Yet, understanding local nuance is hampered by lack of reliable, regularly produced household food security data (Headey & Ecker, 2013). The work presented here provides a local perspective on progress in food security and discusses remaining challenges with a focus on an impoverished rural area in Mpumalanga Province of South Africa. The study also offers a unique longitudinal perspective and, therefore, adds to existing literature on food security by revealing trends over a 10-year period that encompassed shifting climate and development conditions.

2. Food security in rural South Africa

Studies that have assessed food security at sub-national scales in South Africa (De Cock et al., 2013; Nawrotzki et al., 2014; Shisana et al., 2013; Walsh & van Rooyen, 2015; Hendriks et al., 2016; Chakona & Shackleton, 2019), often do so with an emphasis on comparing urban and rural patterns and dynamics. As an example, Shisana et al. (2013) found that 32.8% of formal rural households and 32.4% of informal urban households are food insecure, compared to a far lower proportion (19%) of households in formal urban areas.

Although insightful, existing studies on food security in South Africa have important gaps. First, patterns of food insecurity vary spatially (Misselhorn & Hendriks, 2017), and in most studies, data are aggregated at the provincial level, thus losing local nuance. Hendriks et al. (2016) specifically pointed out that for the community they studied; local food security data were not at hand. Aggregated data may overestimate or underestimate a community's needs resulting in local food security interventions being off-target. Sub-national analyses are essential for understanding progress in meeting the targets of both the UN SDGs and the South Africa's NDP *in different contexts across the country*.

Second, food security is achieved, 'when all people, at all times, have physical, social and economic access to sufficient, safe, and nutritious food to meet their dietary needs and food preferences for an active and healthy life' (FAO, 2018). This definition implies a dynamic condition, that can ebb and flow in ways that support or constrain healthy daily lives. Yet most existing studies are cross-sectional, and therefore, do not allow for dynamism. For example, the fluctuating nature of rural household income tends to affect a households' access to food variably across time. Fluctuating income is shaped by household characteristics and research indeed demonstrates that food insecurity in rural South Africa varies with household structure and socioeconomic status (Masuku et al., 2017; Oduniyi & Tekana, 2020). Household socio-demographics and

livelihoods in rural South Africa are complex and varied (Hunter et al., 2014; Ragie et al., 2020), while shifting over time. Hence regular measurement offers an important perspective for tracking progress towards targets, allowing for more accurate assessments and useful contribution to knowledge on the dynamic nature of food security. Yet very few studies have traced the progress over time.

Against this background, we report on a longitudinal study on food security of a cohort of rural households in Bushbuckridge, Mpumalanga Province, South Africa between 2010 and 2019. The novelty of this study is the provision of insights on local nuances in temporal patterns and trends in household food security using several individual food security indicators (consumption patterns, dietary diversity and food sufficiency). We also aggregate from individual food security indicators into a composite indicator to aid in a more comprehensive understanding of how rural households have persisted and/or transitioned into different food security classes. Finally, we investigate the predominant socioeconomic and demographic characteristics of the different food security classes to help policy makers design programmes that address food insecurity based on the context under study.

3. Materials and methods

3.1. Study area

This study was conducted in the Agincourt Health and Socio-Demographic Surveillance System (HDSS) site located in the Bushbuckridge Local Municipality, Ehlanzeni District, Mpumalanga Province, South Africa. Our study site is typical of rural former Apartheid Bantustan ('homeland') rural areas across South Africa, characterised by poverty, high human densities, and high levels of unemployment, and which lag behind in terms of development and availability of services (Hunter et al., 2014).

3.2. Data

This research uses panel data from the Sustainability in Communal Socio-Ecological Systems (SUCSES) study focused on selected households from a subset of 12 villages nested within the Agincourt HDSS. The aim of the SUCSES study is to understand the dynamic interactions between people, their livelihoods, and the natural environment in rural communities, with particular emphasis on the consequences of these interactions on household food security. A detailed questionnaire was used to collect data on household food security metrics between April and June, annually from 2010 to 2014, and again in 2019. At baseline, SUCSES included 587 households representing a random sample of 8% of households in the study villages. Attrition has resulted in an uneven panel of 3260 observations reflecting between 587 and 505 households each year.

3.3. Preparation of variables

The Household Meal Consumption Frequency Score (HMFS) quantifies the number of meals consumed by a household in a typical day. In this study, the HMFSa represents a 24-hour quantitative recall of household consumption of breakfast, lunch and dinner,

resulting in a frequency score of 0–3. The HMFSb is a recall of consumption of snacks between main meals, with a score of 0–4.

The Household Dietary Diversity Score (HDDS) is a quantitative measure of 13 food groups consumed by household members. The recommended 12 food groups, proposed by the FAO, World Health Organisation (WHO), and the Food and Nutrition Technical Assistance (FANTA), were used in calculating the HDDS, with maize added as a 13th food group because it is the staple starch and we did not want to mask the consumption of other cereals. The 13 food groups were as follows: maize and maize products, other cereals, roots and tubers, vitamin A rich fruit, other fruit, vitamin A vegetable, other vegetables, meat-poultry and fish, eggs, legumes-nuts and seeds, dairy products, oil/fats, and sugars. The HDDS represents a 24-hour recall of household consumption of any food that belonged to the groups listed above. The scores are summed to create the HDDS variable with a range of 0–13.

We adopted one question from the eight food insecurity experience scale (FIES) questions to measure experience of food shortage at household level at the scale of a year. We denoted this modified Experience of Food Shortage Score in the last 12 months as EFSS. The household respondents were asked if over the last 12 months the household had experienced any shortage of food with a dichotomous measure (1 = yes; 0 = no). The Household Food Insecurity Access Scale (HFIAS) is a measure of household food access over a specified period of time; the last 30 days in this case. The HFIAS 9-item questionnaire for measuring experience-based food insecurity (Coates et al., 2007) was adapted to the local context of our study using three questions. The three specific questions were as follows: (i) whether the household had encountered hunger due to lack of food or money to buy food, (ii) whether any household member went to bed hungry and (iii) and whether any household member went a whole day without eating anything because there was not enough food. A scoring procedure was used and the frequency was assigned a quantitative measure with 0 for non-occurrence, 1 for 1–2 times (rarely), 2 for 3–10 (sometimes) and 3 for more than 10 times (often). Since we used 3 questions, a total score of 9 indicates the highest level of food insecurity. We denoted this adapted measure HFIASa.

Another indicator of food insecurity is the Coping Strategy Index (Maxwell et al., 2008). The Coping Strategy Index (CSI) captures the food access and food vulnerability component of food security. In this study, the CSI consisted of four questions on coping strategies that captured if in the last 7 days a household had (i) reduced the size of servings of food, (ii) had compromised the quality of food eaten due to shortage of food, (iii) reduced the number of meals eaten per day due to shortage and (iv) if they had asked neighbours, friends and relatives for food. The four questions were a dichotomous measure (1 = yes; 0 = no). The CSI scores ranged from 0 to 4 with higher numbers reflecting the use of more strategies (less food secure).

3.4. Overall assessment of household food security

In our case, assessment of overall food security was done through a Principal Component Analysis (PCA) to realise an unbiased weighting procedure of the six indicator variables together (namely HMFSa, HMFSb, HDDS, EFSS, HFIASa and CSI). The six indicators mentioned above were rescaled such that a score of 1 represented the maximum possible

of food security for each metric while a score of 0 represented the highest level of household food insecurity. A polychoric PCA was carried out on the six indicator variables, and the PCA results were used to construct a composite measure which we denoted the 'household food security index' (HFSI). The composite household food security index was calculated as given by equations 1 and 2 below:

$$PF_{jk} = \sum_{l} a_k^l (X_j^l) \tag{1}$$

where PF_{jk} : kth principal factor for jth household; a_k^l : factor loading of kth factor for lth indicator; X_j^l indicators of jth households.

$$HFSI_j = \sum_{k} V_k (PF_{jk}) \tag{2}$$

where: composite score of $HFSI_j$ for jth household; V_k: variance accounted by kth principal factor.

The range of possible HFSI scores was rescaled such that 0 represents the least food secure household and 1 represents the most food secure household. The HFSI was then divided into four objective and equal levels of relative food security such that scores of between 0–0.25 were level 1, 0.26–0.5 were level 2, 0.51–0.75 were level 3 and 0.76–1.0 were level 4. Level 4 households were regarded highly food secure while level 1 household 1 were regarded highly food insecure. This approach to categorisation, using bins of equal size, allows for relative understanding of food security across the sample. Such an approach has been used in other developing countries and was based on earlier studies by Rammohan & Pritchard (2014), Sam et al. (2019) and Sam et al. (2021). Table 1 summarises the food security metrics used in this study, the score ranges and the level of food security status implied by the indicator scores.

3.5. Persistence and transitions between food security classes

Using the four food security levels derived from the HFSI scores, 16 trajectories for persistence and transitions were possible between the four food security levels. The persistence and transition probabilities between levels from year 2010 to 2014, 2014–19 and from 2010 to 2019 were quantified as the proportion of households per pairwise comparison of level in the start and end year. For the purpose of tracking over the entire period, only households with complete data for the tracking period were considered. A total of 518 households were successfully tracked between 2010 and14, 480 households were

Table 1. Food security measure and food security classification.

Metric	Acronym	Score range	Highest food security score	Lowest food security score
Household meal frequency score (main)	HMFSa	0–3	3	0
Household meal frequency score (snack)	HMFSb	0–4	4	0
Household dietary diversity score	HDDS	0–13	13	0
Experience of food shortage	EFSS	0–1	0	
Adapted Household Food Insecurity scale	HFIASa	0–9	0	9
Coping Strategy Index	CSI	0–4	0	4
Household food security index	HFSI	0–1	1	0

successfully tracked between 2014 and19 and 503 households were successfully tracked between 2010 and 2019.

3.6. Determinants of food security

The final part of analysis involved identifying factors affecting the households' levels of food security. We wanted to determine how household socio-economic factors affect household levels of food security. In our case, our dependent variable was categorical with more than two categories. Each category value had clear sequential order where each category value was greater than the preceding one. Hence an ordered probit model was the most appropriate. We used an approach similar to the one used by Rammohan & Pritchard (2014) to assume that the ordered categories of food security are expressed by an ordered variable V that assumes the discrete ordered values of 1, 2, 3 and 4. The ordered probit model for V (conditional on explanatory variables x) can be attained from a latent variable model. It is assumed that this latent variable F* can be obtained from $F^* = x'\beta+\varepsilon$, where x is a vector of socio-economic and demographic characteristics of households being entered into the equation and ε refers to the error term, which is assumed to be normally distributed across household observations. The latent variable, F* can be presented as:

$$F = \begin{cases} 1 \textit{ if level } 1 \textit{ of food security} \\ 2 \textit{ if level } 2 \textit{ of food security} \\ 3 \textit{ if level } 3 \textit{ of food security} \\ 4 \textit{ if level } 4 \textit{ of food security} \end{cases}$$

Each of the categories of the dependent variable, which can be explained by the same set of explanatory variables that include demographic and socioeconomic characteristics known to affect household food security. The following 11 demographic and socioeconomic measures were calculated yearly for each household during the study period and are described in detail below.

1) Household size – total number of household members including temporary migrants;
2) Gender ratio – proportion male to female members;
3) Dependency ratio – proportion of household non-working population (<15 and ≥65 years) to household working population (>15 < 65 years);
4) Temporary migrants' ratio – number of adult temporary migrants as a proportion of total household working age population;
5) Employment ratio – number of self-employed and employed household members as a proportion of total household working age population;
6) High value assets – total number of assets owned from the specified four (car, motorbike, tractor and cart);
7) Domestic assets – total number of assets owned from the specified eleven (stove, fridge, TV, video/DVD player, satellite dish, radio, fixed line phone, cellphone, sewing machine, plough and bicycle);
8) Grants total – total social grant payments received monthly including child support, foster care, disability and pension;

9) External fields – total number of fields cultivated outside the homestead;
10) Age of the household head;
11) Gender of the household head – expressed as 0 = female and 1 = male

3.7. Data analysis

Statistical test and analyses were undertaken in R (version 4.0.3) and SPSS (version 27). Household food security indicators were first examined using descriptive statistics, followed by analysis of variance (ANOVA) to compare mean values between years. The Tukey *post-hoc* test at $\alpha = 0.05$ was used to determine the significant differences between years. A correlation analysis of the standardised food security metrics was done to reveal the relationships between the six food security indicators. We used an ordered probit regression model to identify factors that influence food security status.

4. Results

4.1. Household main meal and snack meal frequency

The Household Meal Frequency Score (HMFS) is the proxy we use to show food availability in a household. We examined the frequency of main meals eaten by a household using an indicator we denoted HMFSa. Most households (between 81–92%) had consumed three meals the previous day across the six study rounds (Figure 1). Few households (between 0–0.4%) had not consumed any meals the previous day. The lowest proportion of households with three meals occurred in 2010 and 2019 with 81.6% and 81.4% respectively and the mean number of main meals in 2010 and 2019 was significantly lower than in the years between 2011 and 2014. The yearly mean for household

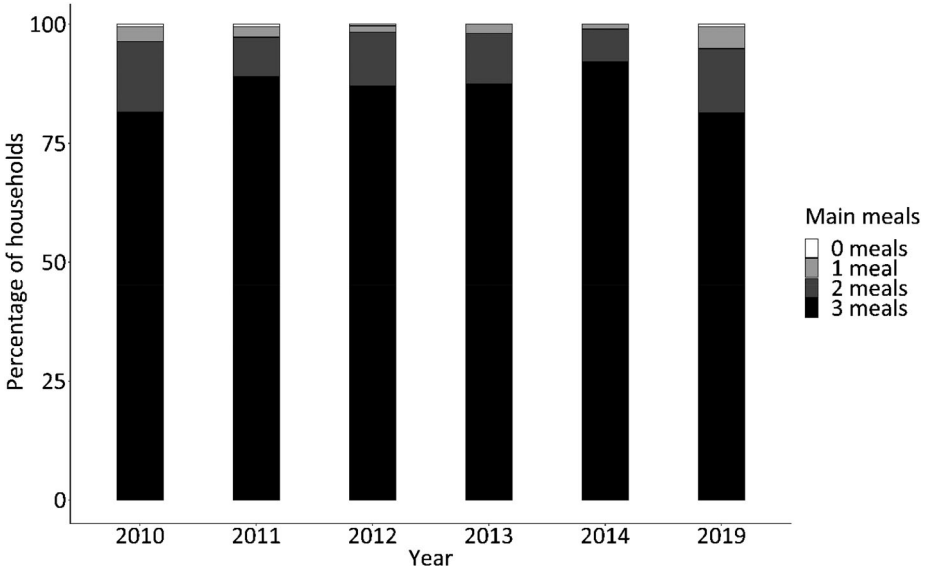

Figure 1. Household main meal frequencies.

main meal frequency score over the whole period was 2.83 ± 0.45 SD and was significantly different across years ($p < 0.05$) (Table 2). We also examined the frequency of snack meals with the indicator denoted HMFSb. Few households (between 1.4–4.3%) had consumed four snack meals the previous day across the six study rounds (Figure 2). About 50% of the households did not consume any snack meals and the yearly mean for snack frequency score was 0.82 ± 1.05 SD for the six study rounds and differed significantly in some years ($p < 0.05$) (Table 2).

4.2. Dietary diversity

Using the diversity lens, the most commonly eaten foods were maize, sugars, other cereals and oil and fats. The minimally consumed food groups were vitamin A fruits, eggs and root tubers (Table 3). Our results show a decline in the percentage of households that consumed other cereals, other fruits, vitamin-A-fruits and vitamin-A-vegetable in 2019. The overall household dietary diversity score (HDDS) had a mean value 7.11 ± 2.12 SD (Table 3) although it varied substantially across the study period. The 2019 yearly mean HDDS varied significantly ($p < 0.05$) from the other years. The yearly mean HDDS for the year 2014 was the highest (7.68) followed by 2011 (7.45) while 2019 had the lowest score of 6.19 (Table 2).

4.3. Assessment of households' experience and severity of food insecurity

Scores of experience of food shortage (EFSS) in the previous 12 months showed an increase in the proportion of households that were generally food secure (Figure 3). Of the six study rounds, 2019 had the highest percentage (80.7%) of households with EFS scores of 0 indicating no food shortage in the past year. This represented substantial improvement from 2010 when only 56.4% of households reported no food shortage in the past year (Figure 3). The highest EFS scores were observed in 2010 (0.44) and in 2011 (0.33), suggesting relatively high levels of food insecurity during these (Table 4).

As compared to the recall over a one-year period, household food shortage in the last 30 days revealed less food insecurity, a logical finding given the shorter time frame (Table 4). The proportion of households that experienced hunger in the past 30 days ranged from 8.8 to 31.1% with HFIASa scores of 1 up to 9 while the proportion of food secure households with HFIASa scores of 0 ranged from 68.7 to 91.2% over the study period (Figure 4). The mean HFIASa score in the last 30 days preceding the survey was 0.45 ± 2.11 SD and the yearly mean scores varied and were significantly different

Table 2. Yearly mean household scores for main meals, snack meals and dietary diversity.

Year	Main meal (HMFSa) Mean (SD)	Snack meals(HMFSb) Mean (SD)	Dietary diversity (HDDS) Mean (SD)
2010	2.78^{b} (0.51)	0.81^{ab} (0.99)	7.23^{b} (2.16)
2011	2.86^{a} (0.44)	0.90^{a} (1.13)	7.45^{ab} (2.04)
2012	2.85^{a} (0.42)	0.96^{a} (1.13)	7.42^{ab} (1.92)
2013	2.85^{a} (2.08)	0.81^{ab} (1.92)	6.66^{c} (2.08)
2014	2.91^{a} (0.31)	0.81^{ab} (1.05)	7.68^{a} (1.92)
2019	2.76^{b} (0.56)	0.69^{b} (0.88)	6.19^{d} (2.20)
Average	2.83 (0.45)	0.83 (1.05)	7.11 (2.12)

Years not sharing the same letter are not significantly different ($p < 0.05$).

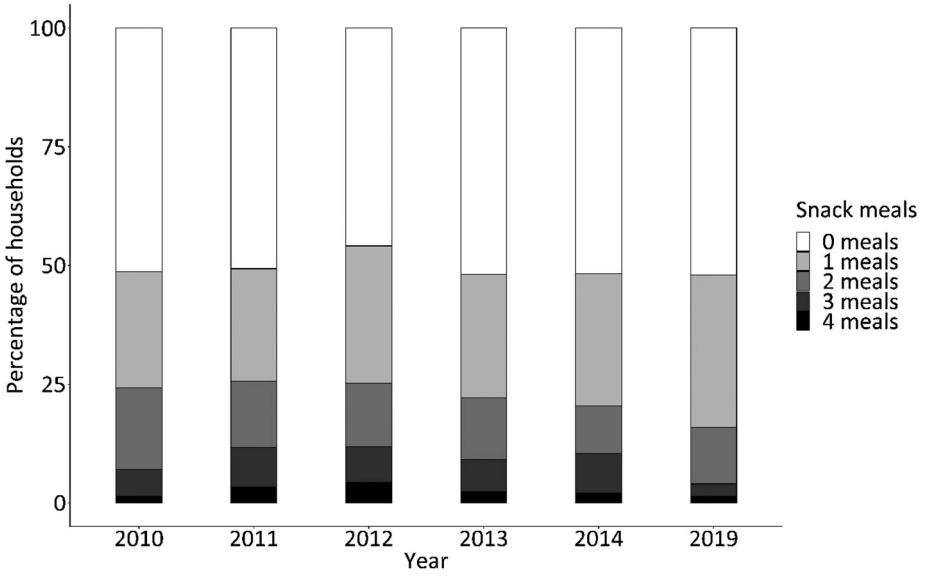

Figure 2. Household snack meal frequencies.

($p < 0.05$) across study years. The yearly mean HFIASa for the year 2010 was the highest (0.77) followed by 2012 (0.65) (Table 4), suggesting these were the years when more hunger was experienced. The lowest mean scores were observed in 2014 (0.19) and in 2013 (0.29) (Table 4), indicating lower levels of food insecurity during these times.

Based on the mean yearly coping strategy index (CSI) scores, a significant decline in food insecurity was observed over the study period as indicated by lower numbers of coping strategies. Households, which did not engage in any coping strategy (CSI scores of 0) ranged from 66.3% to 85.9% (Figure 5). The mean CSI score was 0.48 ± 1.02 SD. The yearly mean scores progressively improved and differed significantly ($p < 0.05$) over the study years with 2010 and 2011 having the highest scores of 0.76 and 0.59, respectively (Table 4). The lowest mean CSI scores were observed in 2019 (0.22) and in 2014 (0.32), indicating fewer coping strategies implemented in these years.

Table 3. Dietary diversity trends for rural households.

	% of households						
Food group	2010	2011	2012	2013	2014	2019	Average
Maize	98.5	98.2	99.1	97.0	98.7	96.4	98.0
Cereals	81.1	83.1	84.1	84.7	86.8	67.3	81.3
Root tubers	25.4	30.2	22.2	30.2	31.4	18.2	26.3
Vitamin A fruit	5.6	3.6	4.7	14.2	3.8	7.1	6.4
Other fruit	51.1	51.4	56.7	51.2	60.2	28.7	50.1
Vitamin A vegetables	44.0	47.3	41.0	45.3	41.6	34.3	42.4
Other vegetables	44.0	47.3	41.0	45.3	41.6	34.3	42.4
Meat, poultry fish	67.8	68.7	73.9	73.2	74.9	63.8	70.4
Eggs	20.4	18.9	23.1	24.7	20.9	31.9	23.2
Legume-nuts-seeds	42.6	45.4	26.8	29.8	42.2	25.3	35.6
Dairy	42.4	45.9	50.8	49.1	49.1	42.0	46.5
Oil/fats	77.0	79.5	82.5	83.9	82.8	80.2	80.9
Sugars	92.7	92.1	92.5	93.0	95.0	92.9	93.0

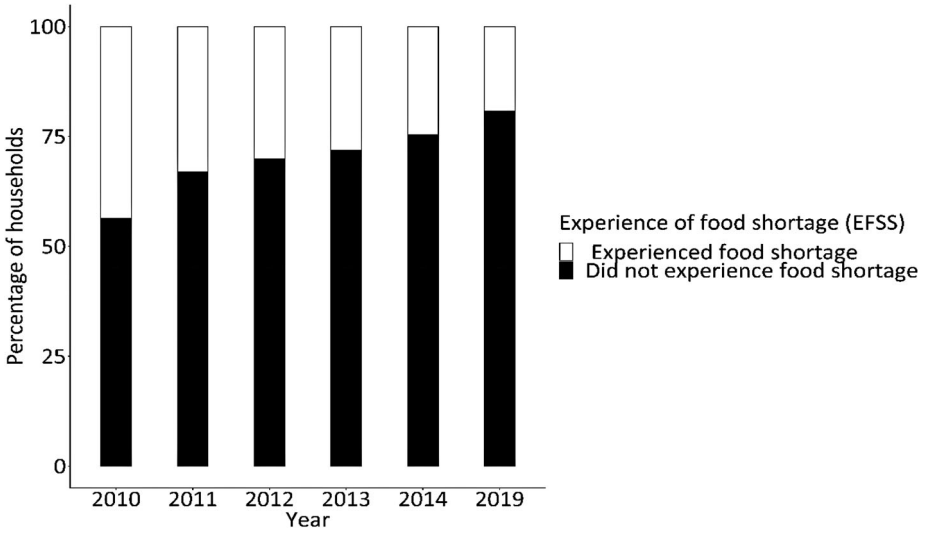

Figure 3. Household food insecurity over past year.

Table 4. Yearly mean scores of experience and severity of food insecurity.

Year	EFSS Mean (SD)	HFIASa Mean (SD)	CSI Mean (SD)
2010	0.43[a] (0.50)	0.77[a] (1.58)	0.76[a] (1.24)
2011	0.33[b] (0.47)	0.36[c] (0.98)	0.59[b] (1.09)
2012	0.30[b] (0.46)	0.64[ab] (1.58)	0.51[bc] (1.06)
2013	0.28[bc] (0.45)	0.29[cd] (0.93)	0.42[cd] (0.97)
2014	0.25[cd] (0.43)	0.19[cd] (0.76)	0.32[de] (0.85)
2019	0.19[d] (0.39)	0.55[b] (1.04)	0.22[e] (0.64)
Average	0.30 (0.46)	0.48 (1.22)	0.48 (1.02)

Years not sharing a common letter are significantly different ($p < 0.05$).

4.4. Relationship between the household food security indicators (HMFS, HDDS, EFSS, HFIASa and CSI)

Another important aspect of adding nuance is understanding the relationships between various food security indicators. As shown in Table 5, significant positive associations ($p < 0.05$) were found between (i) between HMFSa and HDDS and (ii) between EFSS, HFIASa and CSI. Significant negative association was observed between while HDDS and EFSS, HFIASa and CSI.

Table 5. Pairwise correlation matrix of household food security indicators.

	HMFSa	HMFSb	HDDS	EFSS	HFIASa	CSI
HMFSa	1.00					
HMFSb	−0.03	1.00				
HDDS	0.18*	0.17*	1.00			
EFSS	−0.06*	−0.01	−0.20*	1.00		
HFIASa	−0.13	0.01	−0.23*	0.45	1.00	
CSI	−0.08*	0.03	−0.17*	0.52*	0.52*	1.00

* $p < 0.05$.

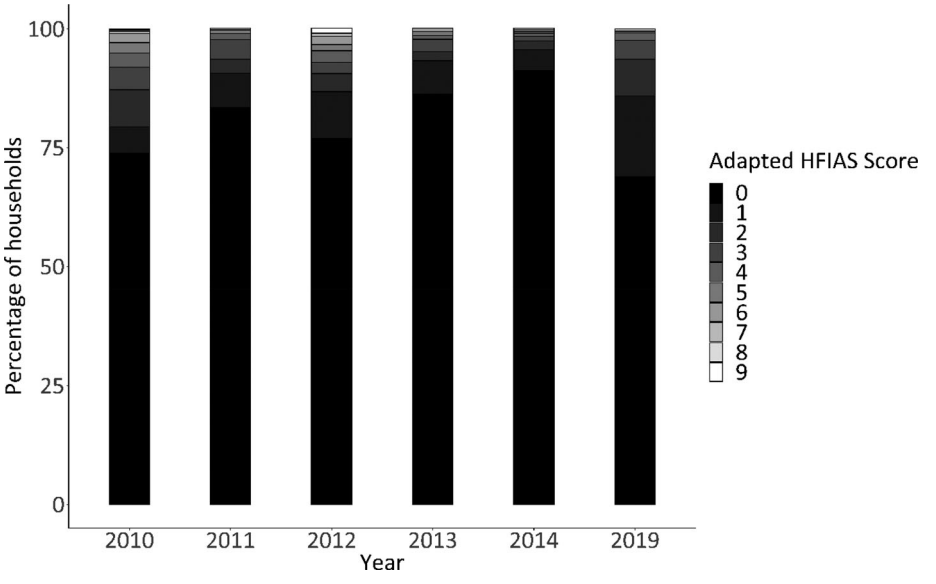

Figure 4. Household food insecurity over past 30 days.

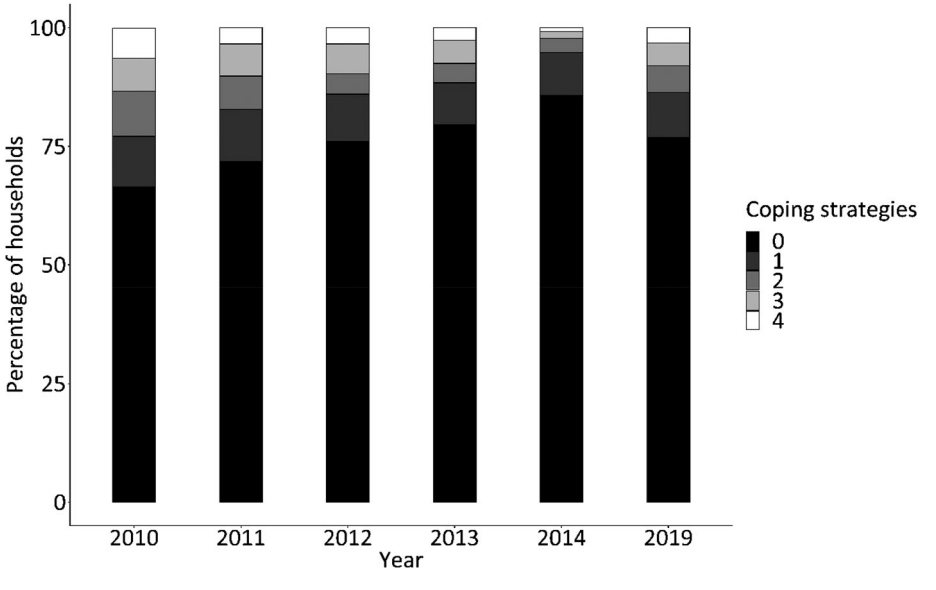

Figure 5. Household use of food consumption-coping strategies.

4.5. Construction of the overall composite food security indicator

The development of a composite food security index FSI, that portrayed the food security status of a household was a key result of our research. A polychoric PCA approach similar to the one applied by Rammohan & Pritchard (2014) and Sam et al. (2019) in their research studies were employed to construct a composite food security indicator HFSI using 6 food security indicators, all of which capture different food security

Table 6. Eigen values and variance of factors used in the HFSI construction.

Factor	Eigen value	Variance (%)	Cumulative variance (%)
F1	2.14	34	34
F2	1.15	19	53
F3	1.00	18	72

aspects. This approach for choosing the number of principal factors, which was proposed by Kaiser (1960) and was also used by Osorio et al. (2013) for a similar objective was used in this study. This approach advocates for retention of factors with eigen values higher than 1 (Table 6). Based on the approach, three factors revealing 72% of the total variance were identified.

Table 7 presents the polychoric PCA results. The interaction or relationship between a factor and variable in PCA is known as factor loadings. These loadings reveal the food security indicators contribution to the variance accounted by each factor (Li et al., 2016). In table 7 and in bold letters are the highest factor loading for each food security indicator variable that were used in coming up with the HFSI indicator variable after varimax rotation with the Kaiser Normalisation procedure using equation 2.

The first factor (F1) unravel 34% of the variance and is correlated with three food security indicators namely EFSS, HFIASa and the CSI. The second factor unravel 19% of the variance, is correlated with HMFSb and HDDS. The third factor is correlated with HMFSa while unravelling 18% of the variance. Figure 6 depicts the percentage of households falling into the four food security levels (1 being the least and 4 the most secure), based on the composite HFSI score. We find that a large proportion of households were in level 3 (29.56–51.68%) or level 4 (39.52–63.34%) of food security. Nevertheless, a small proportion of the households were consistently either in level 2 (6.72–18.06%) or level 1 (0.2–1.70%) of food security, an important insight that suggest further need for food-related interventions. The mean composite HFSI score was 0.71 $\pm$ 0.14 SD and the yearly mean scores varied significantly different ($p < 0.05$) across time (Table 8). The score was highest in 2014 (0.74) and lowest in 2010 (0.66).

4.6. Household food security transitions between food security classes

Table 9 shows 4 × 4 transition matrices tracking the stability and transitions of households categorised by food security levels. These matrices show the percentage of households which either persisted in a food security level or transitioned into another food security level between 2010–14, 2014–19 and 2010–19. The percentages in the diagonals (in bold) represent within-level stability over time, and the percentages in the off-diagonals represent between-level changes. With regard to the diagonals, it was clear that stability within a level was generally constant between 2010–14 and 2014–19. However, a significant transition from level 4 to level 3 was observed in the period 2014–19 as some households became less food secure resulting in a decline within level 4 stability for the period 2010–19. Turning to patterns in the off-diagonal elements in Table 9, of particular interest is that 1.16%, 9.65%, and 24.52% of households that were in the level 1, level 2 and level 3 respectively successfully transitioned to the highly food secure level (level 4) between 2010–14. During the tracking period 2014–19 0%, 2.33% and 9.75% of households that were in level 1, level 2 and level 3 respectively successfully

Table 7. Polychoric PCA factors used for HFSI construction.

Food security indicator	Factors F1	F2	F3
HMFSa	0.02	−0.04	**0.93**
HMFSb	−0.08	**0.89**	−0.04
HDDS	0.25	**0.59**	0.44
EFSS	**0.80**	0.07	−0.01
HFIASa	**0.79**	0.04	0.13
CSI	**0.84**	−0.02	0.02

Bold figures highlight the highest factor loading.

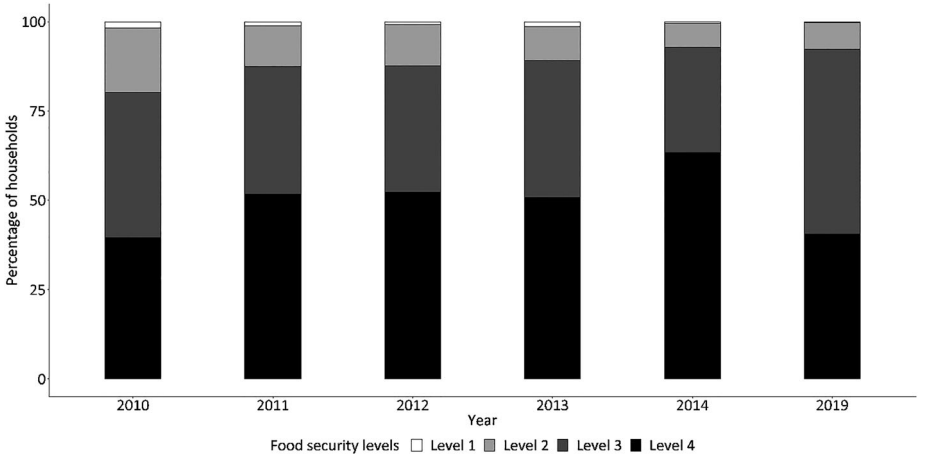

Figure 6. Percentage distribution of households in different food security profiles.

transitioned to be in highly food secure level (level 4). After nearly a decade (2010–19), our results show that 0.4%, 6.16% and 15.71% of households that were level 1, level 2 and level 3 respectively successfully transitioned to the highest food secure level (level 4). A worrisome 1.35%, 3.39% and 1.59% of households that were in the highest food secure level (level 4) transitioned to a lower level of food security (level 2) during the tracking periods 2010–14, 2014–19 and 2010–19, respectively.

4.7. Determinants of household food security classes.

Table 10 shows the mean annual values for household demographic and socioeconomic characteristics and the estimated coefficients of the ordered probit model for overall household food security (HFSI) are displayed in Table 11. Most of the estimated coefficients are statistically significant and have the expected signs. Household size and dependency ratio are statistically significant, but with negative coefficients, which indicates that an increase in household size or the ratio of dependents to prime age adults increases the likelihood of a household to experiencing high levels of food insecurity. Furthermore, our results reveal statistically significant and positive effects of employment, temporary migration, assets and social grants on level of food security. Interestingly, neither gender ratio nor age and gender of the household head had an effect.

Table 8. Yearly mean Household Food Security Index scores.

Year	Mean	SD
2010	0.65[c]	0.17
2011	0.70[b]	0.15
2012	0.70[ab]	0.15
2013	0.70[b]	0.15
2014	0.73[a]	0.12
2019	0.71[ab]	0.12
Average	0.70	0.15

Years not sharing a common letter are significantly different ($p < 0.05$).

Table 9. Transition matrices showing percent persistence and transitions of households into different food security classes.

Household transitions as a percentage 2010–14				
	Levels 1	Level 2	Level 3	Level 4
Level 1	**0**	0.19	0.39	1.16
Level 2	0	**2.51**	6.95	9.65
Level 3	0.39	2.70	**12.55**	24.52
Level 4	0	1.35	9.46	**28.19**
Household transitions as a percentage 2014–19				
	Levels 1	**Level 2**	**Level 3**	**Level 4**
Level 1	**0**	0	0.42	0
Level 2	0.21	**0.64**	3.81	2.33
Level 3	0	3.81	**15.89**	9.75
Level 4	0	3.39	31.36	**28.39**
Household transitions as a percentage 2010–19				
	Levels 1	**Level 2**	**Level 3**	**Level 4**
Level 1	**0**	0.20	1.39	0.40
Level 2	0.20	**2.78**	9.54	6.16
Level 3	0	2.98	**20.87**	15.71
Level 4	0	1.59	19.88	**18.29**

Table 10. Yearly demographic and socioeconomic characteristics of the households.

	Year					
Explanatory variables	2010	2011	2012	2013	2014	2019
Household size	8.11 (4.14)	8.12 (4.18)	7.91 (4.08)	8.51 (4.27)	8.28 (4.08)	6.66 (3.59)
Gender ratio	1.04 (0.79)	1.07 (0.93)	1.10 (0.95)	1.15 (1.09)	1.11 (0.91)	1.10 (1.00)
Dependency ratio	0.80 (0.61)	0.77 (0.60)	0.75 (0.67)	0.71 (0.62)	0.67 (0.55)	0.56 (0.49)
Gender of household head	0.61 (0.98)	0.57 (0.50)	0.57 (0.50)	0.57 (0.50)	0.55 (0.50)	0.56 (0.50)
Age of household head	52.0 (13.9)	53.4 (13.9)	53.8 (14.3)	55.1 (14.0)	56.2 (13.6)	58.7 (14.7)
Employment ratio	0.38 (0.29)	0.41 (0.29)	0.42 (0.29)	0.41 (0.30)	0.43 (0.27)	0.36 (0.29)
Total migrants ratio	0.29 (0.28)	0.26 (0.24)	0.28 (0.27)	0.27 (0.25)	0.27 (0.24)	0.24 (0.29)
Domestic assets	4.88 (1.63)	5.14 (1.49)	5.48 (1.47)	5.21 (1.58)	5.22 (1.50)	5.31 (1.44)
High value assets	0.27 (0.51)	0.29 (0.52)	0.30 (0.53)	0.33 (0.55)	0.32 (0.51)	0.31 (0.50)
Total grants received	1024 (905)	1157 (993)	1265 (1103)	1434 (1229)	1485 (1244)	1361 (1130)
External fields	0.58 (0.79)	0.53 (0.76)	0.38 (0.60)	0.50 (0.68)	0.47 (0.66)	0.11 (0.32)

5. Discussion

This study evaluated the patterns and trends in household food security in a cohort of rural households in Mpumalanga Province of South Africa over a decade. Diverse indicators (consumption patterns, dietary diversity and food sufficiency) and a composite indicator aggregated from the individual food security measures were used to capture the multi-faceted nature of food security. First, we identified interesting patterns and

Table 11. Ordered probit regression estimates of the determinants of HFSI categories.

Variable	Coef	SE	Wald	*P* value
Household size	−0.31	0.01	−3.01	<0.01*
Gender ratio	−0.03	0.04	−0.93	0.35
Dependency ratio	−0.13	0.06	−2.02	0.04*
Gender of the household head	−0.04	0.06	−0.70	0.48
Age of the household head	0.00	0.00	0.85	0.39
Employment ratio	0.95	0.14	6.58	<0.01*
Total migrants ratio	0.55	0.15	3.56	<0.01*
Domestic assets	0.33	0.02	13.14	<0.01*
High value assets	0.40	0.08	5.15	<0.01*
Total grants received	0.00	0.00	3.13	<0.01*
External fields	0.12	0.06	2.23	0.03*
Y> = 2	2.64	0.27	9.87	<0.01*
Y> = 3	−0.12	0.21	−0.58	0.56
Y> = 4	−2.34	0.21	−11.18	<0.01*

Model diagnostics: observations; 3235, LR chi2; 431.66, PR(>chi2) < 0.01, $R^2 = 0.14$.
*significant at $p < 0.05$.

trends of food security including the positive outcome that most rural households in our study region (81–92%) had an average of three meals per day, the typical recommended pattern (Paoli et al., 2019). In terms of trends of main meal consumption, the picture is more mixed, there was a significant increase in 2011 that remained stable until 2013 with 2014 and 2019 showing sharp increases and decreases, respectively. Our results also showed snacking (HMFSb) was not common, as over 50% of the household did not consume any snack meals over the 24-hour recall period.

We also examined the dietary diversity among the households. Our results showed stability in dietary quality, although a notable change occurred in 2013 and 2019 where there was substantial decline in the consumption of fruits and vegetables. This could be due to below-average rainfall in those years, which inhibited food production. Due to the multifaceted nature of malnutrition, the study was not able to determine whether the dietary diversity scores obtained were sufficient for nutritional adequacy. In this way, our work aligns with Ruel & Alderman (2013) who argued that dietary diversity is necessary to measure food access and availability but not sufficient to ensure adequate nutrition. Although the HDDS used in this study is not a perfect indicator of nutritional sufficiency, it does provide insight into the quality of the diet. Additional research is still needed on how to better capture nutritional adequacy using HDDS at household level.

The indicators of food shortage in past the 12 months (EFSS) and hunger experienced in the past 30 days (HFIASa) were devised to gauge the access component of household food insecurity. The study revealed year to year fluctuations with the EFSS showing a significant decrease in household food shortage over time. Hunger in the past month (HFIASa) did not, however, exhibit such a positive trend as it fluctuated across the study period, and was higher in 2019 than prior years. This fluctuation points to fragility of food access in some rural households. The CSI scores showed changes in household food security status, with a trend of lower CSI scores over the years representing low extent and frequency of employing coping strategies, and hence indicating an improvement of household food security. The significant positive correlation between food shortage and hunger (EFSS and HFIASa) and the measure of coping strategies (CSI) means that the results are internally consistent. However, the low positive correlation observed

between the metrics might be as a result of metrics that did not all improve over time in the same way.

Assessing a household's overall food security status requires evaluating the four dimensions namely access, availability, utilisation and stability. Hence it was important to develop a composite indicator that tries to capture at least these four aspects of food security over time There was a general improvement in rural households' food security status by 5% in terms of the composite measure (HFSI) over the study period. A growing proportion of households became highly food secure. This can be seen through the high outward transition of households from level 1 and level 2 of food security compared to the inward movement. After nearly a decade (2010–19), severely food insecure households (level 1) were very uncommon, but at least 7% of the households were still in level 2 by the end of the study period. This is a key finding and indicates that food challenges remain even in the context of general improvement.

The second key finding of this study is the importance of household demographic and socioeconomic status in shaping household food security. Our results show that the households in different food security classes have varying levels of human, financial, physical and natural capital. The four levels of food security lay along a gradient of livelihood capitals and household food security significantly differed in terms of ratio of employment and migrants per active adults and wealth profile (assets). High prevalence of food security was higher in households with high levels of employment and more migrant members. This may be due to the fact that households whose members are employed or have migrated to towns and cities in search of better employment opportunities have higher incomes to purchase sufficient food.

The third key finding is that the longitudinal nature of the data is able to reveal the dynamic nature of food security than the more typical cross-sectional approach. For example, the mean score for the HFIAS indicator showed significant year-to-year fluctuations, an indication that household's food security is not static. These findings also have important policy implications for rural development as they can be used to assess the impacts of different rural development trajectories or assess the progress of the different rural development trajectories in achieving their intended objectives.

The final key finding of this study regards the need for local nuances and specificities. Our results unravel and contextualise the heterogeneity of rural food security in South Africa. Compared to other studies on food security in rural areas in South Africa that suggests that food insecurity challenges are geographical and structural, this study provides a far more local nuanced understanding of drivers of food insecurity over time than previous work at provincial or national scales. The study enabled us to identify who is food insecure and why – an understanding that is often masked in national or provincial assessments but yet it is essential for the design of appropriate local interventions.

We interpret the study findings bearing in mind some limitations. First, although these longitudinal data are particularly useful for assessing patterns and trends in food security over time, it is limited by the missing years between 2014 and 2019. Therefore, the capacity to come up with causal linkages for any changes in food security for that period is limited. Second, the use of self-reporting to determine household food security status is a limitation as it may be prone to both intentional and unintentional misreporting, which could be misleading or decieving. In our case, we anticipate social desirability

bias. Third, the EFSS and the HFISa metrics used in this study were modified from the original metrics in order to keep the interview time to a reasonable length. These modifications satisfactorily captured the intended objective of the measurement and were relatively easy to collect from the households. However, a different study using the original metrics or a combination of the metrics might yield a different picture. Finally, although the composite food security measure (HFSI) is multidimensional derived from measures of dietary diversity, recent hunger, and the use of coping strategies and these components were equally weighted and combined to capture overall food security. However, we also recognise that composite indicators can oversimplify or hide complexity at the local scale. Despite this limitation, our study suggests that the composite HFSI indicator may be useful in conveying broad messages on the overall food security situation.

6. Conclusion

Food insecurity is a critical and persistent problem facing most households in rural southern Africa. This study provides an overview of the food security situation and progress that has been made in reducing food insecurity in specific rural communities by examining trends and patterns over the past decade in a rural area in Mpumalanga Province, South Africa. Considering the multidimensional nature of food security, our results suggest general improvement in food access. Improvement in food access was critical as it triggered stability in food availability as well as utilisation of various food groups within households. The study also noticed high outward transition from highly food insecure or moderately food insecure compared to the inward movement towards moderate food security and high food security. A key finding is that while the majority and a growing proportion of households are food secure, a significant number remain food insecure. More than 7.8% of households remained food insecure after the decade covered here. This is of concern and further research is needed to identify the major determinants of food security to inform targeted government policy and interventions aimed at eradicating food insecurity.

Our findings lead to several important policy implications for improving food security in rural South Africa. First, empowering rural households through availing non-farm employment opportunities has potential to improve food security of rural households. Second, economic opportunities create wealth, which increases the purchasing power of households. Thus enabling increased outward transition from highly food insecure and moderately food insecure classes to moderately food secure or highly food secure classes. It is our contention that this analytical lens provides a far more nuanced understanding of food insecurity over time than previous work at provincial or national scales- an understanding that is essential for the design of appropriate local interventions.

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